FEEDING MANAGEMENT :
A PRO-DAIRY MANAGEMENT FOCUS WORKSHOP FOR DAIRY FARM MANAGERS
PARTICIPANT'S MANUAL

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FEEDING MANAGEMENT

DAY 1

Welcome at the Door and Start Warm-up Exercise

Warm-up Exercise - Ranking Hay Visually

Teaching team and Participant Introductions

Quality Forage

The Farm Business Environment

Ruminant Digestive Physiology

Session 1 Homework

DAY 2

Allocation of Forage Inventories

Forage Analysis

Dry Matter Intake

DAY 3

Protein

Energy

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DAY 4

Feeding Management Strategy

Your Farm Feeding System; Self Evaluation, Strategic and Tactical Planning

Conclusion and Course Evaluation

PRO-DAIRY
FEEDING MANAGEMENT

PARTICIPANT'S MANUAL INDEX

Section 1 - Workshop Materials

Section 2 - Resource Material by Day and Exercise

Day 4

Section 3 - General Reference

Note: All feed weights are on an as-fed basis

D. Calculation of Feed Cost and Income Over Feed Cost

1. Ask the participants for the following information:

   Milk, $/cwt =

   Corn silage, $/ton =
   Hay-1, $/ton =
   Hay-2, $/ton =
   Hay-3, $/ton =
   Grain, $/ton =

2. Calculate total and grain feed cost

   Example:

Feed	$/ton	$/cwt	lbs. fed	$
Corn silage	24	1.20	37	.44
Hay	85	4.25	14	.60
Grain	175	8.75	22	1.93

   Total feed cost (TFC) = $2.97

   Grain feed cost (GFC) = $1.93

3. Calculate income over feed cost (IOFC)

   a. Assume milk is $12/cwt

   b. Milk income (MI) = $12 * .6 = $7.20

   c. IOFC = MI - TFC = $7.20 - $2.97 = $4.23

   d. IOFC = MI - GFC = $7.20 - $1.93 = $5.27

4. Discussion points

   a. Impact of forage quality on forage intake and the quantity of grain required.

   b. Forage quality and IOFC

   c. Forage quality, grain cost and income over grain cost.

FEEDING MANAGEMENT

The Farm Business Environment

Key Points:

1. Internal resources include the farm physical plant (buildings, land and storage facilities), equipment, livestock and most importantly - PEOPLE! Beyond the obvious day to day operations personnel, other people supplying goods and services to the business can be considered an internal resource once they or their products have been selected.

2. It is these internal resources that can be manipulated through management to adapt technology to further the realization of goals, objectives and ultimately the mission of the farm business.

3. While it is important to understand the forces external to the farm business that affect it day to day and in the short run, consider these forces, but recognize that they cannot be changed through the efforts of the farms management.

4. Occasionally the farm manager may take the risk that he or she can accurately predict changes in the external environment, and make plans accordingly. Again the external forces are not being managed, but planning is merely reflecting a predicted change in those forces.

THE FARM BUSINESS ENVIRONMENT

NTERNAL RESOURCES

(I can readily manipulate to enact change)

EXTERNAL FORCES

(Exist whether I'm in business or not)

Forage Analysis Exercise:

The following example can be used to show how a forage analysis is used and the importance of knowing forage dry matter content and amount of feed consumed. To be completed with ration analysis sheets.

Mature 1400 pound cow
80 pounds 4% milk

Cow Requirements:	Dry Matter Intake:	50.3 pounds
	Crude Protein:	8.12 pounds
	Energy, NEL:	37.42 Mcal

--------DM Basis-------------

Feeds	Dry Matter %	Crude Protein %	NEL Mcal/lb
Haylage	45	18	0.56
Corn Silage	35	8.5	0.72
High Moisture Shell Corn	75	8.2	0.92
Mixed Grain	90	30	0.80

Using ration analysis worksheets, to calculate the amounts of dry matter, crude protein, and energy supplied by the following ration:

Corn Silage:	20	"Lbs. as Fed"
HM Shell Corn:	21	"Lbs. as Fed"
Mixed Grain:	13	"Lbs. as Fed"
Haylage:	35	"Lbs. as Fed"

How well are cow requirements filled?

With corn silage, HM shell corn and mixed grain remaining the same, change the dry matter on the haylage to 35%. Calculate the new dry matter, crude protein and energy values. What effect does this have on fulfillment of the cow's requirements (assume that the cow is limit fed and only allowed the original as fed amount)? What might her production response be?

If time allows, calculate what changes occur when the haylage dry matter increases to 55%.

RATION ANALYSIS WORKSHEET

Body Weight _______ Lb   Milk Production _______ Lb   Butterfat _______ %
First Lactation, Second, Mature, Dry or Heifer _______________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb
________	____	X	___	=	______	X	________	=	______ lb
							________	=	______ lb

Total Ration Dry Matter = ________ *Lb*	*Total Nutrient Supplied* = ________ *Lb*	*Total Nutrient Supplied* = ________ *Lb*
Expected DMI = ________ *Lb*	*Required Nutrient* = ________ *Lb*	*Required Nutrient* = ________ *Lb*
Difference DMI ________ *Lb*	*Nutrient* ________ *Lb*	*Nutrient* ________ *Lb*

FEEDING MANAGEMENT

Allocation of Forage Inventories

Key Points:

1. The tendency of Dairy Farm businesses in the Northern U.S. dairy areas to combine a cropping enterprise with the dairy enterprise can be both a competitive strength and weakness. On the negative side, it is not financially feasible to set yourself up with enough equipment and personnel to beat mother nature on every field within every crop. The positive side is that through careful planning, which includes several iterations of contingency plans, we can maximize physical and labor resources and deliver an optimal forage to each class of cattle on the farm, using constantly changing allocation strategies.

2. Silo capacity charts for top and bottom unloading upright silos, trench and bunker silos and bags, stacks etc. require evaluation of actual storage conditions for reasonable capacity estimates.

3. Forage dry matter disappearance varies with the quality of the forage as well as the animal group to which it is being fed.

4. Large dividends are the rule when limited quantities of quality forage are allocated to early lactation cows and weanling heifers; even when additional labor expense is accrued in order to segregate the herd.

Recognizing the limitations the current mode of storage places on herd performance and profitability, opens a door for creative integration of animal forage needs, the land resource, the storage facilities and harvest equipment and techniques. This type of planning is both time consuming and requires a "fresh" mind. (Some counties or areas may be offering a regular Extension unit on "Integrated Forage Resource Management". This might be the opportune time to first mention this offering.)

ESTIMATING DAIRY FORAGE REQUIREMENTS

Dairy cattle will eat a consistent amount of forage dry matter based on their bodyweight and forage quality. The better the feed, the more they will eat.

By knowing the average size and number of animals, quality of forage, and number of days desired to feed, it's relatively easy to calculate a farm's forage dry matter needs.

Number of cows X lbs. of dry matter/day X number of days = lbs. of dry matter/year.

Dividing the lbs. dry matter by the percent dry matter of the feed gives the lbs. of as-fed feed.

TO ESTIMATE YOUR FARM FORAGE NEEDS:

1. *Determine the number of animals by bodyweight.*
2. *Find the estimated dry matter intake/day according to quality and hay or haycrop silage to corn silage ratio (inside tables).*
3. *Figure the number of feeding days.*
4. *Follow the outline on the back page to estimate the total tons dry matter needed.*
5. *Divide by the percent dry matter of the as-fed feed.*

Corn Silage	*30-35%*	*(average range)*	*dry matter*
Dry Hay	*85-90%*	*(average range)*	*dry matter*
Haycrop Silage	*30-50%*	*(average range)*	*dry matter*

6. *"Hay Crop" refers to a combination of Baled Hay and Hay Crop Silage.*

TABLE 1A

COWS

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY (> 53% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage		1/2 Hay Crop 1/2 Silage		1/3 Hay Crop 2/3 Silage		Hay Crop or Silage
	Hay Crp.	Silage	Hay Crp.	Silage	Hay Crp.	Silage	Silage
800	11.3	5.5	8.4	8.4	5.5	11.3	16.8
1000	14.0	7.0	10.5	10.5	7.0	14.0	21.0
1200	16.9	8.3	12.6	12.6	8.3	16.9	25.2
1300	18.2	9.0	13.6	13.6	9.0	18.2	27.2
1400	19.7	9.7	14.7	14.7	9.7	19.7	29.4
1600	22.5	11.1	16.8	16.8	11.1	22.5	33.6

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY (47-52% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage		1/2 Hay Crop 1/2 Silage		1/3 Hay Crop 2/3 Silage		Hay Crop or Silage
	Hay Crp.	Silage	Hay Crp.	Silage	Hay Crp.	Silage	Silage
800	13.0	6.4	9.7	9.7	6.4	13.0	19.4
1000	16.2	8.0	12.1	12.1	8.0	16.2	24.2
1200	19.4	9.6	14.5	14.5	9.6	19.4	29.0
1300	21.2	10.4	15.8	15.8	10.4	21.2	31.6
1400	22.7	11.2	16.9	16.9	11.2	22.7	33.9
1600	25.9	12.8	17.4	17.4	12.8	25.9	38.7

POUNDS OF FORAGE DRY MATTER PER DAY - SUPERIOR QUALITY (<46% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage		1/2 Hay Crop 1/2 Silage		1/3 Hay Crop 2/3 Silage		Hay Crop or Silage
	Hay Crp.	Silage	Hay Crp.	Silage	Hay Crp.	Silage	Silage
800	15.3	7.6	11.5	11.5	7.6	15.3	22.9
1000	19.3	9.4	14.3	14.3	9.4	19.2	28.6
1200	23.0	11.4	17.2	17.2	11.4	23.0	34.4
1300	24.9	12.3	18.6	18.6	12.3	24.9	37.2
1400	26.8	13.2	20.0	20.0	13.2	26.9	40.0
1600	30.7	15.1	22.9	22.9	15.1	30.7	45.8

TABLE 1B

HEIFERS

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY (> 53% NDF)
(includes 10% waste)

Weight of Heifer (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	Never feed young replacements poor feed						
500	5.0	2.5	3.8	3.8	2.5	5.0	7.5
700	7.0	3.0	5.0	5.0	3.0	7.0	10.0
900	9.8	4.8	7.3	7.3	4.8	9.8	14.6
1100	10.6	5.2	7.9	7.9	5.2	10.6	15.8

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY (47-52% NDF)
(includes 10% waste)

Weight of Heifer (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	3.4	1.6	2.5	2.5	1.6	3.4	5.0
500	6.8	3.2	5.0	5.0	3.2	6.8	10.0
700	10.0	5.0	7.5	7.5	5.0	10.0	15.0
900	13.1	6.5	9.8	9.8	6.5	13.1	19.6
1100	15.4	7.6	11.5	11.5	7.6	15.4	23.0

POUNDS OF FORAGE DRY MATTER - SUPERIOR QUALITY (< 46% NDF)
(includes 10% waste)

Weight of Heifers (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	4.9	2.1	3.5	3.5	2.1	4.9	7.0
500	8.4	4.2	6.3	6.3	4.2	8.4	12.6
700	12.0	6.0	9.0	9.0	6.0	12.0	18.0
900	14.2	7.0	10.6	10.6	7.0	14.2	21.2
1100	15.4	7.6	11.5	11.5	7.6	15.0	23.0

FORAGE NEEDS WORKSHEET

Average Number Cows (milking & dry) ____________________

Average Body Weight ____________________

Average Number of Heifers (900 lbs.-calving) ____________________

Average Number of Heifers (500-900 lbs.) ____________________

Average Number of Calves (300-500 lbs.) ____________________

FORAGE DRY MATTER NEEDS (From Tables 1A and 1B)
Hay Crop and Corn Silage

	Average Number of Animals	X	Average Number of Days	X	Lbs. Drymatter (Table)	÷ 2000 =	Drymatter Tons Needed
Cows - Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Cows - Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Heifers 900 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Heifers 900 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Heifers 500 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Heifers 500 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Calves 300 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Calves 300 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage

SUMMARY AND CONVERSION TO AS FED BASIS

Hay Crop

Dry Hay Tons Dry Matter Needed __________ ÷ _________ *(% DM Hay) =* ________________*
Tons DM Hay As Fed

Hay Crop Silage Tons Dry Matter Needed __________ ÷ _________ *(% DM Hay Crop Silage) =* ______*
Tons Hay Crop Silage As Fed

Corn Silage

Total Tons Corn Silage __________ ÷ _________ = ______________________________*
% DM *Tons Corn Silage As Fed*

* *A final conversion to Lbs. Per day on an As Fed Basis can be obtained by dividing the Total by the number of days used in workspace above, and multiplying by 2,000.*

FORAGE INVENTORY AND ALLOCATION

In order to develop a year-round program for the dairy herd, it is necessary to know how much of any given forage is available to feed.

The procedure to figure your own farm forage inventory is easy, all of the information necessary is on these sheets.

1. *Determine the amount of silage dry matter in your silo(s) and record on the appropriate page. (Be sure to account for any removed; procedure is illustrated inside).*

2. *Divide the dry matter figures recorded by the percent dry matter of your feed. (Your DHI Supervisor or Cooperative Extension specialist can help you determine the percent dry matter of your feed).*

   Example: *150 Tons DM ÷ 0.45 (45%) = 333 Tons as Fed*

3. *Total the tons of "as-fed" feed available and subtract a storage and feeding loss (8-15%).*

4. *Divide the available tons of feed by the number of feeding days. (Days to next harvest, subtract for cows on pasture). Then divide by the number of animals. Multiply by 2,000 to find the pounds/head/day available to feed.*

FORAGE AVAILABLE: PER HEAD - PER DAY

FORAGE CAPACITY

SILO	*TYPE*	*DIMENSIONS*	*DRY MATTER CAPACITY*		*% DRY MATTER OF FORAGE*		*AS FED CAPACITY*
#1	______	______	______	÷	______	=	______
#2	______	______	______	÷	______	=	______
#3	______	______	______	÷	______	=	______
#4	______	______	______	÷	______	=	______
#5	______	______	______	÷	______	=	______
#6	______	______	______	÷	______	=	______

TOTAL STORAGE CAPACITY - HAY CROP SILAGE ________ *TONS -* ______ (*% storage & feeding loss*) = ____________ (*Tons Avail. Feed*)

TOTAL STORAGE CAPACITY - CORN SILAGE ____________ *TONS -* ______ (*% storage & feeding loss*) = ____________ (*Tons avail. Feed*)

TOTAL STORAGE CAPACITY - DRY HAY

________ (*# of bales*) X ________ (*avg. wgt./ bale*) ÷ 2000 = ________ (*tons hay & feeding loss*) - ________ (*% storage & feeding loss*) = ________ (*Tons avail. Feed*)

OR

________ (*Hay in feet*^{3}) x *8 lbs.* / *feet*^{3} ÷ 2000 = ________ (*tons hay*) - ________ (*% storage & feeding loss*) = ________ (*Tons avail. Feed*)

	Tons Feed ÷	Number of Feed Days	Number of Animals X	2000 =	lbs/head/day
Corn Silage	________ ÷	________________ ÷	______________	X 2000 =	____________
Hay Crop Silage	________ ÷	________________ ÷	______________	X 2000 =	____________
Dry Hay	________ ÷	________________ ÷	______________	X 2000 =	____________

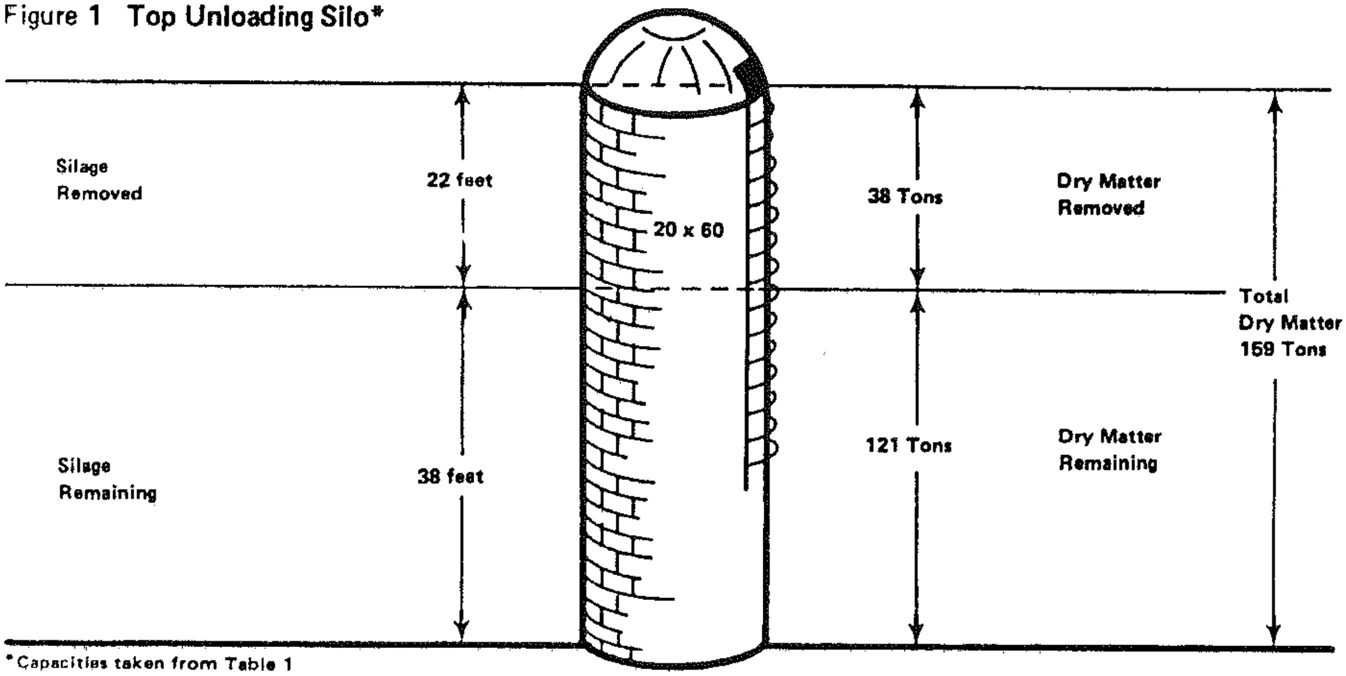
(Compare total available to feed to your calculated forage requirements).

Table 1 Approximate dry matter capacity of silos

Depth of settled silage	Inside diameter of silo											
	10	12	14	16	18	20	22	24	25	26	28	30
(ft.)	Tons of silage											
2	0	0	1	1	1	1	1	2	2	2	2	3
4	1	1	2	2	3	3	4	5	5	6	6	7
6	1	2	3	4	5	6	7	9	9	10	12	13
8	2	3	4	6	7	9	11	13	14	15	17	20
10	3	4	6	8	10	12	15	18	19	21	24	28
12	4	6	8	10	13	16	19	23	25	27	31	36
14	5	7	10	13	16	20	24	29	31	34	39	45
16	6	9	12	15	19	24	29	35	38	41	47	54
18	7	10	14	18	23	28	34	41	44	48	56	64
20	8	12	16	21	27	33	40	48	52	56	65	74
22	9	14	19	24	31	38	46	55	59	64	74	85
24	11	15	21	27	35	43	52	62	67	73	84	97
26	12	17	24	31	39	48	58	69	75	81	94	108
28	13	19	26	34	43	54	65	77	84	90	105	120
30	15	21	29	38	48	59	71	85	92	100	116	133
32	16	23	32	41	52	65	78	93	101	109	127	146
34	18	25	35	45	57	71	85	102	110	119	138	159
36	19	28	38	49	62	77	93	110	120	130	150	172
38	21	30	41	53	67	83	100	119	129	140	162	186
40	22	32	44	57	72	89	108	128	139	151	175	200
42	24	34	47	61	77	96	116	138	149	161	187	215
44	26	37	50	65	83	102	124	147	160	173	200	230
46	27	39	53	70	88	109	132	157	170	184	213	245
48	29	42	57	74	94	116	140	167	181	195	227	260
50	31	44	60	78	99	123	148	177	192	207	240	276
52	32	46	63	82	104	128	155	185	201	217	252	289
54	34	48	66	86	109	134	163	194	210	227	263	302
56	35	50	69	90	114	140	170	202	219	237	275	316
58	37	53	72	94	118	146	177	210	228	247	286	329
60	38	55	75	97	123	152	184	219	238	257	298	342
62			77	101	128	158	191	227	247	267	310	355
64			80	105	133	164	198	236	256	277	321	369
66			83	109	137	170	205	244	265	287	333	382
68			86	112	142	176	212	253	274	297	344	395
70			89	116	147	182	220	261	284	307	356	408
72					152.	187	227	270	293	317	367	422
74					157	193	234	278	302	327	379	435
76					161	199	241	287	311	337	390	448
78					166	205	248	295	320	347	402	461
80					171	211	255	304	330	357	413	475
82							262	312	339	366	425	488
84							270	321	348	376	437	501
86							277	329	357	386	448	514
88							284	338	366	396	460	528
90							291	348	376	406	471	541
92							298	355	385	416	483	554
94							305	363	394	426	494	567
96							312	372	403	436	506	581
98							319	380	412	446	517	594
100							327	389	422	456	529	607

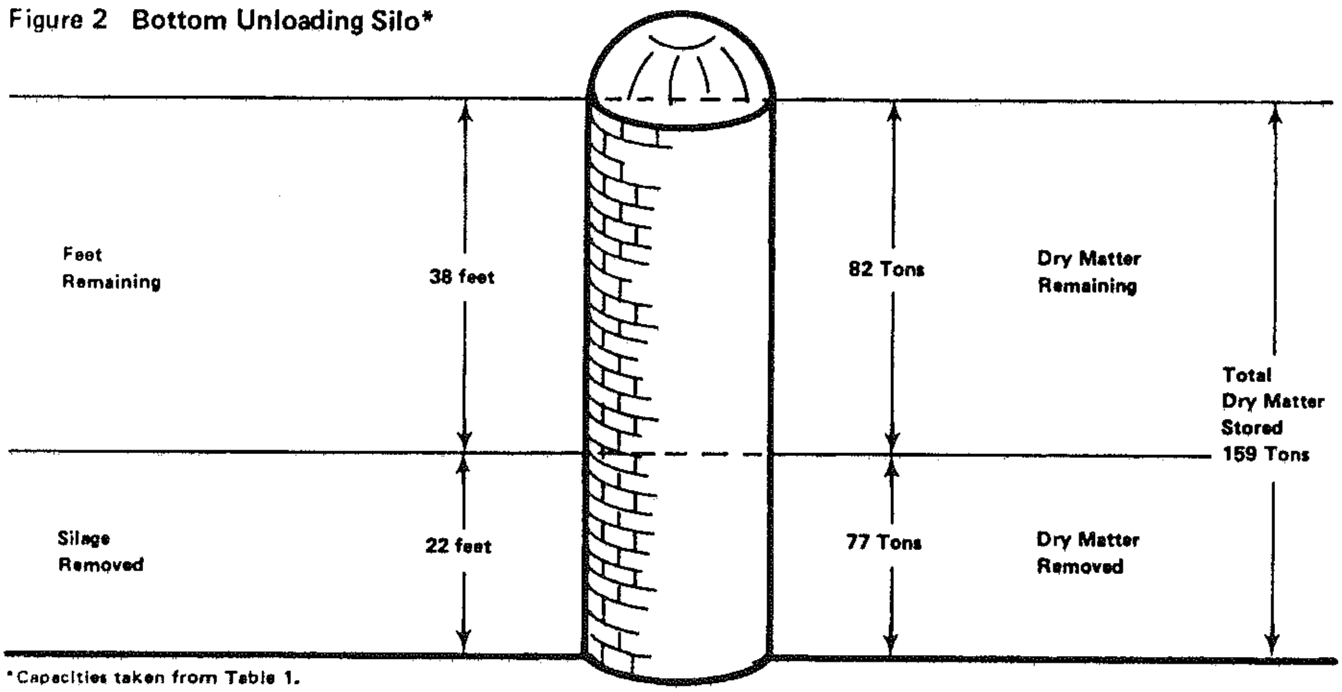
To find the tons remaining in a top unloading silo after part of the silage is removed: (1) find the tons of silage when the silo was filled, (2) find the tons in a silo filled to the height equal to the depth of silage removed, (3) subtract the number of tons in Step 2 from the number of tons in Step 1. Example: A 20-ft. silo filled to a settled depth of 60 ft. and 22 ft. was fed off, (1) 20x60 = 152 tons, (2) 20x22 = 38 tons, (3) 152 tons − 38 tons = 114 tons remaining.

Figure 1 **Top Unloading Silo***



*Capacities taken from Table 1

Figure 2 **Bottom Unloading Silo***



*Capacities taken from Table 1.

DRY MATTER TONNAGE FOR CORN AND HAY CROP SILAGE IN WELL-PACKED HORIZONTAL SILOS wwi-1/89

AVERAGE WIDTH (FT)	AVERAGE DEPTH OF SILAGE (FEET) 6	8	10	12	14	16	18	20
	DRY MATTER (TONS / FOOT OF LENGTH)							
12	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.7
16	0.5	0.7	1.0	1.2	1.4	1.7	2.0	2.3
20	0.7	0.9	1.2	1.5	1.8	2.1	2.5	2.9
24	0.8	1.1	1.4	1.8	2.2	2.6	3.0	3.5
30	1.0	1.4	1.8	2.2	2.7	3.2	3.8	4.3
40	1.3	1.8	2.4	3.0	3.6	4.3	5.0	5.8
50	1.7	2.3	3.0	3.7	4.5	5.4	6.3	7.2
60	2.0	2.7	3.6	4.5	5.4	6.4	7.5	8.7
70	2.3	3.2	4.2	5.2	6.3	7.5	8.8	10.1
80	2.6	3.7	4.8	5.9	7.2	8.6	10.0	11.6
90	3.0	4.1	5.4	6.7	8.1	9.6	11.3	13.0
100	3.3	4.6	5.9	7.4	9.0	10.7	12.5	14.5

- DENSITY INCREASES WITH DEPTH 4 % / 2 FT

11	11.44	11.90	12.37	12.87	13.38	13.92	14.48

- PERCENT VOLUME LOSS WITH TOP SURFACE SPOILAGE 0.5 FT. DEEP

8.3	6.3	5.0	4.2	3.6	3.1	2.8	2.5

- TOP SPOILAGE CAN EXCEED 15% WITH POOR PROCEDURES

-- AND BE LESS THAN 5% ON VERY LARGE HORIZONTAL SILOS

-- OR WITH CAREFULLY PLACED AND WEIGHTED PLASTIC .

- AVERAGE DRY MATTER RETENTION VS. BURIED BAGS ON 11 FARMS
  - 85% IN 5 SILOS FOR HAY CROP SILAGE
  - 86% IN 40 SILOS FOR CORN SILAGE (1978 CHORE RED.)
- SUMMER FEEDING RATES SHOULD USE 1/2 FT. OF EXPOSED FACE DAILY
  WINTER RATES CAN BE 1/4 FOOT

RATION ANALYSIS WORKSHEET

Body Weight ________Lb   Milk Production ________Lb   Butterfat ________%

First Lactation, Second, Mature, Dry or Heifer ________________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb

Total Ration Dry Matter = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*
Expected DMI = ________*Lb*	*Required Nutrient* = ________*Lb*	*Required Nutrient* = ________*Lb*
Difference DMI ________*Lb*	*Nutrient* ________*Lb*	*Nutrient* ________*Lb*

RATION ANALYSIS WORKSHEET

Body Weight _______ Lb Milk Production _______ Lb Butterfat _______ %
First Lactation, Second, Mature, Dry or Heifer ______________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*
________	____	X	___	=	______	X	________	=	______ *lb*
							________	=	______ *lb*

Total Ration Dry Matter = ________ *Lb*	*Total Nutrient Supplied* = ________ *Lb*	*Total Nutrient Supplied* = ________ *Lb*
Expected DMI = ________ *Lb*	*Required Nutrient* = ________ *Lb*	*Required Nutrient* = ________ *Lb*
Difference DMI ________ *Lb*	*Nutrient* ________ *Lb*	*Nutrient* ________ *Lb*

FEEDING MANAGEMENT

Your Farm Feeding System; Self Evaluation, Strategic and Tactical Planning

Key Points:

1. "Ideal management" as it pertains to feeding milking cows, dry cows, calves or heifers is a transient thing. However, at any given juncture, feeding "experts" and farm managers can agree on what is ideal for the moment. Given that, it is not a lack of understanding the appropriate technology, but rather a question of how to put it into practice under the individualized constraints of a given farm. THIS is management in a nutshell.

2. Although some producers may brainstorm with their counterparts, many operations are either insulated or walled in from the pools of creativity and experience that exists among th 12,000 or so similar businesses in New York State and beyond. The pitfall to soliciting input from others is that not all observations are necessarily accurate, and the economic viability of a certain practice on a farm is too often not known. Good managers learn how to sift and winnow information from many sources.

3. A well conceived and constructed tactical plan may require borrowed capital to engage, or the full support of employees to execute. In either case the time taken to write out the plan(s) will likely contribute to the end result. Employee input in constructing the plan encourages them to buy in to the changes being made. Likewise few lenders would ignore a proposal supported by tactical plans for execution, monitors, controls and cost/benefit projections.

OPTIMAL FEEDING STRATEGIES

FRESH COWS (0-30 days)

EARLY LACTATION (30-90 days)

MID LACATION (90-200 days)

LATE LACTATION (200+ days)

EARLY DRY

LATE DRY

OPTIMAL FEEDING STRATEGIES

BABY CALVES (to weaning)

WEANLING HEIFERS (2-6 months)

GROWING HEIFERS (6-14 months)

BRED HEIFERS (15-23 months)

SPRINGING HEIFERS (23-24+ months)

FEEDING STRATEGIES (tie barn)

FEEDING STRATEGIES (free stalls)

MANAGEMENT FOCUS WORKSHOP: FEEDING MANAGEMENT

FEEDBACK SHEET

Date ______________________________

County ______________________________

Workshop site ______________________________

Section 1. Please help us to improve the course by answering the following general questions.

a. What did you like best about the course?

b. What did you like least about the course?

c. If you could change one thing about the course, what would it be?

d. Please rate the content of the workshop by circling one number in each category.

Useless	1	2	3	4	5	Useful
Impractical	1	2	3	4	5	Practical

e. Please rate the discussion leaders for the workshop by circling one number in each category.

Amateur	1	2	3	4	5	Professional
Disorganized	1	2	3	4	5	Well prepared
Uninformed	1	2	3	4	5	Knowledgeable

f. Please give your comments about the written resource materials you received during the course.

Section 2. Please rate each part of the course on a scale of 1 (low value) to 5 (high value) according to its value to you in managing your farm's feeding program. Circle one number for each area.

Forage Quality and the Dairy Farm
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

The Farm Business Environment
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Rumen Metabolism
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Forage Analysis - Monitoring the Forage Supply
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Allocating the Forage Supply
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Dry Matter Intake
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Protein and Energy Utilization
(Low value) 1 2 3 4 5 (High value)

Comments:____________________________________

Body Condition Scoring - a Monitoring Tool... and More
(Low value) 1 2 3 4 5 (High value)

Comments:____

Dry Cow Management
(Low value) 1 2 3 4 5 (High value)

Comments:____

Heifer Management
(Low value) 1 2 3 4 5 (High value)

Comments:____

Feeding Strategy
(Low value) 1 2 3 4 5 (High value)

Comments:____

"Homework" assigned during the course
(Low value) 1 2 3 4 5 (High value)

Comments:____

Developing a Feeding Management Tactical Plan for Your Farm
(Low value) 1 2 3 4 5 (High value)

Comments:____

Approximately how many minutes did you drive (one-way) to attend this course?

______ Minutes (one-way)

Considering your answer to the above, approximately how many additional minutes (further than you drove for this course) would you be willing to drive for a similar course in the future?

______ Additional minutes (one-way)

General comments on resource materials, meeting facility, location, food, room setup, or anything else!

____

____

____

Have you identified opportunity areas in your Feeding Management Systems in which you intend to enact changes?

YES ___ NO ___

If yes, in what areas?

____

____

____

____

QUALITY FORAGES

R. Clinton Young
Extension Specialist

One of the primary resources of virtually any well managed, profitable dairy farm is high quality forages. While it is certainly possible to feed and supplement less than high quality forages for milk production, it will likely be done at a penalty in the form of increased out-of-pocket expenditures, less than optimum milk production, poorer herd health and other negative production parameters. It is obvious than that one of the goals to increased profitability should be the raising, harvesting, storing and, then, proper utilization of high quality forages.

While profitable forage management is an opportunity area in itself, the end product, the forage, is an indispensable item within the well conceived feeding program. Because the two topics (Feeding and Forage Management) are so basicly intertwined, considerations in long term plans need to be made addressing this joint issue to maximize the productivity and profitability of both enterprises.

In considering goals for quality forage, it should be recognized that there may be differences in those goals depending on the end use of the forage. While goals such as optimum harvest date and proper harvest and storage techniques are something everyone should work towards, the type of forage also needs to be recognized. Milkers in early lactation and young calves may best utilize high quality alfalfa, dry cows would be better off with a relatively low quality mixed grass. Heifers, depending on their age, could be fed varying qualities of hay crop depending on the total makeup of their ration. Goals need to be thought of in terms of what the final objective may be.

Another point that needs to be emphasized is that protein content is not the sole criteria for determining forage quality. A good illustration is quality grass forage or corn silage and their importance, if not absolute need, in a well balanced feeding program for certain groups within the milking herd. The rather widespread misconception that the only high quality haycrop forage is clear seeded alfalfa, needs to be put into proper perspective. In talking about forage, the word quality (as a goal) has little to do with the species involved. Consideration of fiber values (both ADF and NDF) to measure feeding value are as, if not more, important than looking at protein as the sole means of judging quality.

High quality forage can be raised on virtually any tillable land resource. Dairy farm managers with less than optimum soil types may feel that they are at a disadvantage in raising quality forage when their basic disadvantage is actually only in yield potential. The maximum utilization of the available land resources should be the prime consideration in planning an effective program for the production of quality forages. It is worth noting that quality forages can be grown on virtually any farm but, neither harvested nor fed as such due to incomplete plans for harvesting and storage.

Under the above reasoning then, quality forage might be defined as: The field crops that can potentially be used to optimize the productivity and profitability of all herd groups on the dairy farm.

Exactly how much quality forage might be worth depends on how it is utilized on your farm. In terms of general benefits, it can yield higher milk production, less out-of-pocket costs for supplemental feed, better herd health, higher dry matter intakes and higher profits if sold. Exact dollar value can be closely determined by comparing supplemental costs in a feeding program with forages of varying quality. The value, if sold as a cash crop, is readily apparent based on market value.

If optimum profitability and productivity are to be objectives of the dairy farm, one of the critical keys to reaching them needs to be goals with well developed tactical plans for the production and feeding of high quality forages.

BALANCING DAIRY RATIONS TO OPTIMIZE RUMEN FERMENTATION AND MILK PRODUCTION

L. E. Chase and C. J. Sniffen
Department of Animal Science
Cornell University

Introduction

As the genetic potential for milk production in our dairy cattle population continues to increase, the ration formulation process becomes more challenging. Higher levels of milk production require greater daily nutrient intake. The goal in formulating dairy rations is to provide sufficient nutrients to support these higher levels of productivity while controlling feed costs. At the same time, the incidence of metabolic disorders and alterations in reproductive performance should be minimized.

At the same time, some other significant changes are taking place in the overall structure of the dairy enterprise. These changes have some definite impacts on ration formulation and feeding management practices. Dairy herds continue to increase in size and a higher proportion of the cows are housed in free-stalls and managed as groups. Silages, high moisture grains and ingredient feeding are becoming important components of the overall feeding system. In many of our smaller herds, intensive, rotational grazing is being rediscovered and is gaining in interest and acceptance.

All of these factors are interacting in an attempt to enhance the productivity and profitability of today's dairy herd. How do we realistically put together feeding and management programs for herds producing in excess of 20,000 pounds of milk per cow? When will we see the first herd to average 30,000 pounds of milk per cow? Even though there are many gaps in our research knowledge, we are all faced with the challenge of formulating rations for these herds. This is an exciting challenge and one which all of us are willing to accept.

The Feeding System

The overall feeding system on your farm is the sum of many factors. On most Northeast dairy farms, the soil resource is the base of our feeding system. This valuable resource determines the types, qualities and quantities of the forages and other homegrown feeds that will be available for developing feeding programs. Forage storage and the dairy physical facilities are the next key components of the total picture. The animals are the next component. Here we are interested in breed, frame size and genetic potential. Too often, we tend to overlook these factors in developing feeding programs. As we continue to move ahead in improving the milk production potential of our dairy herd, these factors must be more carefully evaluated and controlled if we are to attain the desired levels of production efficiency to maintain our competitiveness with other regions of the U.S. The actual process of formulating rations is only a small, but important, part of a total feeding system.

The overall goals of designing a feeding program are:

1. To provide the proper balance of nutrients to attain our production goals and to maximize our efficiency of producing milk.

2. To develop a feeding management system to provide the right nutrients in the required quantities at the right time to the cow.

3. To do this at a favorable cost per unit of milk produced. This may not mean the cheapest ration that could potentially be formulated but rather should be the best cost ration for the particular situation.

The Rumen Environment

Ruminants are a unique group of animals which have the ability of converting forages and other feedstuffs into high quality and nutritious foods for human consumption. Basically, we are working with a two component digestive system. The first component is the rumen which is inhabited by billions of bacteria and protozoa. This can be thought of as a microbial fermentation vat. The second component is the postrumninal digestive tract. This is similar to the monogastric digestive system. The key to optimizing production and profit is to balance this two component system to maximize the conversion of feed into animal products.

Our objective in feeding the dairy cow is to maximize the digestion of fiber in the rumen. This implies that we need to meet the microbial requirements for growth. At the same time, it is desirable to maximize the growth of the fiber digesting microorganisms and control the growth of the bacteria that digest sugars and starches. Table 1 provides an overview of the types of microorganisms in the rumen and their requirements. To achieve this goal requires a balance of energy, protein, vitamins and minerals.

Energy Sources

Energy is one of the key factors in determining the potential milk yield. Carbohydrates are the primary source of energy for ruminant animals. Improper levels or types of carbohydrates will depress animal productivity. Symptoms of a carbohydrate imbalance can include a depressed milk fat test, low or fluctuating feed intakes, large body condition changes in early lactation cows, excessive amounts of corn in the manure, increased incidence of off-feed problems, low peak milk yield or poor milk persistency.

Carbohydrates are organic compounds composed of carbon, hydrogen and oxygen. Sugars, starches, cellulose and hemicellulose are common examples of carbohydrates. The carbohydrates serve as the primary repository of photosynthetic energy and comprise between 50-80% of the total dry matter in forages and grains.

In terms of structure, carbohydrates can be divided into 2 basic components. These are the cell wall and cell content fractions. The composition and digestibility of the total carbohydrate in a forage or grain varies considerably. Table 2 contains the concentrations of carbohydrate fractions in selected feedstuffs. This table also provides an estimate of the nonstructural carbohydrate (NSC) values for these same feeds. Figure 1 is an overview of the breakdown of the total carbohydrates in a feedstuff.

Carbohydrates are digested in both the rumen and intestinal tract in ruminants. In the rumen, carbohydrates are the primary energy source for the growth of the microbial population. The normal degradation pathways result in glucose being produced. This glucose is then utilized by the rumen micro-organisms. However, there are a number of other compounds such as volatile fatty acids (VFA's) and lactic acid which are also produced. The VFA's become a primary energy source for the host animal. In addition, some of the carbohydrates escape rumen fermentation and may be digested by enzymatic processes in the intestinal tract.

There are 3 major factors which influence the digestion of carbohydrates in the rumen. These are:

1. Carbohydrate availability -- The solubility, crystallinity, degree of lignification and the distribution of the various carbohydrate fractions. As an example, British workers have shown that about 90% of the carbohydrate in most grains is fermented in the rumen. Corn and sorghum grains appear to be an exception and may only be 60-70% fermented in the rumen. Figure 2 is an example of the relative differences in fermentation rates of various feedstuffs.

2. Rumen protein and cofactor availability -- The microbial population requires ammonia, amino acids (in the form of peptides), iso acids, vitamins and minerals for normal fermentation. A deficiency of any of these can decrease the quantity of carbohydrates fermented.

3. Rate of passage -- There is a decrease in carbohydrate fermentation in the rumen as rate of passage increases. Basically, there is less time available for the micro-organisms to attack and degrade the material before it passes to the lower tract.

A key factor to remember is that all carbohydrates are not the same in terms of ruminal availability. The following factors can influence the availability of carbohydrates in the rumen.

1. Maturity

   a. Forages - As the plant matures, there is normally greater lignification of the cell wall. This results in a less readily-available carbohydrate. This lowers the rate and extent of digestion, energy availability and dry matter intake.

   b. Grains - With increasing maturity, a larger proportion of the carbohydrates move into storage forms. This may increase the energy density but may also reduce the rate of digestion in the rumen especially in the case of corn where the starch becomes more crystalline.

2. Environment

   Rainfall, soil temperature, fertility and cloud cover all affect the physiological processes in the plant. As an example, the rate of lignification is slower in cool weather.

3. Processing

   a. Particle size reduction - As particles become smaller, more surface area is available for bacterial attachment. This will potentially increase the rate of digestion.

   b. Steam, extrusion, popping and drying - All of these processes change the form of starch and alter availability. Generally, these processes tend to increase the rate of digestion.

   c. Fermentation - During the ensiling process, the rapidly fermentable sugars are converted to VFA's. Wetter materials are more rapidly fermented and less carbohydrate is crystallized. Fermenting dry materials may result in a Maillard reaction in which the sugars and lignin condense and bond with the protein.

4. Species

   a. Forage - In legumes, the NDF is rapidly fermented, as are the sugars and pectins. As the degree of lignification increases, there is less fermentable carbohydrate available. The NDF in grasses is usually more slowly fermented. High starch corn silages may be rapidly fermented.

b. Grains - These feedstuffs vary widely in availability and rapidity of digestion in the rumen. A rough ranking from fast to slow is wheat, barley, oats, corn and sorghum.

This becomes a very complex system when we attempt to integrate the above factors with rate of passage. As the level of feed intake increases, the feed particles pass through the rumen at a faster rate. The bacteria which digest fiber grow slowly and thus as intake increases a higher proportion of the fiber will escape ruminal digestion. Basically, our challenge is to attain a balance between the rate of passage and the rate of digestion. If at the same time that intake increases, we also allow particle size to decrease, the net effect can be quite devastating on both the rumen environment and animal health. Not only will the escape of fiber be increased but eating and rumination activity will be decreased significantly. The total daily chewing (eating plus rumination) time should be about 9 - 11 hours per day. This will allow for the production of an adequate quantity of saliva and the resulting natural buffering which is essential for the fiber bacteria and protozoa to survive.

Fats can also be utilized as an energy source by the dairy cow. Adding fat to the ration helps in increasing the energy density of the ration while maintaining an adequate dietary fiber level. Normal ration ingredients contain about 3% fat. If additional fat is to be used, it is suggested that commercial feed fats (tallow, animal-vegetable blends) or whole oilseeds (whole cottonseed, whole soybeans) be added to provide an additional 2-3% fat. This would bring the total ration fat level to 5-6% fat. After this, the inert fats would be added to provide an additional 2-3% fat. Dr. Don Palmquist of the Ohio Agricultural Research and Development Center has suggested that the total dietary fat could equal the total quantity of fat secreted in the milk.

Balancing Carbohydrate Fractions

The amount of carbohydrate fractions in the ration is really a combination of structural and non-structural fractions (Figure 1, Table 2). Practically, this involves balancing the fiber and nonfiber fractions.

The two most common measures of fiber content are acid detergent fiber (ADF) and neutral detergent fiber (NDF). ADF is a better predictor of energy value of a forage. NDF has been shown to be a better predictor of intake and potential milk production. Table 3 contains estimates of the optimum ADF and NDF contents of rations. It has been suggested that the NDF requirement of the dairy cow is 1.2 ± 0.1% of body weight. Approximately, 70-75% of this total should be provided by long or coarse chopped forages.

The nonfiber carbohydrates can be measured by nonstructural carbohydrate (NSC). Table 2 provides a list of the NSC content of common feedstuffs. The actual requirements for NSC are not well defined. A minimum quantity is required to provide for microbial growth. A maximum level is needed to prevent acidosis. Some people have suggested a minimum NSC of 30% of the total ration dry matter with a maximum of 40%. These should be viewed as "rough" guidelines and will require adjustment and refinement in many situations. A key factor which will alter these guidelines is the rate of digestion of the NSC fraction. A more rapidly digesting NSC source would result in a lowering of both the minimum and maximum values.

Protein

Protein can be thought of as the total quantity of nitrogen in a feedstuff multiplied by 6.25. The term which has been most commonly used in ration formulation to date has been total or crude protein.

However, a large amount of research over the last 10-15 years has indicated that total protein is not an adequate measure for formulating rations to maximize milk production and efficiency. As a result, the 1988 NRC publication on the nutrient requirements of dairy cattle has adapted an absorbable protein system. The specific terms used in this system are:

Degraded Intake Protein (DIP) - This fraction represents the proportion of the total intake protein that is degraded in the rumen. Soluble intake protein (SIP) is included within this fraction.

Undegraded intake protein (UIP) - This fraction represents the proportion of the total intake protein that is not degraded in the rumen. Bypass or escape protein are terms which have previously been used to describe this fraction. ADF-N is a component of the UIP fraction.

The 1988 NRC publication incorporates tables which provide UIP and DIP requirements for dairy cattle. Table 4 provides estimates of the UIP and DIP requirements for dairy cattle. In addition, we suggest that about 50% of the DIP be in the soluble intake protein form. Table 5 and 6 provide estimates of these fractions in feedstuffs.

Putting the System Together

The following guidelines can be utilized for formulating rations:

1. Define the group of cows relative to body weight and milk production. Adjust for the proportion of first-calf heifers in the group.

2. Predict dry matter intake.

3. Use Table 3 or the NDF equation to determine the NDF required

in the ration.

4. Balance for NDF

   a. Ensure that at least 70-75% of the total NDF comes from long or coarsely chopped forage (discount the NDF in fine-particle size concentrates to about 12% NDF).

   b. Evaluate the ration NSC content. Adjust if outside of the range of 30-40% of the total ration dry matter.

5. Balance for UIP and DIP using 1988 NRC requirements. SIP should be about 50% of DIP.

6. Check the ration energy content. It should be ± 3 Mcal/day of the NRC requirement.

7. Balance minerals and vitamins.

8. Make sure an adequate quantity of quality water is available.

9. Evaluate feedbunk management.

   a. Hours the bunk is empty
   b. Feeding frequency
   c. Feeding sequence

10. After balancing and implementing the ration, do the following:

    a. Measure milk yield by group, if possible.
    b. Have milk samples checked for milk fat (and possibly protein).
    c. Observe changes in body condition score.
    d. Watch the cows for chewing and rumination activity.
    e. Examine the manure for wetness, corn passage and fiber content.

11. Adjust rations and bunk management if indicated.

Table 1. Characteristics of Classes of Organism

Class of Organism	Substrate Preference	Major Need	Major Product of Importance	Ph Tolerance	Time to Double
Fiber Bacteria	Cellulose Hemicellulose	NH_3 Iso-acids	Volatile fatty acids	Neutral	8-10 hrs.
General Purpose Bacteria	Cellulose Starch	NH_3 Amino acids	Volatile fatty acids NH_3	Acid	6-8 hrs.
Starch & Sugar Bacteria	Starch Sugar	Amino acids NH_3	Volatile fatty acids Lactic acid NH_3	Acid	1/4-2 hrs.
Secondary Bacteria	Bacterial Fermentation Products	Amino acids	Iso-acids	Neutral	6-8 hrs.
Protozoa	Starch Sugar Bacteria	Amino acids	Volatile fatty acids	Neutral	15-24 hrs.

Table 2. Carbohydrate fractions in selected feedstuffs[a]

Feed	NDF	Lignin	ADF	Hemi-Cellulose	NSC[b]
Corn silage	40-55	3-6	24-34	16-21	28-43
Alfalfa hay	36-58	5-14	26-44	10-14	19-27
Timothy hay	55-72	3-9	30-45	25-27	14-20
Wheat straw	85	14	54	31	1.6
Bakery waste	18	1	13	5	55
Barley grain	19	2	7	12	62
Beet pulp	59	5	3	21	26
Brewers grains	46	6	24	22	15
Canola meal	28	-	16	12	22
Citrus pulp	23	3	22	1	60
Corn cobs	90	7	35	55	5
Corn grain	9	.2	3	6	75
Corn gluten feed	45	1	12	33	19
Corn gluten meal	14	1	5	9	16
Cottonseed meal	28	7	21	7	14
Cottonseed, whole	39	16	29	10	14
Distillers grains (with solubles)	44	4	16	28	13
Hominy	27	2	13	14	48
Linseed meal	25	7	17	8	25
Oat grain	31	3	17	14	48
Peanut meal	14	-	6	8	22
Soybeans, whole	9	-	8	1	24
Soy hulls	67	2	50	17	14
SBM-44	14	1	10	4	25
SBM-49	10	1	6	4	23
Wheat bran	51	3	15	36	21
Wheat grain	16	1	5	11	67
Wheat midds	37	3	10	27	35

[a] Adapted from VanSoest et al., 1984 and Mertens, 1986

[b] Nonstructural carbohydrates (NSC) =
100 - (NDF + Protein + Ether extract + Ash)

Table 3. Ration fiber and energy concentrates for dairy rations

Milk, lbs/day	NE_1, (Mcal/lb DM)	ADF, %	NDF, %
<40	.65-.69	>24	>35
40-60	.69-.72	21-24	31-35
60-80	.72-.75	21	28-31
>80	.75-.77	19-21	25-28

[a] Adopted from Mertens, 1986 and Muller, 1987

Table 4. UIP and DIP Requirements[a]

Body Weight, lbs	Milk, lbs	Milk Fat, %	DIP lbs	UP, lbs
900	29	5.0	2.34	1.55
900	58	5.0	3.90	2.34
1100	36	4.0	2.70	1.71
1100	73	4.0	4.46	2.65
1300	47	4.0	3.42	2.07
1300	93	4.0	5.61	3.24
1500	52	3.5	3.69	2.18
1500	104	3.5	6.01	3.40

[a]Adapted from Appendix Table 4, 1988 NRC.

Table 5. Protein degradability of various feedstuffs

Ingredient	% DM	% Protein	Solubility	Degradability	Undegradability	Bound
		% DM	--------------% of Crude Protein------------			
GRAINS						
Apple Pomace	90	4.4	8	20	80	58.0
Bakery Waste	92	10.3	40	80	20	5.3
Barley, grnd[1]	90	11.3	35	79	21	2.0
Beet Pulp	91	9.3	3.9	70	30	10.8
Citrus Pulp	90	6.7	26	80	20	5.0
Corn,crkd	89	10	12	30	70	6.2
Corn, Ear	86	8.8	16.0	35	65	6.2
Corn, Ear, Wet	70	8.8	40	65	35	6.2
Corn, grnd[1]	89	10	12	35	65	6.2
Corn, Shell, Wet	70	10	40	65	35	6.2
Hominy	91	12.1	19	35	65	3.5
Molasses	75	4.1	100	100	0	0
Oats, grnd	89	13.5	31	80	20	5.0
Wheat, grnd	89	14.6	23	80	20	3.0
Wheat Midds	89	18.0	40	80	20	1.0
INTERMEDIATE PROTEIN						
Alfalfa meal[1]	88	19.3	28	38	62	20
Brewers grns	93	25.6	2.9	47	53	13
Corn gluten feed	88	21.7	48	70	30	2.6
Cottonseed whole	92	24.0	33.0	55	45	10
Distillers grns[1] W/sol	90	27.8	15	38	62	15
Whey dry	94	17.7	80	90	10	0
HIGH PROTEIN						
Bloodmeal	90	98	9.5	18	82	10
Cottonseed meal[1] (solvent)	94	43.6	22	59	41	2.7
Cottonseed meal[1] propress	94	44	25	64	36	2.7
Cottonseed meal[1] (screw press)	90	68.9	15	50	50	3.0
Canola meal[1]	90	40	28	77	23	2.5
Corn gluten[1] meal	90	68.9	4	45	55	5.0
Fishmeal[1]	93	64.5	12	20	80	5.0
Linseed meal[1]	89	38.4	41	56	44	7.9
Meat meal[1]	90	51	13	24	76	5
Meat & bone meal[1]	90	47	15	40	60	5

Table 5. Protein degradability of various feedtsuffs --continued

Ingredient	% DM	% Protein	Solubility	Degradability	Undegradability	Bound
		% DM	---------------% of Crude Protein		-------------	
HIGH PROTEIN						
Peanut meal[1]	90	51.1	40	70	30	2.5
Soybean meal,48[1]	88	54.5	20	72	28	2.0
Soybean meal,44	90	49	20	72	28	2.0
Soybean meal,44 (Expeller)	90	49	15	55	45	3.0
Sunflower meal[1]	93	49	30	76	24	2.5
Urea	99	281	100	100	0	0
Whole soybeans (Raw)	90	41.1	40	80	20	2.9
Whole soybeans (Roasted)	93	41	16	51	49	4.0
Whole soybeans (Cooked)	93	40	17	52	48	4.0
Whole soybeans (Extruded)	93	41	17	52	48	4.0

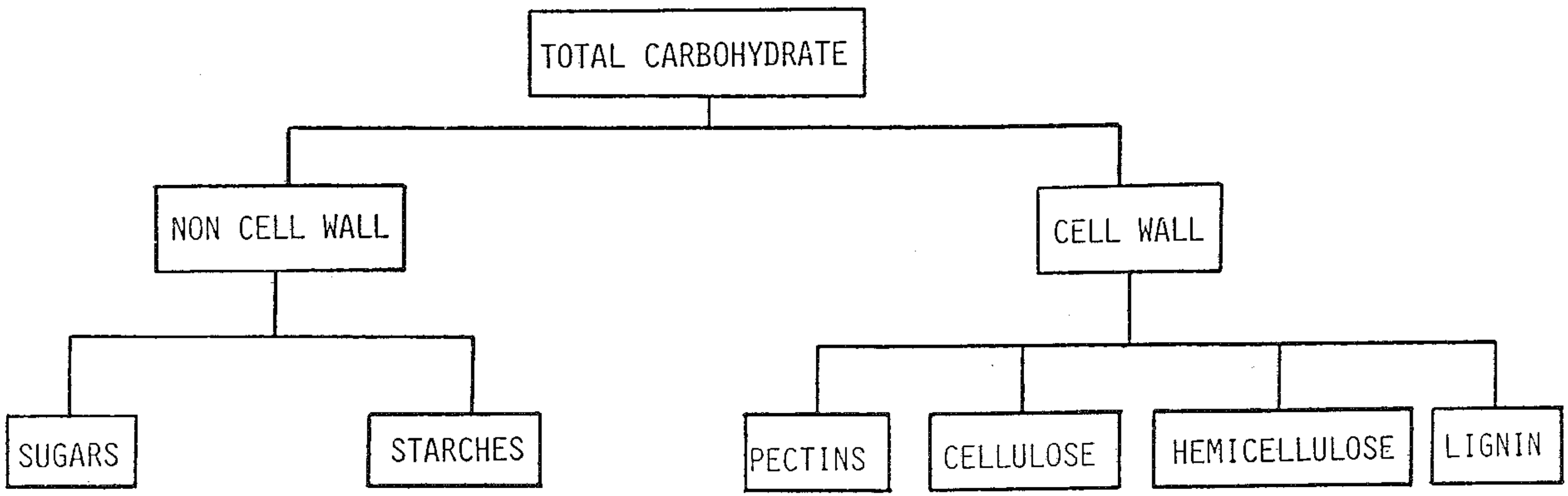
1Degradability derived from NRC 1985. Solubility and bound protein information from Sniffen and others. Degradability values without superscript are derived based on protein characteristics.

Table 6. Protein Fractions In Various Forages

	Alfalfa[2] Hay	Alfalfa Silage LS	Alfalfa Silage HS[3]	Grass[2] Hay	Ammonia-Treated Grass Silage LS	Ammonia-Treated Grass Silage HS	Corn[2] Silage	Corn Silage
Dry Matter	89	40	30	89	40	30	35	35
Total Protein, % DM	20	20	20	12	12	12	8.5	12
Solubility[1]	20	45	60	20	40	55	50	55
Degradability	72	80	90	63	70	80	73	73
Undegradability	28	20	10	37	30	20	27	27
Bound	5	10	10	5	10	10	4	4

[1]Fractions % of Crude Protein
[2]From NRC, 1985
[3]LS=low solubility
HS=high solubility

FIGURE 1.



ADF = Cellulose + Lignin

NDF = ADF + Hemicellulose

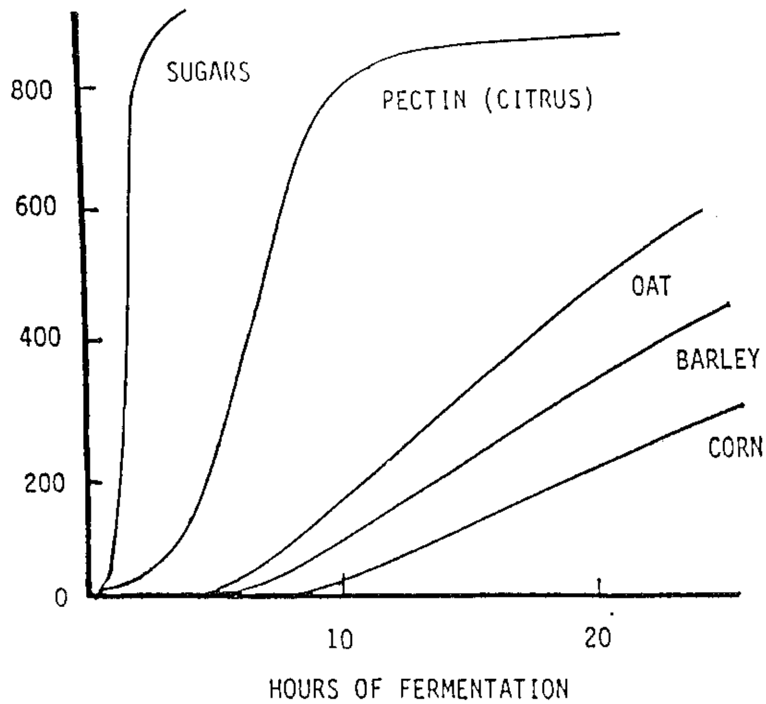


FIGURE 2. Relative fermentation rates of some carbohydrates.
(VanSoest, 1986)

FORAGE ANALYSIS

R. Clinton Young
Extension Specialist

Forage analysis has received a great deal of promotion over the past 5-10 years. Today, on virtually any well managed dairy farm, forage analysis is a routine part of the forage and feed management. There is no better way to monitor the crop from field to animal---if it is done properly. The importance of forage analysis in the feeding program is perhaps equaled only by obtaining the proper dry matter intakes fed to the dairy animal.

The greatest source of error in forage analysis is at its origin. Obtaining a representative sample is far more difficult than it might appear and is an easily overlooked part of the entire process. A representative forage sample might be defined as one that both the person taking the sample and the dairy farm manager agree is not only what might be fed at the time, but perhaps more importantly, what is going to be fed at the time the sample is returned and for a meaningful time thereafter.

The actual analysis may be done at any reputable forage laboratory. Do not confuse number of analysis done with the quality of the laboratory work. Analysis for dry matter, protein, fiber and major mineral will provide sufficient information to structure a basic feeding program and ordinarily enough to judge the implementation of the cropping program. At a later date, more detailed analysis may be necessary to fine tune the program or make more refined conclusions about the cropping program.

Once the analysis have been returned to the farm, they must be interpreted properly if they are to have any positive impact. Here, the decision of the dairy farm manager to do it, or to turn that responsibility over to someone else, presents itself. If the decision to let someone else interpret the results is made, the farm manager must not abdicate his management responsibilities to that person. Only the responsibility to interpret results is being delegated and not the management of the forage analysis program.

It should go without saying that taking forage analysis without using the results is an exercise in futility.(But so is any record keeping for record keepings' sake) Using these same results to monitor the cropping program or to put together a meaningful feeding program to maximize the forage and minimize out-of-pocket costs, is not only desirable, but a necessity, to optimize productivity and profitability on the dairy farm.

OBTAINING A REPRESENTATIVE SAMPLE

Before forage analysis is done, it must first be decided what forages or feedstuffs are to be sampled. Samples of the feedstuffs to be used in the feeding program at the time the samples are to be returned are the obvious objectives. However, it is also obvious that those exact feedstuffs may not be available for sampling due to location in the silo, haymow or other storage facility. At this point, a decision between the farmer and the person taking the samples must be made whether the feedstuffs available at that time will in fact be representative. If the answer is no, sampling should be put off until a meaningful sample can be obtained. In some cases, there may not be a clear-cut answer because the inventories of the feedstuffs may be unknown as to their location in storage. Only an "educated guess" at that point may head you in the right direction. It should be stressed that agreement between both farmer and sample taker as to the representative quality of the sample is essential.

1-Agree on feedstuffs to be sampled.

2-Agree on the potential representative quality of each.

3-Fill out information forms, which should include location and type of feedstuff, for each sample and attach to sample bags before or immediately after sampling to avoid confusion and error.

4-If at all possible, insist on sampling feedstuffs directly from the storage structure and not from the feeding bunk or manger, to insure a fresh, meaningful and representative sample.

5-In an upright silo, run enough of the feedstuff out to be able to take several grab samples. Ideally, these will be placed in a container, such as a plastic bucket, mixed and then sub-sampled into a closable air-tight plastic bag.

6-Bunker silos should be sampled across the face in at least 6-8 locations, mixed and then subsampled.

7-If a sample of a TMR is desired, it should be taken at the time the mix is being run into the bunk. 8-10 grab samples, mixed and then subsampled, should give a representative sample assuming the mixing time of the TMR mixer is consistent on a daily basis. It is possible to overmix as well as undermix.

(An alternative for the dairy farmer who is familiar with forage sampling, is to have sample bags made available for filling when the cows are being fed,and greater quantities of feedstuff are available, for an even more representative sample).

8-Hay samples should ONLY be taken with a Penn State forage sampler or similar boring device capable of taking a core sample of the bale. Grab samples of hay bales are not acceptable. At least 6-8 bales of a given cutting should be cored and done so in a random manner across the face of the mow.
An excellent management tool for the dairy farm manager is

sampling of the feedstuffs as they are being put into storage. Along with as accurate a record as possible of the amount of the feedstuff sampled and markers between cuttings or fields (such as foam egg cartons),this will allow those working with the feeding program the opportunity to prepare for changes before they happen. While there are equations available to estimate the changes in quality from ensiling, they should not substitute for occasional checks through the feedout of the feedstuffs.

UNDERSTANDING FORAGE ANALYSIS RESULTS

While containing some of the most important data for the optimum use of the feedstuffs on the dairy farm, the forage analysis return sheet is unfortunately confusing in its message to many dairy farm managers.

Return Sheet Format

Depending on where a dairy farm manager has analysis work done, dictates what the return sheet will look like. Each laboratory has their own format for listing the results of the analysis completed and as a result, there is no "typical" return sheet that can be referred to in an explanation. Simply stated, if you feel confident that the laboratory you are using is giving you meaningful results, you will continue to use that laboratory and consequently get used to their return format (and probably be at least mildly confused by some other laboratories).

ANALYSIS TERMINOLOGY

While format may be mildly confusing, the terminology in describing the results of analysis of feedstuffs can be very confusing to many people attempting to use them. Part of the reason for this problem stems from simple ignorance of the definitions of the terms and the other part from the usage of different terms or abbreviations to describe the same information. We will take this opportunity to define a basic vocabulary list common to most forage analysis return sheets.

DRY MATTER (DM)
100% minus the moisture in the feedstuff. Simply stated, the feedstuff with the water taken out. This method of stating nutrient values (on a dry matter basis) keeps them on a comparable basis.

CRUDE PROTEIN (CP)
The total protein content of the feedstuff or, by analysis, the nitrogen content(%) x (a conversion factor of) 6.25.

UNAVAILABLE PROTEIN
The protein (nitrogen), bound to the acid detergent fiber fraction, which is not usable by the animal. Some analysis reports record only the percentage caused by heat damage, while others include the approximately 1% naturally occurring bound or

unavailable protein fraction.

AVAILABLE PROTEIN
Here, a conflict of terms within analysis reports occurs. Virtually all reports list this figure as the crude protein minus the unavailable protein. The difference occurs with the laboratories which show the additive approximately 1% naturally occurring bound or unavailable protein. They make a further calculation to show what they term adjusted crude protein. Laboratories which do not show the naturally occurring bound fraction, expect available protein to be used in calculation of feeding programs.

ADJUSTED CRUDE PROTEIN
The term used by some laboratories to reflect the addition of the 1% naturally occurring protein back into the available protein percentage if heat damage has occurred. When listed, this is the protein result which should be used in ration balancing.

ACID DETERGENT FIBER(ADF)
The fiber fraction of feedstuffs containing primarily lignin and cellulose. It is used to predict energy values in forage. In general, the lower the value, the higher the energy.

NEUTRAL DETERGENT FIBER(NDF)
The fiber fraction of feedstuffs containing lignin, cellulose and hemicellulose. It is used to predict intakes of feedstuffs with lower values generally indicating higher intakes.

CRUDE FAT
A measurement of fat content(%) as determined by the laboratory technique of ether extraction.

ENERGY VALUES
These values for forages are obtained by most laboratories from ADF analysis and equations developed through extensive digestion trials. Data for calculation of energy values for feedstuffs other than forage is limited in its reliability and scope. It should be emphasized that there is NO LABORATORY TEST FOR ENERGY.

SOLUBLE PROTEIN
The protein fraction which is rapidly degraded or broken down in the rumen. It is composed of both NPN (non-protein nitrogen) and true protein. It may be expressed as a percentage of the dry matter or, a percentage of the crude protein if described as % protein solubility on the return sheet.

RELATIVE FEEDING VALUE--(RFV)
A measure of forage quality. Calculated by combining the digestibility and potential intake of a forage into one number. ADF is negatively correlated with digestibility and NDF is negatively correlated with intake. Crude protein is not included in the equation because it is not highly correlated with digestibility or intake. The reference hay has an RFV of 100 and

contains 41% ADF and 53% NDF. The higher the RFV the better the hay.

NONSTRUCTURAL CARBOHYDRATES--(NSC)
Primarily starches and sugars that are used by the plants for energy. It is expressed as a calculated estimate using analysis values for CP and NDF and average values for fat and ash. Fat and ash values in forage do not vary much. The equation is as follows: 100%-(CP% + NDF% + FAT% + ASH%)

pH
A means of describing the acidity of the feedstuff being tested. It is usually a good indication of the quality or completeness of the fermentation of ensiled forages.

MINERAL ANALYSIS
(Major minerals)Critical to almost any feeding program would be analysis for Calcium(Ca), Phosphorus(P), Magnesium(Mg), Potassium(K) and Sulfur(S).

(Trace minerals)
The most commonly analyzed are: Iron(Fe), Zinc(Zn), Copper(Cu), Manganese(Mn) and Molybdenum(Mb). Analysis for other trace minerals, when gauging the effectiveness of cropping practices, may also be appropriate. These values are normally expressed in parts per million(PPM).

Other analysis are virtually unlimited in scope. These may include analysis for urea, ammonia and nitrates. They may be reported in different ways, all of which may be correct, but all with different values. At this point, someone with the necessary expertise is needed to properly interpret the results.

Other parameters may be tested for as needs are recognized. However, they should not be done without justification and certainly not as part of any routine analysis program.

A well conceived forage analysis program is as important and potentially as profitable as any other management program on the well managed dairy farm. It becomes even more critical in nature because it impacts the effectiveness of the quality forages on the productivity of the dairy herd.

METHODS OF ANALYSIS

Until the early 1980's, the only type of analysis for feedstuffs was done by what is generally referred to as "wet" or "bench" chemistry. This type of laboratory analysis is the standard and is accurate, but often slow, in relationship to the need for timely results at the farm.
Today, most laboratories doing any significant amount of forage analysis are using equipment to perform a technique called Near Infra Red (NIR) analysis in addition to their standard wet chemistry methods. This technique can, and is, being used for

different types of feedstuff analysis with varying degrees of accuracy and success. The accuracy of any NIR analysis is for the greatest part, directly correlated with the accuracy, or lab error, of the laboratory involved in making the "wet" chemistry determinations for the calibration of the NIR computer program. NIR analysis can never be more accurate than the labs wet chemistry creating these calibrations, and in fact, can not be as accurate. It will, however be more consistent in its' results. These statements should not be taken as an implication that NIR is not a valid form of analysis. Some analysis done by NIR are simply more accurate than others. The standard error of any analysis should be known and a decision made whether that error is, or is not, acceptable for the usage of that analysis. This standard error will differ for all laboratories. It should be appreciated that differences can and will occur from one laboratory to another but, may or may not be of a significant nature. An error in crude protein determination of .1% is insignificant, while that same error in a magnesium determination could be critical. NIR is a significant step forward in speed and consistency of results for feedstuff analysis for the dairy farm but, in most situations, should not be used for all of the analysis desired.

ON-FARM DRY MATTER DETERMINATION

To maximize feedstuff utilization, knowing the amount of dry matter being fed is imperative. While these determinations can be made in the laboratory, they should also be made on a regular (sometimes daily) basis on the farm if the usage of feedstuffs is to be monitored properly and the feeding program is to be accurate.

They're are many types of electronic moisture (dry matter) testers of varying degrees of accuracy available. Cost of these instruments vary significantly, making the purchase of them a situation that must be looked into with care.
Arguably the most accurate, economical tester is a small microwave oven and a scale that will weigh in grams. This combination is quick in dry matter determination (less than 10 minutes) and requires little expertise to operate efficiently. These items can be purchased for under $200. and can serve other purposes in the barn or machinery shed. Another tester that has proven effective is the Koster. This unit will give accurate results in about 20-30 minutes.

A quick example to illustrate the importance of always knowing the dry matter of the feedstuffs being fed is illustrated below.

1 pound of DM from 18% protein haylage = .18 pounds of crude protein

.18 pounds of crude protein will support about 2 pounds of milk

.18 pounds of crude protein is equal to .375 pounds of 48% soy

If you underfeed by 1 pound of DM of the above forage you lose about 2# of milk.

Worth of cwt. of milk(dollars)/100 x 2 pounds x # of cows fed = cost of loss of milk from underfeeding per day.

If you overfeed by 1 pound of DM of the above forage you lose .375 pounds of soy you supplemented unnecessarily.

Cwt. of 48% soy cost (dollars)/100 x .375 x # of cows fed = cost of overfed soy per day.

Obtaining Samples for Forage Testing

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Forage testing is an essential component in the design and evaluation of dairy feeding programs. The use of forage testing provides an opportunity to balance rations more accurately and economically. Forage analysis data is essential in trying to evaluate nutritional problems or inadequacies with a feeding program.

Even though many dairymen realize the value of forage testing, the techniques for obtaining samples are often less than would be desired. If the sample submitted is not representative of the forage fed, then the analytical results will be of little value.

There are 2 primary sources of error involved in the forage testing process. These are sampling error and laboratory error. Yes, there is some variation between analytical labs in terms of results. However, it is likely that the larger source of error is in the sampling area. The combination of these two errors can be quite large.

The following guidelines should be useful in helping to obtain representative forage samples.

Equipment:

1. Hay core sampler
2. Brace or electric drill (1/2")
3. Large plastic pail
4. Plastic bags
5. Mailers to send samples to the laboratory

Sampling Baled Hay

The only way to sample baled hay is with a bale corer. Currently, there are 2 basic types of hay corers on the market. One version (Penn State) has a probe with a diameter of about 1" and a length of about 18". The other type (E-Z Probe) has a probe diameter of about 5/8" and a length of 12".

Separate samples should be taken for each defined lot of hay. Hay should be separated by forage type, date of cutting, etc. at the time of harvest and storage. This will also provide the opportunity for feeding specific types of forages to selected groups of animals to better match nutrient needs.

Steps to follow are:

1. Sample a minimum of 10 bales from each lot of hay (many people suggest 15-20 bales rather than 10).

2. Bore only into the ends of the bales. Do not bore into the sides of the bale. There has also been no advantage demonstrated from diagonal boring.

3. The hay cores should be placed in a plastic pail and thoroughly mixed. A composite should be sent to the laboratory for analysis. This step may not be needed with the E-Z Probe since the cores are collected in a canister.

Sampling Silages

There are 2 basic approaches to sampling silages. The first is to sample the forage material at the time when the silo is filled. The second alternative is to sample the silage after fermentation has been completed.

Do you want to plan ahead or would you rather study history? This is the basic difference between sampling as the silo is being filled versus sampling as the silage is being fed. By sampling as the silo is being filled, the average nutrient content of the silo (or portion of the silo) is determined before the silage is fed. This permits a ration with the appropriate protein and mineral supplementation to be formulated ahead of time.

By taking samples as the silage is being fed, you will be making ration adjustments after the silage has been fed. However, certain analyses such as pH, ADF-N and soluble protein can only be done after the silage has fermented.

A. Sampling during silo filling

1. Take grab samples from each load of silage as it is being put into the silo.

2. Place the grab samples in a container such as a large plastic bag or garbage can.

3. Make notes relating to the number of loads and when field changes are made.

4. Consider using a marker, such as colored plastic strips, to define areas within the silo.

5. Mix the grab samples thoroughly, subsample and submit for analysis.

6. When the results come back, construct a diagram of the silo with the nutrient content of the appropriate sections indicated.

B. Sampling fermented silage

1. Upright silos

   a. Fill a silage cart and take small samples from a number of locations in the cart.

   b. Try not to sample the material on the exposed surface of the silo.

2. Bunker silos

   a. Rake the entire working surface of the silo with a front end loader. Take grab samples form this material or from a mixer wagon after it has run for a few minutes.

b. If grab samples from the face are desired, make sure that you dig back 3-6" behind the exposed surface for your sample. Take at least 10-12 subsamples from across the feeding area.

Sampling Bunk Mixes and TMR's

The sampling and analysis of bunk mixes and TMR's can be a very useful diagnostic tool. This will provide a check on the adequacy of the mixing process and provides a true picture of what the cow is actually consuming. It is desirable to take 6-10 grab samples from different locations in the bunk and to submit a subsample of the mixed composite for analysis.

Summary:

Forage analysis is a key component in the design and analysis of feeding programs. However, unless truly representative samples are obtained, the results are of little value. A few extra minutes spent collecting representative samples is a small investment to enhance the accuracy and usefulness of this system.

RATION ANALYSIS WORKSHEET

Body Weight ________Lb Milk Production ________Lb Butterfat ________%
First Lactation, Second, Mature, Dry or Heifer ________________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*

Total Ration Dry Matter = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*
Expected DMI = ________*Lb*	*Required Nutrient* = ________*Lb*	*Required Nutrient* = ________*Lb*
Difference DMI ________*Lb*	*Nutrient* ________*Lb*	*Nutrient* ________*Lb*

RATION ANALYSIS WORKSHEET

Body Weight _______Lb Milk Production _______Lb Butterfat _______%
First Lactation, Second, Mature, Dry or Heifer _______________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	*X*	*.DM*	*=*	*# DM Fed*	*X*	*.Nutrient (%)*	*=*	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	___	=	______	X	________	=	______lb
							________	=	______lb

Total Ration Dry Matter = ________Lb	*Total Nutrient Supplied* = ________Lb	*Total Nutrient Supplied* = ________Lb
Expected DMI = ________Lb	*Required Nutrient* = ________Lb	*Required Nutrient* = ________Lb
Difference DMI ________Lb	*Nutrient* ________Lb	*Nutrient* ________Lb

RATION ANALYSIS WORKSHEET

Body Weight ________Lb Milk Production ________Lb Butterfat ________%
First Lactation, Second, Mature, Dry or Heifer ________________

RATION EVALUATION WORKSHEET

Feed	# Fed	X	.DM	=	# DM Fed	X	.Nutrient (%)	=	Nutrient lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb
________	____	X	___	=	______	X	__________	=	______lb
							__________	=	______lb

Total Ration Dry Matter = ________Lb	*Total Nutrient Supplied* = ________Lb	*Total Nutrient Supplied* = ________Lb
Expected DMI = ________Lb	*Required Nutrient* = ________Lb	*Required Nutrient* = ________Lb
Difference DMI ________Lb	*Nutrient* ________Lb	*Nutrient* ________Lb

RATION ANALYSIS WORKSHEET

Body Weight ________Lb Milk Production ________Lb Butterfat ________%
First Lactation, Second, Mature, Dry or Heifer ________________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*
________	____	X	___	=	______	X	________	=	______*lb*
							________	=	______*lb*

Total Ration Dry Matter = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*	*Total Nutrient Supplied* = ________*Lb*
Expected DMI = ________*Lb*	*Required Nutrient* = ________*Lb*	*Required Nutrient* = ________*Lb*
Difference DMI ________*Lb*	*Nutrient* ________*Lb*	*Nutrient* ________*Lb*

RATION ANALYSIS WORKSHEET

Body Weight ________Lb   Milk Production ________Lb   Butterfat ________%
First Lactation, Second, Mature, Dry or Heifer ________________

RATION EVALUATION WORKSHEET

Feed	*# Fed*	X	*.DM*	=	*# DM Fed*	X	*.Nutrient (%)*	=	*Nutrient lb*
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb
________	____	X	____	=	______	X	________	=	______lb
							________	=	______lb

Total Ration Dry Matter = __________Lb   *Total Nutrient Supplied* = __________Lb   *Total Nutrient Supplied* = __________Lb

Expected DMI = __________Lb   *Required Nutrient* = __________Lb   *Required Nutrient* = __________Lb

Difference DMI __________Lb   *Nutrient* __________Lb   *Nutrient* __________Lb

ESTIMATING DAIRY FORAGE REQUIREMENTS

Dairy cattle will eat a consistent amount of forage dry matter based on their bodyweight and forage quality. The better the feed, the more they will eat.

By knowing the average size and number of animals, quality of forage, and number of days desired to feed, it's relatively easy to calculate a farm's forage dry matter needs.

Number of cows X lbs. of dry matter/day X number of days = lbs. of dry matter/year.

Dividing the lbs. dry matter by the percent dry matter of the feed gives the lbs. of as-fed feed.

TO ESTIMATE YOUR FARM FORAGE NEEDS:

1. *Determine the number of animals by bodyweight.*
2. *Find the estimated dry matter intake/day according to quality and hay or haycrop silage to corn silage ratio (inside tables).*
3. *Figure the number of feeding days.*
4. *Follow the outline on the back page to estimate the total tons dry matter needed.*
5. *Divide by the percent dry matter of the as-fed feed.*

Corn Silage	*30-35%*	*(average range)*	*dry matter*
Dry Hay	*85-90%*	*(average range)*	*dry matter*
Haycrop Silage	*30-50%*	*(average range)*	*dry matter*

6. *"Hay Crop" refers to a combination of Baled Hay and Hay Crop Silage.*

TABLE 1A

COWS

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY (> 53% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage: Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage: Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage: Hay Crp.	Silage	Hay Crop or Silage
800	11.3	5.5	8.4	8.4	5.5	11.3	16.8
1000	14.0	7.0	10.5	10.5	7.0	14.0	21.0
1200	16.9	8.3	12.6	12.6	8.3	16.9	25.2
1300	18.2	9.0	13.6	13.6	9.0	18.2	27.2
1400	19.7	9.7	14.7	14.7	9.7	19.7	29.4
1600	22.5	11.1	16.8	16.8	11.1	22.5	33.6

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY (47-52% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage: Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage: Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage: Hay Crp.	Silage	Hay Crop or Silage
800	13.0	6.4	9.7	9.7	6.4	13.0	19.4
1000	16.2	8.0	12.1	12.1	8.0	16.2	24.2
1200	19.4	9.6	14.5	14.5	9.6	19.4	29.0
1300	21.2	10.4	15.8	15.8	10.4	21.2	31.6
1400	22.7	11.2	16.9	16.9	11.2	22.7	33.9
1600	25.9	12.8	17.4	17.4	12.8	25.9	38.7

POUNDS OF FORAGE DRY MATTER PER DAY - SUPERIOR QUALITY (<46% NDF)
(includes 10% waste)

Weight of Cows (lbs.)	2/3 Hay Crop 1/3 Silage: Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage: Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage: Hay Crp.	Silage	Hay Crop or Silage
800	15.3	7.6	11.5	11.5	7.6	15.3	22.9
1000	19.3	9.4	14.3	14.3	9.4	19.2	28.6
1200	23.0	11.4	17.2	17.2	11.4	23.0	34.4
1300	24.9	12.3	18.6	18.6	12.3	24.9	37.2
1400	26.8	13.2	20.0	20.0	13.2	26.9	40.0
1600	30.7	15.1	22.9	22.9	15.1	30.7	45.8

TABLE 1B

HEIFERS

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY (> 53% NDF)
(includes 10% waste)

Weight of Heifer (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	Never feed young replacements poor feed						
500	5.0	2.5	3.8	3.8	2.5	5.0	7.5
700	7.0	3.0	5.0	5.0	3.0	7.0	10.0
900	9.8	4.8	7.3	7.3	4.8	9.8	14.6
1100	10.6	5.2	7.9	7.9	5.2	10.6	15.8

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY (47-52% NDF)
(includes 10% waste)

Weight of Heifer (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	3.4	1.6	2.5	2.5	1.6	3.4	5.0
500	6.8	3.2	5.0	5.0	3.2	6.8	10.0
700	10.0	5.0	7.5	7.5	5.0	10.0	15.0
900	13.1	6.5	9.8	9.8	6.5	13.1	19.6
1100	15.4	7.6	11.5	11.5	7.6	15.4	23.0

POUNDS OF FORAGE DRY MATTER - SUPERIOR QUALITY (< 46% NDF)
(includes 10% waste)

Weight of Heifers (lbs.)	2/3 Hay Crop 1/3 Silage Hay Crp.	Silage	1/2 Hay Crop 1/2 Silage Hay Crp.	Silage	1/3 Hay Crop 2/3 Silage Hay Crp.	Silage	Hay Crop or Silage
300	4.9	2.1	3.5	3.5	2.1	4.9	7.0
500	8.4	4.2	6.3	6.3	4.2	8.4	12.6
700	12.0	6.0	9.0	9.0	6.0	12.0	18.0
900	14.2	7.0	10.6	10.6	7.0	14.2	21.2
1100	15.4	7.6	11.5	11.5	7.6	15.0	23.0

FORAGE NEEDS WORKSHEET

Average Number Cows (milking & dry)	______________
Average Body Weight	______________
Average Number of Heifers (900 lbs.-calving)	______________
Average Number of Heifers (500-900 lbs.)	______________
Average Number of Calves (300-500 lbs.)	______________

FORAGE DRY MATTER NEEDS (From Tables 1A and 1B)
Hay Crop and Corn Silage

	Average Number of Animals	X	Average Number of Days	X	Lbs. Drymatter (Table)	÷ 2000 =	Drymatter Tons Needed
Cows - Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Cows - Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Heifers 900 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Heifers 900 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Heifers 500 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Heifers 500 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage
Calves 300 lbs. Hay Crop	________	X	________	X	________ Hay Crop	÷ 2000 =	________ Tons Hay Crop
Calves 300 lbs. Corn Silage	________	X	________	X	________ Corn Silage	÷ 2000 =	________ Tons Corn Silage

SUMMARY AND CONVERSION TO AS FED BASIS

Hay Crop

)ry Hay Tons Dry Matter Needed __________ ÷ _________ *(% DM Hay)* = ________________*
Tons DM Hay As Fed

lay Crop Silage Tons Dry Matter Needed __________ ÷ _________ *(% DM Hay Crop Silage)* = ______*
Tons Hay Crop Silage As Fed

Corn Silage

'otal Tons Corn Silage __________ ÷ _________ = ______________________________*
% DM *Tons Corn Silage As Fed*

A final conversion to Lbs. Per day on an As Fed Basis can be obtained by dividing the Total by the number of days used in workspace above, and multiplying by 2,000.

FORAGE INVENTORY AND ALLOCATION

In order to develop a year-round program for the dairy herd, it is necessary to know how much of any given forage is available to feed.

The procedure to figure your own farm forage inventory is easy, all of the information necessary is on these sheets.

1. *Determine the amount of silage dry matter in your silo(s) and record on the appropriate page. (Be sure to account for any removed; procedure is illustrated inside).*

2. *Divide the dry matter figures recorded by the percent dry matter of your feed. (Your DHI Supervisor or Cooperative Extension specialist can help you determine the perc dry matter of your feed).*

   Example: *150 Tons DM ÷ 0.45 (45%) = 333 Tons as Fed*

3. *Total the tons of "as-fed" feed available and subtract a storage and feeding loss (8-15%).*

4. *Divide the available tons of feed by the number of feeding days. (Days to next harvest, subtract for cows on pasture). Then divide by the number of animals. Multiply by 2,000 to find the pounds/head/day available to feed.*

FORAGE AVAILABLE: PER HEAD - PER DAY

FORAGE CAPACITY

SILO	TYPE	DIMENSIONS	DRY MATTER CAPACITY		% DRY MATTER OF FORAGE		AS FED CAPACITY
#1	________	________	________	÷	________	=	________
#2	________	________	________	÷	________	=	________
#3	________	________	________	÷	________	=	________
#4	________	________	________	÷	________	=	________
#5	________	________	________	÷	________	=	________
#6	________	________	________	÷	________	=	________

TOTAL STORAGE CAPACITY - HAY CROP SILAGE ________ TONS - ______ = ____________
(% storage & feeding loss) (Tons Avail. Feed)

TOTAL STORAGE CAPACITY - CORN SILAGE ____________ TONS - ______ = ____________
(% storage & feeding loss) (Tons avail. Feed)

TOTAL STORAGE CAPACITY - DRY HAY

____________ X ____________ ÷ 2000 = __________ - __________ = ____________
(# of bales) (avg. wgt./bale) (tons hay & feeding loss) (% storage & feeding loss) (Tons avail. Feed)

OR

____________ x 8 lbs./feet^3 ÷ 2000 = __________ - __________ = ____________
(Hay in feet^3) (tons hay) (% storage & feeding loss) (Tons avail. Feed)

	Tons Feed	÷	*Number of Feed Days*		*Number of Animals*	*X 2000 =*	*lbs/head/day*
Corn Silage	________	÷	________________	÷	______________	*X 2000 =*	____________
Hay Crop Silage	________	÷	________________	÷	______________	*X 2000 =*	____________
Dry Hay	________	÷	________________	÷	______________	*X 2000 =*	____________

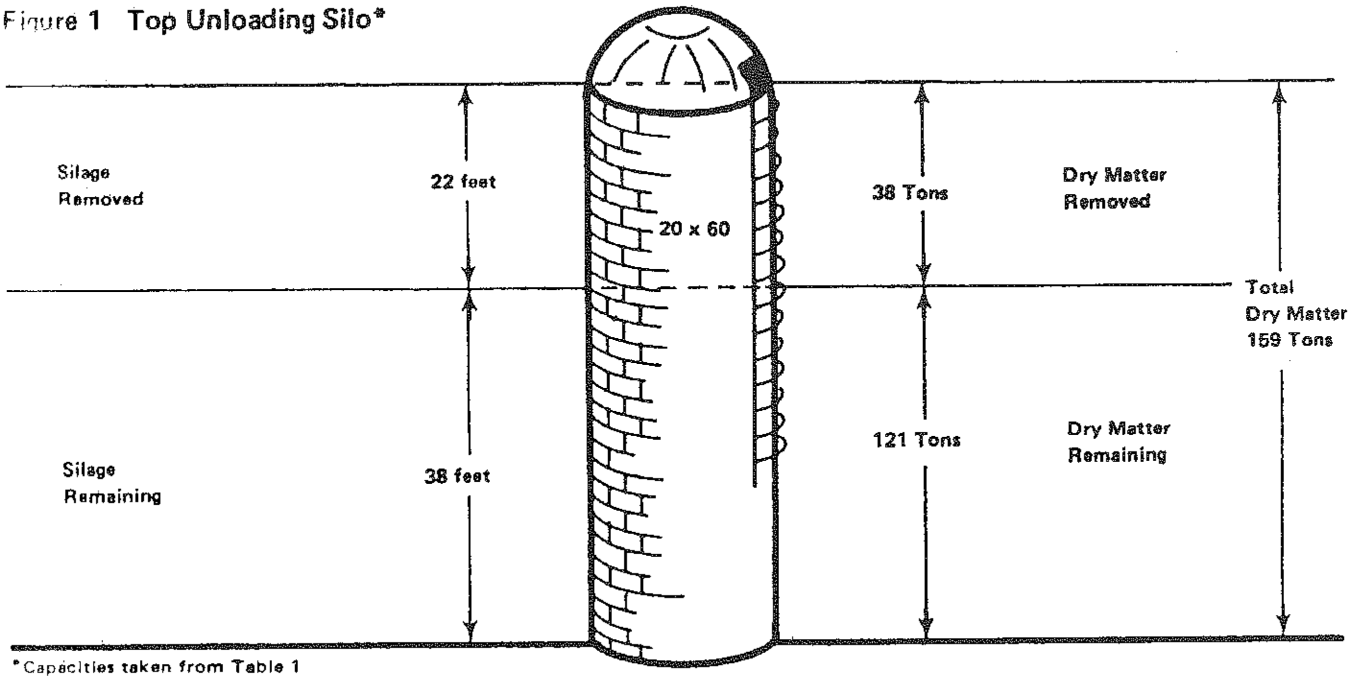
(Compare total available to feed to your calculated forage requirements).

Table 1 Approximate dry matter capacity of silos

Depth of settled silage	Inside diameter of silo											
	10	12	14	16	18	20	22	24	25	26	28	30
(ft.)	Tons of silage											
2	0	0	1	1	1	1	1	2	2	2	2	3
4	1	1	2	2	3	3	4	5	5	6	6	7
6	1	2	3	4	5	6	7	9	9	10	12	13
8	2	3	4	6	7	9	11	13	14	15	17	20
10	3	4	6	8	10	12	15	18	19	21	24	28
12	4	6	8	10	13	16	19	23	25	27	31	36
14	5	7	10	13	16	20	24	29	31	34	39	45
16	6	9	12	15	19	24	29	35	38	41	47	54
18	7	10	14	18	23	28	34	41	44	48	56	64
20	8	12	16	21	27	33	40	48	52	56	65	74
22	9	14	19	24	31	38	46	55	59	64	74	85
24	11	15	21	27	35	43	52	62	67	73	84	97
26	12	17	24	31	39	48	58	69	75	81	94	108
28	13	19	26	34	43	54	65	77	84	90	105	120
30	15	21	29	38	48	59	71	85	92	100	116	133
32	16	23	32	41	52	65	78	93	101	109	127	146
34	18	25	35	45	57	71	85	102	110	119	138	159
36	19	28	38	49	62	77	93	110	120	130	150	172
38	21	30	41	53	67	83	100	119	129	140	162	186
40	22	32	44	57	72	89	108	128	139	151	175	200
42	24	34	47	61	77	96	116	138	149	161	187	215
44	26	37	50	65	83	102	124	147	160	173	200	230
46	27	39	53	70	88	109	132	157	170	184	213	245
48	29	42	57	74	94	116	140	167	181	195	227	260
50	31	44	60	78	99	123	148	177	192	207	240	276
52	32	46	63	82	104	128	155	185	201	217	252	289
54	34	48	66	86	109	134	163	194	210	227	263	302
56	35	50	69	90	114	140	170	202	219	237	275	316
58	37	53	72	94	118	146	177	210	228	247	286	329
60	38	55	75	97	123	152	184	219	238	257	298	342
62			77	101	128	158	191	227	247	267	310	355
64			80	105	133	164	198	236	256	277	321	369
66			83	109	137	170	205	244	265	287	333	382
68			86	112	142	176	212	253	274	297	344	395
70			89	116	147	182	220	261	284	307	356	408
72					152	187	227	270	293	317	367	422
74					157	193	234	278	302	327	379	435
76					161	199	241	287	311	337	390	448
78					166	205	248	295	320	347	402	461
80					171	211	255	304	330	357	413	475
82							262	312	339	366	425	488
84							270	321	348	376	437	501
86							277	329	357	386	448	514
88							284	338	366	396	460	528
90							291	346	376	406	471	541
92							298	355	385	416	483	554
94							305	363	394	426	494	567
96							312	372	403	436	506	581
98							319	380	412	446	517	594
100							327	389	422	456	529	607

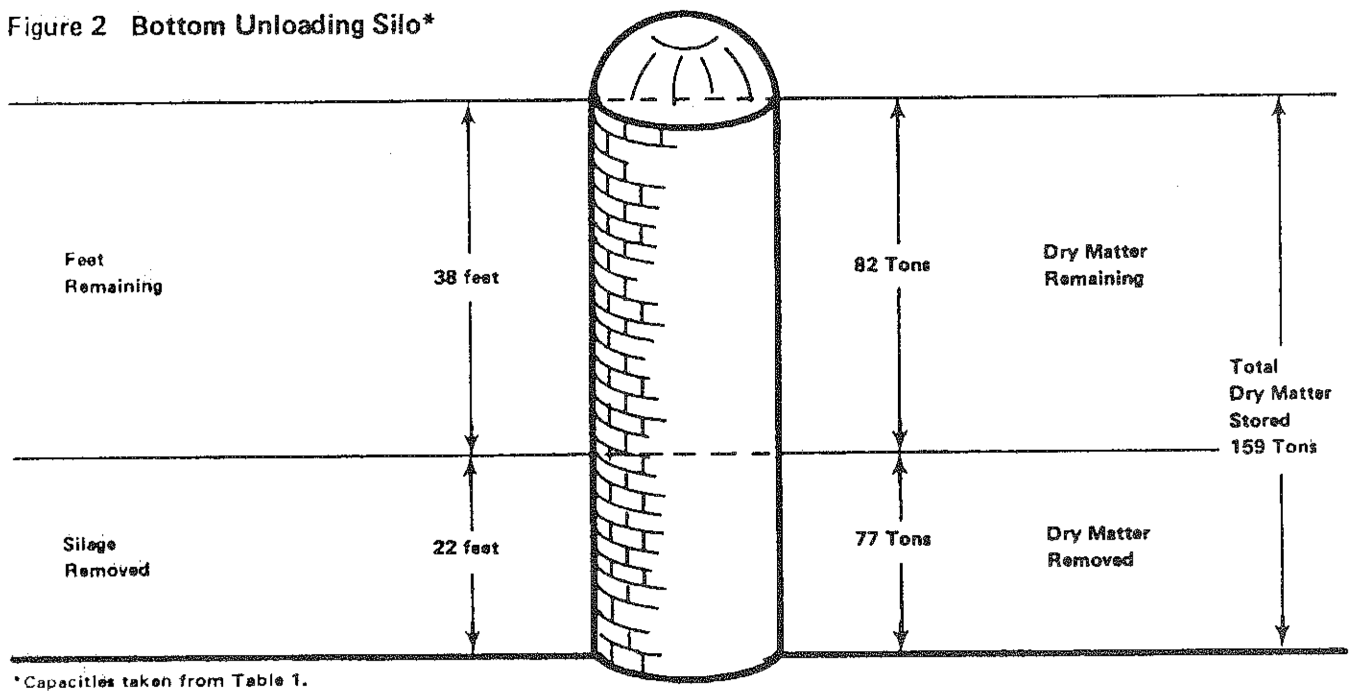
To find the tons remaining in a top unloading silo after part of the silage is removed: (1) find the tons of silage when the silo was filled, (2) find the tons in a silo filled to the height equal to the depth of silage removed, (3) subtract the number of tons in Step 2 from the number of tons in Step 1. Example: A 20-ft. silo filled to a settled depth of 60 ft. and 22 ft. was fed off, (1) 20x60 = 152 tons, (2) 20x22 = 38 tons, (3) 152 tons − 38 tons = 114 tons remaining.

Figure 1 Top Unloading Silo*



*Capacities taken from Table 1

Figure 2 Bottom Unloading Silo*



*Capacities taken from Table 1.

DRY MATTER TONNAGE FOR CORN AND HAY CROP SILAGE IN WELL-PACKED HORIZONTAL SILOS wwi-1/89

AVERAGE WIDTH (FT)	AVERAGE DEPTH OF SILAGE (FEET) 6	8	10	12	14	16	18	20
	DRY MATTER (TONS / FOOT OF LENGTH)							
12	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.7
16	0.5	0.7	1.0	1.2	1.4	1.7	2.0	2.3
20	0.7	0.9	1.2	1.5	1.8	2.1	2.5	2.9
24	0.8	1.1	1.4	1.8	2.2	2.6	3.0	3.5
30	1.0	1.4	1.8	2.2	2.7	3.2	3.8	4.3
40	1.3	1.8	2.4	3.0	3.6	4.3	5.0	5.8
50	1.7	2.3	3.0	3.7	4.5	5.4	6.3	7.2
60	2.0	2.7	3.6	4.5	5.4	6.4	7.5	8.7
70	2.3	3.2	4.2	5.2	6.3	7.5	8.8	10.1
80	2.6	3.7	4.8	5.9	7.2	8.6	10.0	11.6
90	3.0	4.1	5.4	6.7	8.1	9.6	11.3	13.0
100	3.3	4.6	5.9	7.4	9.0	10.7	12.5	14.5

- DENSITY INCREASES WITH DEPTH 4 % / 2 FT

11	11.44	11.90	12.37	12.87	13.38	13.92	14.48

- PERCENT VOLUME LOSS WITH TOP SURFACE SPOILAGE 0.5 FT. DEEP

8.3	6.3	5.0	4.2	3.6	3.1	2.8	2.5

- TOP SPOILAGE CAN EXCEED 15% WITH POOR PROCEDURES

-- AND BE LESS THAN 5% ON VERY LARGE HORIZONTAL SILOS

-- OR WITH CAREFULLY PLACED AND WEIGHTED PLASTIC

- AVERAGE DRY MATTER RETENTION VS. BURIED BAGS ON 11 FARMS

  85% IN 5 SILOS FOR HAY CROP SILAGE

  86% IN 40 SILOS FOR CORN SILAGE (1978 CHORE RED.)

- SUMMER FEEDING RATES SHOULD USE 1/2 FT. OF EXPOSED FACE DAILY

  WINTER RATES CAN BE 1/4 FOOT

DRY MATTER INTAKE IN DAIRY CATTLE NUTRITION

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As the genetic potential for milk production in our dairy cattle population continues to increase, the formulation of dairy rations becomes more challenging. Higher levels of milk production require greater daily intakes of nutrients such as energy and protein. The goal in formulating dairy rations is to provide adequate nutrients to support these high levels of milk production while controlling feed costs. At the same time, metabolic disorders and reproductive problems should be minimized.

Dry matter intake is the foundation upon which dairy cattle rations are built. It is essential that the daily nutrients required to support milk production be provided within a quantity of feed that the cow can realistically be expected to consume. This requires a reasonable estimate or actual measurement of dry matter intake. Maximizing dry matter intake permits high levels of production to be supported at a lower feed cost per unit of milk produced. If rations are formulated on a nutrient density basis, an accurate dry matter intake value is essential.

An understanding of the factors controlling dry matter intake is a basic component in developing dairy feeding programs. Nutritional troubleshooting is essentially impossible without reliable dry matter intake values. The percent crude protein in a ration is interesting but must be converted to pounds of crude protein intake before the nutritional adequacy of the ration can be determined.

What factors control dry matter intake in dairy cattle rations? What are the reasonable maximum dry matter intakes which can be expected? What can be done to assure maximum dry matter intakes? The answers to these questions are needed as the basis for designing and refining rations for high producing dairy cows.

What Controls Dry Matter Intake?

The controls of dry matter intake in ruminants are a combination of both physical and physiological factors (Figure 1). Physical factors are related primarily to the capacity of the digestive tract, the fiber content of the feedstuffs and the rates of degradation and passage. From an alternative viewpoint, the indigestible dry matter in the feed may be the primary physical factor limiting intake. Physiological controls involve the potential feedback of the end products of digestion and metabolism on neural receptors in the brain.

The intake of low energy high fiber rations appears to be controlled primarily by physical factors. As the level of concentrates in the ration increase, the physiological controls become more important. The point at which this transition occurs varies with the energy demand level of the animal.

What are the Practical Limits of Dry Mater Intake?

As a general guideline, maximum expected dry matter intake in dairy cows ranges between 3.5 to 4% of body weight. For a 600 kg cow, this would be 21 to 24 kg of dry matter intake per day. Some high producing cows will consume dry matter in excess of these levels. Feed, feeding management and environmental conditions can alter these values. A large number of equations have been developed to predict dry matter intake. The majority of these are based on body weight and milk production. Other factors which may also be included are days in milk, lactation number, season of the year and ration fiber content. Table 1 provides an estimate of expected dry matter intake.

Dry Matter Intake and Practical Feeding Programs

The integration of the regulatory mechanisms for dry matter intake, predictive equations and development of feeding programs is a challenge for nutritionists. A basic problem is the large biological variation between cows and the multiplicity of factors which can alter intake. Ration formulation programs must contain some predictive mechanism for estimating intake. However, flexibility must be present to permit alteration of these dry matter intake values for specific field situations. If this flexibility is not present, the nutritional adequacy of the feeding program relative to nutritional requirements will always be in question. Table 2 contains an example of the interrelationship of dry matter intake and ration nutrient density.

Ideally, standard predictive equations would not be used in ration formulation. Rather, the actual intake of the cow or group of cows could be utilized. Practically, it is a rare situation where this information is available on a field basis. Thus, alternative mechanisms must be used in designing dairy rations.

The exact approach to be taken on an individual farm will vary with the management ability and interest of the manager and the control that exists of the feeding program. A total mixed ration with no supplemental grain, minerals or forages fed separately is a tightly controlled feeding situation. There is no reason that dry matter intake can't be monitored in this situation. A feeding program where both grain and forage are fed in two or three locations is almost impossible to either control or monitor.

Development of a monitoring program for intake is a key factor in putting together the total feeding management program. You should insist that dairymen purchase and use a moisture tester. This is necessary for both daily management of the feeding program and monitoring dry matter intake.

The next step is to obtain actual weights of feeds consumed. This can be done using mixer wagons with load cells or a variety of manual weighing methods. You will need to be innovative to design a workable system for each farm. However, even in stanchion barns, reliable data can be collected with a little thought and effort.

The net result of this effort will not be estimates of intake in a strict research context. They will be better than a guess or no data at all. This information should provide a firmer base upon which to design nutritionally adequate and cost effective feeding programs.

Maximizing Dry Matter Intake

The goal should be to maximize dry matter intake for most cows and heifers. This will permit higher forage, lower concentrate rations to be fed to attain the same level of milk output. One result of this should be a lower purchased feed cost per unit of milk produced. A second possibility is that stimulating a higher intake of a ration should permit higher levels of milk production to be achieved. This situation should also improve the profit potential for the dairy enterprise.

In attempting to maximize dry matter intake, there are a number of factors which must either be evaluated or controlled. These factors are primarily ones which tend to depress dry matter intake. Some of these are:

A. Feed availability - In many situations, feed intake is restricted due to lack of feed being available to the cows. How many hours per day are the bunks empty How long are cows in the holding area and milking parlor? Is there adequate feedbunk space for all cows to consume fresh feed? If these areas are identified as problems, they are relatively easy to alter.

B. Feed timing - Are fresh feeds available to the cow at the right times? As an example, most cows look for fresh feed after milking. Is fresh feed in the bunks at these times or is stale or spoiled feed present? A shift in the timing of feed delivery may enhance dry matter intake.

C. Feedbunk management - Are the bunks cleaned routinely before being filled with fresh feed? Is the fresh feed just added on top of the old feed? Again, this seemingly small point may be important in achieving maximum feed intake.

D. Ration moisture content - Wet, acid fermented rations have been demonstrated to depress feed intake. The key depressant factor appears to be an unidentified compound which is solubilized in the water rather than the water itself. Some reports have indicated that diets containing less than 60-65% dry matter result in intake depression.

E. Social interactions - Limited information indicates that the social structure of the herd may depress intake in some animals. One example is that first calf heifers spent 10-15% more time eating per day when housed separately from older cows. The end result was an improvement in milk production of 5-10%. This effect should be even more critical if either feed availability or bunk space are limited.

F. Water availability - Studies in England have indicated that decreasing water intake by 40% results in a 16-24% depression in dry matter intake. Check water intakes to determine if it could be depressing feed intake.

G. Feeding frequency - Increased feeding frequency should lead to a more stable rumen environment and improved feed intake. Limited research results are encouraging but not conclusive regarding the relationship of feeding frequency and dry matter intake. More frequent feeding should maintain a fresher, more acceptable feed for the dairy cow. This should be especially important in the hot, summer months.

H. Feeding sequence - Again, conclusive experimental data is lacking to quantify this concept. The goal is to minimize fluctuations in rumen environment which should enhance feed intake. Feeding some forage prior to concentrate feeding appears beneficial.

I. Ration changes - Cows switched between rations with large differences in concentrate level tend to decrease in both dry matter intake and milk yield. To minimize this effect, more production groups or a gradual ration change may be warranted.

J. Environmental effects - Temperature, ventilation and slippery floors can all have detrimental effects on dry matter intake and milk production. Make sure that these factors are not restricting the performance of cows fed nutritionally balanced rations.

The above list is far from complete but does contain many of the factors which can influence the level of dry matter intake attained in a herd. It has been assumed throughout this paper that a nutritionally adequate ration balanced for energy, protein, fiber, vitamins and minerals is available. The intent of this paper was not to balance rations but rather to provide guidelines for implementation and utilization of these rations. The above concepts, in addition to the balanced ration, can assist in attaining maximum dry matter intake.

<u>Summary</u>

Dry matter intake is the cornerstone upon which productive and profitable dairy rations are built. The control of dry matter intake is a combination of both physical and physiological factors. Even though a wide variety of predictive equations are available, none will fit exactly in a specific situation. A better alternative is to develop a monitoring situation for dry matter intake for the herd. The combination of a properly formulated ration, a knowledge of dry matter intake and the fine tuning factors mentioned above should permit efficient and profitable milk production on today's dairy farm.

Basically, 2 kep phrases need to be kept in mind when thinking of dry matter intake in dairy nutrition. These are:

1. Maximize Dry Matter Intake

- Feed frequently
- Keep fresh feed in front of the cows
- Clean the feedbunks
- Have a good, fresh supply of water available
- Maintain an adequate level of "effective" fiber in the ration
- Keep the cows chewing and ruminating
- Don't overfeed grain

2. Monitor Dry Matter Intake

- Know what is fed, refused and consumed
- Use a moisture tester
- Know how many cows are in the group
- Calculate dry matter intake
- Graph dry matter intake

Table 1. Expected maximum daily dry matter intake

Body weight (lbs)	900	1100	1300	1500	1700
	--Dry matter intake, % of body weight--				
FCM[a] (lbs)					
20	2.5	2.4	2.3	2.2	2.2
30	2.9	2.7	2.6	2.5	2.4
40	3.2	3.0	2.8	2.7	2.6
50	3.5	3.2	3.0	2.9	2.7
60	3.9	3.5	3.3	3.1	2.9
70	4.2	3.8	3.5	3.3	3.1
80	4.6*	4.1	3.7	3.5	3.3
90	4.9*	4.3*	4.0	3.7	3.5
100	5.2*	4.6*	4.2	3.9	3.6
	---Dry matter intake, lbs per day---				
FCM (lbs)					
20	22.7	26.5	30.2	33.9	37.6
30	25.8	29.5	33.2	36.9	40.6
40	28.9	32.5	36.3	40.0	43.7
50	31.9	35.6	39.3	43.0	46.7
60	35.0	38.7	42.4	46.0	49.7
70	38.0	41.7	45.4	49.1	52.8
80	41.1*	44.8	48.5	52.2	55.8
90	44.1*	47.8	51.5	55.2	58.9
100	47.2*	50.9	54.5	58.3	62.0

[a]4% fat corrected milk.
*May be higher than is normally achieved.

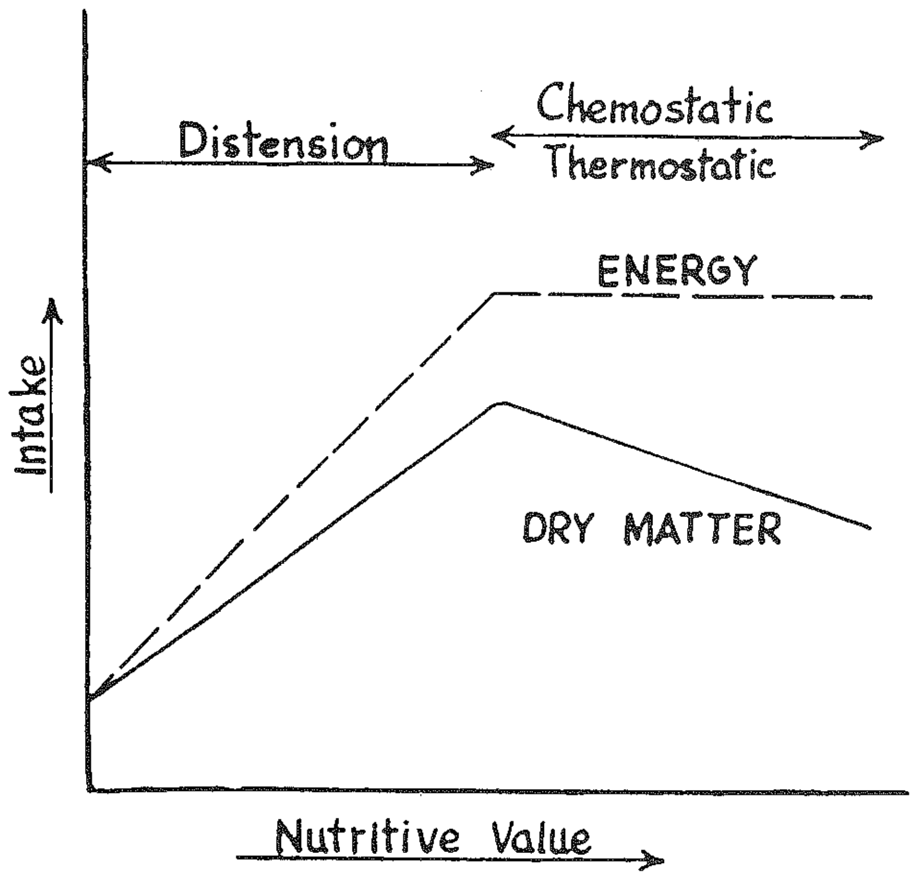
Table 2. Required ration nutrient density[a,b]

Item	Expected DMI (lbs)		
	43	45	47
Crude protein, % of DM	17.7	16.9	16.2
NE_1, Mcal/lb DM	.80	.76	.73
Calcium, % of DM	.77	.73	.70
Phosphorous, % of DM	.46	.44	.42

[a]Assumes a cow weighing 1300 pounds producing 80 pounds of milk with a 3.5% fat test.

[b]Daily requirements are 7.6 pounds of crude protein, 34.4 Mcal NE_1, 150 grams of calcium and 89 grams of phosphorous.

FIGURE 1.



Chemostatic
Distension
Thermostatic
ENERGY
Intake
DRY MATTER
Nutritive Value

WHAT IS NUTRIENT DENSITY?

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Nutrient density is a term which is being used more frequently in dairy cattle nutrition. What does the term nutrient density mean?

Basically, nutrient density is simply an expression of the concentration of a nutrient in a ration. It is calculated by simply dividing the amount of a nutrient by the amount of dry matter. The following example should help to explain this concept.

Example

A dairy cow which is consuming 47 pounds of dry matter per day. Body weight is 1350 pounds with a daily milk production of 78 pounds of milk with a 3.6% fat test. The daily ration contains 34.5 Mcal NE_1, 7.6 pounds of crude protein, 150 grams of calcium and 1200 milligrams of zinc.

The following calculations would be used to calculate nutrient density:

a. Net energy (Mcal/lb) =

Total Mcal NE_1/lbs DMI

34.5/47 = .73 Mcal NE_1/lb DM

b. Crude protein (%) =

(lbs Crude protein/lbs DMI) x 100

(7.6/47) x 100 = 16.2%

c. Calcium (%) =

(gms Ca/lbs DMI)/4.54

(150/47)/4.54 = .7%

d. Zinc (ppm) =

Mg Zinc/(lbs DMI x .4536)

1200/(47 x .4536) = 56 ppm

Similar calculations could be performed for other ration constituents. The actual calculations involved are quite logical and simple to perform.

FORAGE DRY MATTER DETERMINATION USING A MICROWAVE OVEN

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A quick and convenient way to determine the dry matter content of a forage sample is by the use of a microwave oven. This method can provide accurate results if certain steps are followed. The following key points are adapted from information developed by Dr. D. A. Rohweder and V. Dantoin from the University of Wisconsin. This is basically the method they use in their mobile NIR van.

A. Selecting the right equipment

A microwave oven with a power range of 50 to 500 watts is suggested. A scale which weighs in grams is also required. Scales sold for dietetic purposes work well. You could also use a postal scale that weighs to the nearest half ounce. However, this will not be quite as accurate.

B. Collecting the forage sample

If a representative sample is not collected, then the dry matter results will be of little value. Baled hay should be sampled using a bale corer. Loose hay or field samples from windrows will need to be chopped into pieces 1 to 2 inches in length. Obtain a number of samples, chop them to length, place in a bucket, mix and subsample. Silages and high moisture grains can also be used.

C. Determining dry matter content

1. Weigh an empty brown paper lunch bag and record the weight (weight A). It is possible to use other microwave-safe containers such as paper plates.

2. Place a representative sample weighing between 50 to 100 grams in the bag. Weigh the bag plus sample and record the weight (weight B).

3. The sample is placed in the microwave oven and dried slowly to minimize charring. An 8 ounce glass of water, about three-fourths full, should be placed in the back of the oven. This water level should be maintained throughout the drying process.

a. For most samples, an initial drying time of 3 minutes can be used. The following adjustments may be useful.

Estimated Sample Moisture	Initial Drying Time
(%)	(min)
70-80	5
<35	2

b. Use the ovens higher heating or power settings for the initial drying of wet samples. The heat or power setting is then decreased as the sample dries.

c. Check for dryness after the initial drying. Stir the sample in the bag.

d. Repeat the drying cycle using drying times of about 1 1/2 to 3 minutes.

e. Recheck the sample for dryness and again stir the sample. You should be able to detect some loss of moisture at this point.

f. Continue drying for 1 1/2 minute intervals until the sample feels dry. The sample should be stirred between each drying interval.

g. Weigh the sample to monitor moisture loss.

h. Dry for about 30 seconds and reweigh the sample. Repeat this process until the weight of the bag plus sample does not change. Record this as weight C. (Note: The same weight for 3 consecutive weighings indicates that the sample is dry).

4. The total drying time will vary with the sample type and moisture content. Approximate drying times reported by the Wisconsin workers are:

Forage	Time (minutes)
Haylage	4-15
High-moisture corn	10-15
Alfalfa silage	5-6
Corn silage	8-20
Fresh material	8-20

5. Calculating the dry matter content of the sample

A - Bag weight = ________________

B - Bag + wet sample = ________________

C - Bag + dry sample = ________________

Subtract the bag weight (A) from both the wet (B) and dry weights (C).

Line 1 (B-A) = ________________

Line 2 (C-A) = ________________

$$\frac{\text{Line 1} - \text{Line 2}}{\text{Line 1}} \times 100 = \%\ \text{Moisture}$$

100 - % moisture = % Dry Matter

Example

A - Bag weight = 9.0 g
B - Bag + wet sample = 78.0 g
C - Bag + dry sample = 33.0 g

Line 1 (78-9) = 69 g

Line 2 (33-9)= 24 g

$$\frac{69 - 24}{69} \times 100 = 65.2\%\ \text{Moisture}$$

100.0 - 65.2 = 34.8% Dry Matter

Partial list of Supply Companies that carry electronic balances suitable for use with microwave dry matter determination:

Scale Name: OHAUS Lune-O-Gram
Description: Digital Electronic Scale
Model Number: D1001-BA

VENDORS:

CAMX (716) 482-1300
Dave Smith or Angela Williams
CAMX Inventory Number: 11377-088
$99.50 (3-16-89)

Superior Scientific (315) 524-2297
Janice Kennedy
ORDER USING OHAUS MODEL NUMBER
$99.50 (3-16-89)

- D-1000 grams - by 1 gram increments
- Digital readout
- Also will readout by ounces in 0.1 ounce increments
- Has Tare feature

4/89

FIELD APPLICATION OF THE DEGRADABLE PROTEIN SYSTEM

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For several years it has been generally accepted that the crude protein system must be modified if animal performance is to be optimized. This has been done by adjusting for unavailable and soluble protein as well as crude ration protein content. In 1985, the National Research Council (NRC) published recommendations to improve the precision with which the protein requirement can be predicted for growing and lactating ruminants.[1] The system defines the state of the knowledge well but is lacking in terms of being readily applicable. This article clarifies the practical means by which the NRC concepts can be applied.

Protein Degradability in Feedstuffs

Protein systems require a feed data base so that calculations can be made. The data base that the authors have generated for NRC system is provided in Tables I and II. This base is derived from the NRC summary and the data of various researchers.[2-6]

All protein fractions in Tables I and II are expressed as a percentage of the total protein. This allows for changes in any one of the fractions and compensations in the other fractions. All data should be included in the computer data base in this manner.

Table I
Protein Degradability of Various Feedstuffs

Ingredient	Percent DM*	Protein (% DM)	Percent Solubility (% CP)	Degradability (% CP)	Undegradability (% CP)	Bound (% CP)
GRAINS						
Apple pomace	90	4.4	8	20	80	58.0
Bakery waste	92	10.3	40	80	20	5.3
Barley, ground++	90	11.3	35	79	21	2.0
Beet pulp	91	9.3	3.9	70	30	10.8
Citrus pulp	90	6.7	26	80	20	5.0
Corn,cracked	89	10	12	30	70	6.2
Corn, ear	86	8.8	16.0	35	65	6.2
Corn, ear, wet	70	8.8	40	65	35	6.2
Corn, ground++	89	10	12	35	65	6.2
Corn, shell, wet	70	10	40	65	35	6.2
Hominy	91	12.1	19	35	65	3.5
Molasses	75	4.1	100	100	0	0
Oats, ground	89	13.5	31	80	20	5.0

Ingredient	Percent DM*	Protein (% DM)	Percent Solubility (% CP)	Degradability (% CP)	Undegradability (% CP)	Bound (% CP)
Wheat, ground	89	14.6	23	80	20	3.0
Wheat,middlings	89	18.0	40	80	20	1.0
INTERMEDIATE PROTEIN						
Alfalfa meal++	88	19.3	28	38	62	20
Brewers grains	93	25.6	2.9	47	53	13
Corn gluten feed	88	21.7	48	70	30	2.6
Cottonseed,whole	92	24.0	33.0	55	45	10
Distillers grains++ with solubles	90	27.8	15	38	62	15
Whey,dry	94	17.7	80	90	10	0
HIGH PROTEIN						
Bloodmeal	90	98	9.5	18	82	10
Canola meal++	90	40	28	77	23	2.5
Cottonseed meal++ (solvent)	94	43.6	22	59	41	2.7
Cottonseed meal++ (propress)	94	44	25	64	36	2.7
Cottonseed meal++ (screw press)	90	68.9	15	50	50	3.0
Corn gluten++ meal	90	68.9	4	45	55	5.0
Fishmeal++	93	64.5	12	20	80	5.0
Linseed meal++	89	38.4	41	56	44	7.9
Meat Meal++	90	51	13	24	76	5
Meat & bone meal++	90	47	15	40	60	5
Peanut meal	90	51.1	40	70	30	2.5
Soybean meal,48++	88	54.5	20	72	28	2.0
Soybean meal,44	90	49	20	72	28	2.0
Soybean meal,44 (Expeller)	90	49	15	55	45	3.0
Sunflower meal++	93	49	30	76	24	2.5
Urea	99	281	100	100	0	0
Whole soybeans (Cooked)	93	40	17	52	48	4.0
Whole soybeans (Extruded)	93	41	17	52	48	4.0
Whole soybeans (Raw)	90	41.1	40	80	20	2.9
Whole soybeans (Roasted)	93	41	16	51	49	4.0

*DM = dry matter

+CP = crude protein.

++ = Degradability is derived from the NRC 1985 report. Solubility and bound protein information are from work by various researchers.[2-6] Degradability values without a double dagger superscript are derived based on protein characteristics.[1,7]

Table II. Protein Fractions In Various Forages

	Alfalfa* Hay	Alfalfa Silage (LS)	Alfalfa Silage (HS)#	Grass* Hay	Grass Silage (LS)	Grass Silage (HS)	Ammonia Corn* Silage	Corn Silage
Dry Matter	89	40	30	89	40	30	35	35
Total Protein, (% DM)	20	20	20	12	12	12	8.5	12
Solubility#	20	45	60	20	40	55	50	55
Degradability	72	80	90	63	70	80	73	73
Undegradability	28	20	10	37	30	20	27	27
Bound	5	10	10	5	10	10	4	4

*From NRC 1985 recommendations.
#LS = slow solubility, HS = high solubility.
= Fractions in % CP.

If one is to see how these data are derived, it is necessary to understand the protein fractions in feedstuffs. The protein fractions can be defined as follows:

Protein Fraction	Measurement
A NPN nitrogen	Soluble protein
B_1 Rapidly degraded protein	Soluble protein + tungstic acid
B_2 Intermediate degradability	Enzymatic or in situ
B_3 Slow degradable	1-Enzymatic or in situ
C Unavailable	Acid detergent fiber N

In that currently only total, soluble and bound protein can be measured, the various fractions are combined as follows: $A + B_1$ = soluble protein, C = bound protein, degradable = $A + B_1 + B_2$, and undegradable = $B_3 + C$. Modification of the protein values is best illustrated by an example (Table III).

Table III
Modification of Protein Values: An Example

	Total Protein (% DM)*	Degradable: Soluble A (% CP)	Degradable: Soluble B_1 (% CP)	Degradable: Intermediate Degradable B_2 (% CP)	Escape, Bypass or Undegradable: Slowly Degradable B_3 (% CP)	Escape, Bypass or Undegradable: Unavailable C (% CP)
Soybean Meal	54.5	6.0	14.0	52	26	2

*DM = dry matter.
CP = crude protein.

Combining the fractions to obtain degradable and escape yields the results shown in Table IV. Note the following relationships: Protein solubility = A + B_1; B_2 = degradable - soluble; degradability = in vivo, enzymatic, or in situ measurement; B_3 = escape - C; C = acid detergent fiber protein; and degradability = 100 - escape (bypass or undegradable) or B_3 + C.

Table IV
Degradable and Escape Yields: Sample Calculations

	Total Protein (% DM)	A (% CP)		B_1 (% CP)		SOLUBLE (% CP)		B_2 (% CP)		DEGRADABLE (% CP)	B_3 (% CP)		C (% CP)		ESCAPE (% CP)
Soybean Meal	54.5	6.0	+	14.0	=	20	+	52	=	72	26.0	+	2.0	=	28

If one measures the total protein without knowledge of the other protein fractions, these fractions will remain the same. If, for example, the solubility is measured and it is found to change to 25% of the total protein, changes must be made in the appropriate fractions (Table V).

Table V
Changes in Protein Values Needed if Solubility Changes: An Example

	Total Protein (% DM)	A (% CP)	B_1 (% CP)	SOLUBLE (% CP)	B_2 (% CP)	DEGRADABLE (% CP)	B_3 (% CP)	C (% CP)	ESCAPE (% CP)
Soybean Meal	54.5	7.5	17.5	25	47	72	26.0	2.0	28

It should be noted that changes were made only in the A, B_1, soluble, and B_2 fractions. A change means that there has been an increase in the rapidly degraded protein and a reduction in the intermediate degraded proteins. These changes were in the same proportions as in the original NRC analysis. In this example, the authors knew only the protein solubility; if acid detergent fiber protein or degradability has been measured, appropriate changes can be made. It should be added that there is evidence that if the soluble protein in feedstuffs increases, the protein degradability increases. Thus when this is the case, the total degradability can be changed by assuming that the increased soluble protein is due to escape (bypass protein) decreasing. In the example, then, it would be 25-20 = 5, resulting in the profile shown in Table VI.

Table VI
Changes in Total Degradability Assuming Increased Soluble Protein Is Due to Escape: An Example

	Total Protein % DM	A (% TP)*	B1 (% TP)	SOLUBLE (% TP)	B2 (% TP)	DEGRADABLE (% TP)	B3 (% TP)	C (% TP)	ESCAPE (% TP)
Soybean Meal	54.5	7.5	17.5	25	52	77	21	2.0	23

*TP = total protein.

There is a very small B_1 fraction in forages and many feedstuffs. In forages, as soluble protein rises or falls, the amount rapidly degraded increases or decreases accordingly. Increasing the bound protein increases escape but reduces availability. With this system, it is thus possible to formulate rations for protein degradability.

Generally in most feedstuffs, if the solubility changes, the degradability/undegradability can be changed proportionately. This is not the case with ensiled hay crop silages, wherein B_1, and B_2 are essentially changed. When protein solubility in hay crop silage exceeds 60%, the degradability usually increases to 85 to 90% of the total protein unless the ADF protein has also increased then the protein that escapes at least equals this fraction.

In the 1985 NRC they outline that there is a fraction of protein in the feed which is indigestible. This fraction of protein is partially tied up in the indigestible lignin complexes which is in the ADF. Additionally there is available protein which is associated with the cell wall which is slowly digested and not associated with the lignin. This protein has a high potential to escape and be digested in the small intestine. If there is excess heating the amino acids in the proteins can react with the carbohydrates to form Maillard products which are plastic-like in their nature and totally indigestible. Van Soest has shown this fraction can be measured by analyzing the ADF residue for its protein content. This has been measured for over a decade in the Northeast and is known as unavailable protein. From this number is generated two other numbers: available protein and adjusted crude protein. Available protein is the crude protein minus unavailable protein. The adjusted crude protein is the following:

Adjusted crude protein = Crude protein - (Unavailable protein - 1.0)
If (unavailable protein - 1.0) 15 < 0 then Adjusted crude protein = Crude protein

This recognizes that in most feedstuffs that there is normally 1% of the dry matter that is unavailable or ADF protein. The 1978 protein system did not explicitly recognize dry analysis as unavailable protein when the system was developed. So in an attempt to correct for this was developed into the analytical system.

The 1985 protein system states that there is a constant 80% of the protein in undegraded protein that is digested and 20% that is indigestible. Unfortunately in the summarization of the data to obtain the digestibility of the protein escaping fermentation they could not correct for the indigestible protein fraction in the feed. If this had been done the digestibility of the available protein escaping fermentation would have been closer to 95%. However with the exception of one experiment using silage all of the protein fed was probably low in ADF protein.

Our concern can best be shown by example. Suppose we have the following:
2 Alfalfa hay crop silages

	Crude Protein % DM	Soluble Protein	Degradable Protein (DIP)	Undegradable Protein (UIP)	ADF Protein
		% of CP			
Alfalfa 1	20	60	80	20	5
Alfalfa 2	20	60	80	20	20

Lets suppose a producer was feeding 12 lbs of alfalfa dry matter. We would have the following situations:

	Alfalfa 1	Alfalfa 2
Crude protein Intake (lbs)	2.4	2.4
Degradable Intake	1.92	1.92
Undegradable Intake	.48	.48
ADF Protein Intake	.12	.48
Digestible UIP protein (NRC 1985)	.384	.384
Indigestible (.48 x .2)	.096	.096
ADF Digestible	.360	0
Adjusted UIP	18.75	0

The equation to adjust the protein escaping fermentation for the unavailable protein (ADF protein) is:

$$\text{Adjusted UIP (\% of CP)} = \frac{\text{UIP(\% of CP)-ADF Prot (\% CP)}}{.80}$$

If Adjusted UIP is > UIP then Adjusted UIP = UIP

If Adjusted UIP is < 0 then UIP = 0

This equation adjusts the UIP to the NRC protein system. You will note that in the table Alfalfa I UIP is reduced from 20 to 18.75 and most important the forage with a 20% ADF protein has a bypass or undegraded value of 0.

This equation can be used by taking the laboratory analysis and making the appropriate adjustments. It also can be incorporated into a computer program. It is necessary to have in the program the unavailable or ADF protein. This correction assumes that if the ADF protein exceeds the NRC indigestibility of 20% of the UIP that protein will be unavailable. It should be pointed out that this provides a conservative approach which will increase the dietary protein intake. However if the user feels that part of the ADF protein is usable that the .80 can be reduced. Finally in order for the protein system to work it is necessary to take into account the Maillard or burned proteins in feedstuffs. It is felt that this conservative approach will move us in the right direction.

The importance of protein degradability is little understood by many people. Our goal is the optimize rumen fermentation. This provides for maximum digestion of fiber and optimizes the digestion of the nonstructural carbohydrate components. The equation in the 1985 NRC protein system (also in 1989 dairy NRC) is:

Microbial protein flow to the small intestine (g/day) = 6.25 (26.12 TDN Intake kg/day -31.86)

In the examples in the tables a constant microbial protein yield is assumed. This is fine for the example however, in reality the microbial yield will vary as a function of mainly fermentable carbohydrate consumed. It is difficult for us to come up with what is really fermented in the rumen for each feed. The largest data base that we have is TDN. TDN is a summation of the protein, fat, fiber and NSC digested through the whole tract. In the ruminant most of the digestion takes place in the rumen so we can use the TDN value as a beginning estimate of the material fermented in the rumen. This value has to be corrected for the fat content which is not fermented. It is absolutely essential that any program developed using a factorial protein system include an estimate of the rumen fermentable organic matter intake. It is suggested that TDN is a good place to start.

Formulating for Protein Degradability and Undegradability

It should be noted that soluble and C fractions are included in addition to degradable and escape (bypass) protein. This is done in anticipation of future changes and because it is important to include an

Table VII
Protein and Energy Requirements

	Heifer Target Weight*				Lactating Cow&		
	400 lb (ADG!! 1.8)	800 lb (ADG 1.8)	1200 lb (ADG 1.5)	Dry Cow+ ++	Early Lactation	Mid Lactation	Late Lactation
DM intake							
Pounds	8.7	15.8	23.5	26	52.3	48.9	42.4
Percent body weight	2.9	2.6	2.3	2.0	4.02	3.62	3.0
Protein intake							
Pounds	1.4	1.7	2.1	3.2	8.6	7.5	5.9
Percent DM	15.6	10.7	8.9	12.3	16.4	15.4	13.9
Protein Fractions (% CP)							
Solubility	35	50	70	60	30	38	48
Degradability	45	55	71	75	60	61	61
Undegradability	55	45	29	25	40	39	39
Total digestible nutrients intake							
Pounds	5.5	9.3	12.6	13.1	38.2	34.3	27.3
Percent DM	63	58.9	53.6	46	73.0	70.1	64.4
Net energy maintenance							
(Mcal)	3.1	5.2	7.6	-	-	-	-
Net energy maintenance							
(Mcal)	1.9	3.3	3.9	-	-	-	-
Net energy lactation intake							
(Mcal)	-	-	-	13.5	38.9	34.9	27.7
(Mcal/DM)	-	-	-	0.47	0.74	0.71	0.65

*Calculated based on average weight from initial weight to target weight.
+1300 lb body weight frame size, 1450 lb body weight at condition, score 4 to 4-.
++Dry cow requirements have been modified using the Cornell net protein/carbohydrate model.
&Early lactation, 1300 lb body weight, 90 lb milk, 3.6 fat, -0.25 lb reserve weight, net growth gain 0.5 lb. Mid lactation, 1350 lb body weight, 70 lb milk, 3.8 fat, 0.33 lb reserve weight, net growth gain 0.5 lb. Late lactation, 1400 lb body weight, 45 lb milk, 4.1 fat, 0.33 lb reserve weight, net growth gain 0.5 lb.

additional constraint of soluble protein and nonprotein nitrogen (A) since these fractions degrade so rapidly. Further NRC suggests that there is a C fraction but makes no suggestion on how to adjust the availability of the undegraded protein.

The guidelines for the new protein system can be understood by first examining the field approach. The requirements, calculated as a percentage of total protein, are presented in Table VII. These data can be used in one of the following manners, according to how the protein degradability is to be evaluated:

1. By field evaluation
   Examine ingredient degradabilities and degradability ranges. If they are low or high, obtain feeds to correct this. Keep in mind the contribution of total protein.

2. By calculation (Tables I, II, and VII)
   As an example, one needs to develop a ration for a high-milk-production group. The feeds available are hay crop silage, corn silage, high-moisture shelled corn, soy 48, distillers with solubles, and super bypass 32. The solubility is 18%, degradability is 54% of the total protein, and bypass is 46%. The overall farm feedout of forage inventory must be 50:50 on a DM basis, but the ratios can be developed depending on need. First make a table of the feeds and nutrients to be used (Table VIII, and using values from Tables I and II). Next make a table of requirements from Table VII, as shown in Table IX.

Table VIII
Feeds and Nutrients to Be Used: An Example

	Net Energy Lactation (Mcal/lb)	CP (% DM)	Solubility (% CP)	Degradability (% CP)	Undegradability (% CP)
Hay crop silage	0.65	20	45	80	20
Corn silage	0.70	8.5	50	73	27
High-moisture shelled corn	0.80	10	40	65	35
Soybean meal (48% protein)	0.80	54	20	72	25
Distillers with solubles	0.85	27.8	15	38	62
Super bypass 32	0.82	36	18	54	46

Table IX
Protein and Energy Requirements: An Example

	DMI*	Net Energy Lactation (Mcal)	Protein	Solubility	Degradability	Undegradability
Amount	52.3	38.9	8.6	2.58	5.16	3.44
Percent of DM	4.03	0.74	16.4	4.93(30% of CP)	9.87(60% of CP)	6.58(40% of CP)

*DMI = dry matter intake

In order for all of the forage to be fed, at least 25% of the forage DM consumed must be hay crop silage. Therefore, a calculated mix must be developed; an example is shown in Table X. The mix is 11.4% CP and 5.44 soluble protein, or (5.44/11.4) 100 = 47.7% solubility (Table XI).

Table X

Developing a Calculated Mix: An Example

	Protein				Solubility		Soluble
Hay crop silage	25 x 20	=	5.0	x	0.45	=	2.25
Corn silage	75 x 8.5	=	6.4	x	0.50	=	3.19
Total	100		11.4				5.44

Table XI
Calculation of Solubility and Degradability: An Example

Forage Mix	DM (lb)	Net Energy Lactation (Mcal/lb)	Protein	Solubility	Degradability	Bypass
Percent DM	36.3	0.69	11.4	5.44	8.65	2.75
Fractions	-	-	-	47.7	75.9	24.1

A more slowly degradable protein source clearly is needed. First choose the forage:concentrate ratio. The authors have decided that the cow will consume 52.3 lb DM and that it requires 38.9 Mcal net energy lactation on 0.74 Mcal/lb (38.9/52.3). The easiest approach is to use a Pearson square:

Forage	.69		.06	54.5
		.74		
Concentrate	.80		.05	45.4
			.11	100.0

Thus if the cows consume 52.3 lb DM, 52.3 x 54.5% = 28.5 lb of forage is consumed. To calculate the protein required in the concentrate, the amount supplied by the forage must be determined:

28.5 x 11.4/100 = 3.249 lbs protein

Cow requires	8.6 lbs protein
Forage supplied	3.2 lb protein
Required in Concentrate	5.4 lb protein

The 5.4 lb protein is included in the 23.7 lb concentrate DM (52.3 x 45.4% = 23.7) or 5.4/23.7 = 22.7% CP.

High-moisture shelled corn	10		13.3	51.0%
		22.7		
Bypass 32	36		12.7	48.8%
			26.0	100.0%

This means that if the super bypass supplement is used, the protein undegradability is as shown in Table XII.

Table XII
Effect of the Super Bypass Supplement: An Example

Feed	DM (lb)	x	Protein (% of DM)	=	Protein (lb)	x	Undegradability (% of DM)	+	Bypass Protein (lb)
Forage	28.6		22.4		6.4		24.7		0.80
Concentrate	23.7								
High moisture	12.1		10.0		1.21		35		0.42
Bypass 32	11.6		36.0		4.18		46		1.92
Overall	52.3				8.64				3.14
					16.5% CP				36.3% CP

The undegraded protein is short by 0.3 lb. Two strategies are now available: One can make a new concentrate or feed the cows enough more bypass 32 to make up the difference. The authors choose the latter approach. The concentration of undegraded protein in bypass 32 is 16.6 (36 x 46/100). The 0.3 is divided by 0.166 to determine that. One must feed 1.8 to 2.01 lb (rounding up to offset the decrease in corn) more DM of the bypass protein source. This means that 10.1 lb of high-moisture shelled corn (12.1-2.0) will be fed. The total ration protein concentration is then 17.5% CP with a slight increase in undegradability to 37.3. This means that the CP intake and degradable protein will be higher than necessary, but not to a point of being harmful.

Method 2 can be calculated easily on a computer. To determine the specific requirements for a given animal(s), the equations and relationships can be incorporated into either spread sheets or a regular computer program (Table XIII). It should be pointed out that the best way of using the protein system is to incorporate all of the equations into the spreadsheet or dedicated computer program. If one uses just the percent of total protein required then both degradable and undegradable must be exactly balanced. This is not always possible. If we are feeding an alfalfa silage we will have to overfeed degradable and soluble in order to meet undegradable requirement. Further, this approach assumes a constant supply of fermentable carbohydrate (estimated in the 1985 and 1988 NRC using an adjusted TDN value). It is important that the program use the adjusted (ATDN = TDN - ((fat - 4.0) x 0.95 x 2.25)) TDN consumed. This will allow for changes in microbial growth. For example if the producer is feeding high corn silage and corn meal the diet is rich in fermentable carbohydrates for a 1300 lb cow producing 80 lbs of 3.5% fat milk will require less than 3 lbs of undegraded protein. This same cow consuming a diet with added fat, and little corn silage can require 3.2-3.5 lbs of undegraded protein. This results in a much higher protein content in the ration. The protein system revolves around the rumen system; the more microbial protein synthesized, the less protein that needs to escape fermentation.

The formulating strategy should be first to meet the undegraded protein requirement and then to satisfy the degraded protein requirement. Finally, 50% of the degraded protein should contain 50% soluble protein. In rations containing high quantities of hay crop silage, it will be difficult to meet the undegradable protein requirement. It should be satisfied as closely as possible and the degradable rations overfed, increasing the total ration CP content. Do not allow ration CP content to exceed 18.5%. With high corn silage or hay diets, solubility requirements may not be met. The inclusion of more hay crop silage or urea could be beneficial.

The undegradability requirements for 400-lb heifers (Table VII) probably are too high in the NRC system. It might be beneficial to formulate for a 45 to 50% undegradability for the heifers and we have tentatively adjusted them lower. The dry cow requirement according to the NRC 1985 recommendations for the size animal in Table VII is 2.9 lb of CP with 45% of the protein escaping. This is impossible to meet. Examining this with the Cornell net protein/carbohydrate model suggests that the NRC underestimated microbial flow to the small intestine. The numbers shown reflect a higher microbial protein output. There is a requirement for a mix of corn silage, grass hay/silage, and a small amount of distiller or its equivalent, as well as a requirement for non protein nitrogen either from ensiled feed or urea.

Example rations are formulated in Table XIII. The total protein requirement was met in each case, but degradability/undegradability was not. The uncontrolled rations were imbalanced, and the changes made were positive. The alternative, as mentioned earlier, would have been to increase the total ration protein to 17.5 to 18.5, resulting in degradable protein overflow. This approach is to be avoided if possible. It is a temporary solution to the problem.

Adjusting the rations for protein degradability/undegradability is, as has been known for many years, advantageous. There now is a means for being more quantitative. Scientists will be developing methods for estimating the undegradable protein more directly. This will include enzymatic techniques and near infrared analysis.

The new dairy NRC requirements (1988) are now available and have adopted the 1985 protein system with a few modifications - one of which is to increase the efficiency of utilization of absorbed protein for milk synthesis.

The new dairy requirements are now available. Unfortunately there have been a few mistakes in the computer disc resulting in mistakes in the tables in the document. The degraded and undegraded protein values are wrong for replacements. Examine the equations carefully as you put them in the program.

The efficiency of use of the absorbed protein has been increased from .50 in NRC 1985 to .65 in Dairy NRC 1988 for growth and from .65 to .70 for lactation. This means that for the 1300 lb cow this will mean, with all fractions balanced, a reduction in total protein from 16.5 - 16.8 to 15.5-15.8. The 1988 protein guidelines need to be used carefully. Be sure to include several sources of proteins for both degradable and undegradable.

The new protein system is a step in the right direction. With the modifications of soluble protein and the approach suggested for estimating fractions the new system should move you ahead in increasing animal productivity and efficiency.

Table XIII
Example Rations for Controlling Degradability

	Early Lactation*		Late Lactation+			
			1978 NRC Protein Recommendations++		1985 NRC Protein Recommendations+	
Ingredient	Uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled	Controlled
DM Intake (lb/day)						
Mixed mainly legume haycrop silage (18 % CP)	10.0	10.0	10.0	10.0	10.0	10.0
Corn silage	12.2	12.5	17.7	17.5	17.7	17.5
Mixed mainly legume hay	2.0	1.7	2.0	2.0	2.0	2.0
High-moisture shelled corn	17.0	14.1	8.6	6.3	7.0	4.5
Distillers	-	6.1	-	5.2	-	5.8
Soybean meal (48% protein)	6.9	3.1	3.7	.96	5.3	2.2
Total	48.1	47.5	42.0	42.0	42.0	42.0
Ration Analysis (% of DM)						
CP	16.9	16.9	14.9	14.9	16.6	16.6
Degradable (degradable intake protein)	12.0	10.7	10.7	9.4	11.8	10.4
Undegradable (undegradable intake protein)	4.9	6.2	4.2	5.5	4.8	6.2
Neutral detergent fiber	30.1	30.1	36.8	36.7	36.7	36.6
Net energy lactation (Mcal/lb)	0.79	0.78	0.74	0.74	0.74	0.74
Dry matter intake (% body weight)	3.65	3.65	2.99	3.0	2.99	3.0
Forage:concentrate ratio	51	51	71	70	71	70
Protein Fractions (% of CP)						
Solubility	31.6	29.9	36.5	34.6	35.8	33.1
Degradability	70.8	63.0	71.5	62.9	71.4	62.9
Undegradability	29.2	37.0	28.5	37.1	28.6	37.1

*A 1300-lb cow producing 85 lb 3.6% milk fat and losing 0.4 lb/day.
+1400-lb cow producing 55 lb 4.0% milk fat and gaining 0.4 lb/day.
++Increased protein requirement by 10%.

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Dairy Management

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Protein in Dairy Nutrition

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Table 1. Protein partition in hays and silages

Forage	Crude* protein	Percentage of crude protein: Soluble†	ADF bound	Insoluble available
Grass hay	9.7	22.4	6.5	72.8
Mixed hay	12.7	24.8	4.6	71.5
Grass silages	12.4	54.5	8.9	38.9
Mixed silages	13.6	44.7	12.1	41.7

* Percentage of dry matter.
† Extracted in Burroughs buffer.

Protein is one of the major nutrients required by dairy cattle. In discussions of protein, *crude protein* is meant. To determine the crude protein in a feed, the total nitrogen is measured in the feedstuff. This number is multiplied by 6.25 (1/.16), based on the assumption that true protein, on the average, contains 16% nitrogen. The 6.25 conversion does vary according to the type of material being measured, but for practical purposes, this measurement suffices.

Table 2. Protein partition in various feedstuffs

Feedstuff	Crude protein (%)	Protein partition (% of crude protein): Average	Range	Bound	Insoluble, available
Urea	281	100	0	0	0 (1)*
Corn gluten feed	22	50	35-60	2	48 (5)
Distiller's dried solubles	34	43	-	14	43 (2)
Wheat middlings	16	40	35-44	2	58 (2)
Wheat bran	17	38	34-47	2	60 (2)
Citrus pulp	6	31	26-35	8	61 (4)
Potato pulp	6	29	26-39	4	67 (2)
Oats	12	28	23-38	2	70 (2)
Wheat	12	27	26-30	2	71 (2)
Hominy	12	19	8-27	3	78 (4)
Soybean meal	48	16	12-22	2	82 (3)
Distiller's, with sol.	27	15	9-17	18	67 (5)
Corn	9	14	12-15	5	81 (4)
Rice mill feed	6	7	2-11	8	85 (?)
Corn gluten meal	60	6	3-9	8	86 (5)
Distiller's, without sol.	30	3	2-5	20	77 (5)
Beet pulp	9	3	2-7	10	87 (4)
Dried brewer's grains	27	3	0-8	10	87 (4)

* Degradability 1 = very degradable, 5 = very resistant.

Protein Partition in Feedstuffs

The composition of crude protein varies widely among feedstuffs (tables 1 and 2) and can be affected by factors such as feed type, degree of maturity, fertility program, variety, storage, climate, and type of processing. As can be seen in figure 1, (p. 2), several divisions can be made in the protein of feedstuffs. These various fractions are defined and sample calculations given.

The protein in feedstuffs can be divided into three fractions:

Soluble protein is that protein extracted from a feedstuff incubated with a salt buffer (pH 6.5) at 40° C in 1 hour. This protein is completely soluble in the liquid portion in the rumen and is rapidly attacked and degraded by bacteria. Soluble protein is composed of both nonprotein nitrogen (NPN) and true protein, which vary tremendously depending on the protein source: Forages have a high percentage of the soluble protein in the NPN form. The soluble protein in silages is essentially 100% NPN. Soluble protein is presented either as a percentage of the dry matter (DM) (like crude protein) or as a percentage of the crude protein.

$$\% \text{ solubility} = \frac{\% \text{ sol. protein in DM}}{\% \text{ total protein in DM}} \times 100.$$

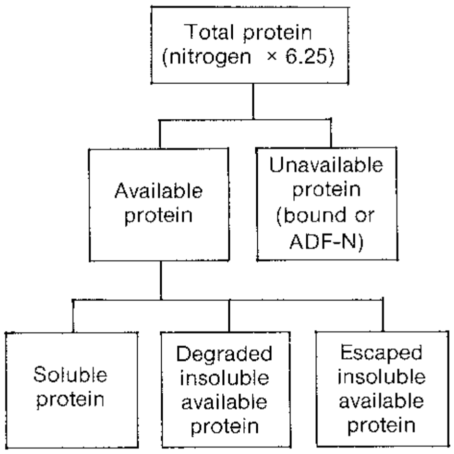

Figure 1. Protein partition in feedstuffs

Bound protein is that fraction commonly measured in the ADF (acid detergent fiber) or fiber fraction in feedstuffs. It is highly variable and greatly affected by heat. The bound protein is completely unavailable to the animal; in calculations of the protein required in a ration, the forage protein content is commonly adjusted for this value. Bound protein is presented either as a percentage of the dry matter or as a percentage of the crude protein.

$$\%\ \text{bound protein} = \frac{\text{crude protein in ADF}}{\text{crude protein in DM}} \times 100.$$

Insoluble available protein is that protein not soluble in a salt solution and not readily soluble in the fluid in the rumen, and excludes the bound protein. This protein is more slowly attacked by the bacteria. The rate at which this fraction is degraded depends on the protein source and the physical form of the diet. Pichard and Van Soest at Cornell demonstrated that a significant part of the insoluble protein can be rapidly degraded within 10 to 15 minutes. Results vary widely among feedstuffs. The protein that is not degraded escapes from the rumen and is almost completely digested (95%) in the lower tract. Insoluble available protein is presented either as a percentage of the dry matter or as a percentage of the crude protein.

$$\%\ \text{insoluble available protein} = 100 \times \frac{\text{crude protein - (sol. protein + bound protein)}}{\text{crude protein}}.$$

Protein Calculations

Example calculations for soybean meal:

Crude protein (total protein)	48.0%
Soluble protein	7.68%

Protein solubility

$$16\%\ \text{protein solubility} = \frac{7.68}{48.0} \times 100.$$

Bound protein

$$20\%\ \text{bound protein} = \frac{.96}{48.0} \times 100.$$

Insoluble available protein

$$82\%\ \text{insoluble available protein} = \frac{48 - (7.68 + .96)}{48} \times 100.$$

Ration Protein Solubility

Analysis	*Dry matter*	*Total protein*	*Solubility*
		percent	
Corn silage	30	8	50
Hay crop silage	40	18	50
High-moisture shell corn	70	8	50
Soybean meal	90	53	16

Feeding Program (lb dry matter/cow/day)

Corn silage	40
Hay crop silage	30
HMSC	25
Soy	6.7
Minerals	.5

Calculations

lb dry matter consumed = % dry matter in feed × lb feed offered,
12 lb corn silage dry matter consumed = .30 × 40.

lb nutrient consumed = % nutrient × lb feed dry matter offered,
.96 lb corn silage protein consumed = .08 × 12.

	Dry matter	*Total protein*	*Soluble protein*
		pounds	
Corn silage	12.0	.96	.48
Hay crop silage	12.0	2.16	1.08
HMSC	17.5	1.40	0.70
Soy	6.0	3.18	.51
Minerals	0.5	0	0
Total	48.0	7.70	2.77

Convert solubility to soluble protein consumed:

soluble protein consumed = % solubility × % crude protein × lb dry matter consumed,

.48 lb corn silage soluble protein consumed = .50 × .08 × 12,

or

lb soluble protein consumed = lb crude protein consumed × % solubility,

.48 lb corn silage soluble protein consumed = .96 × 50.

$$36\%\ \text{ration protein solubility} = \frac{2.77}{7.70} \times 100.$$

How Does the Composition of Feed Protein Relate to Protein Digestion in the Gut?

A few concepts about feed protein composition and how the feed protein is broken down by the cow should be understood. The soluble fraction of protein is mostly the true protein consisting of high-quality proteins. The nonprotein nitrogen is usually in the form of nitrates, ammonia, and other compounds (in concentrates urea can be included). In fermented forages the soluble protein is mostly in the ammonia form as a result of the protein being broken down during the silage fermentation process. The bacteria require both *soluble* and *insoluble available* protein for growth. In fermented forages and some processed ingredients, a significant part of the insoluble protein can be in the bound form. Bound protein is indigestible by the cow. The bound protein is formed by the carbohydrate in the forage or ingredient reacting mostly with the soluble true proteins. The bound protein has to be subtracted from the insoluble protein to give the insoluble available protein.

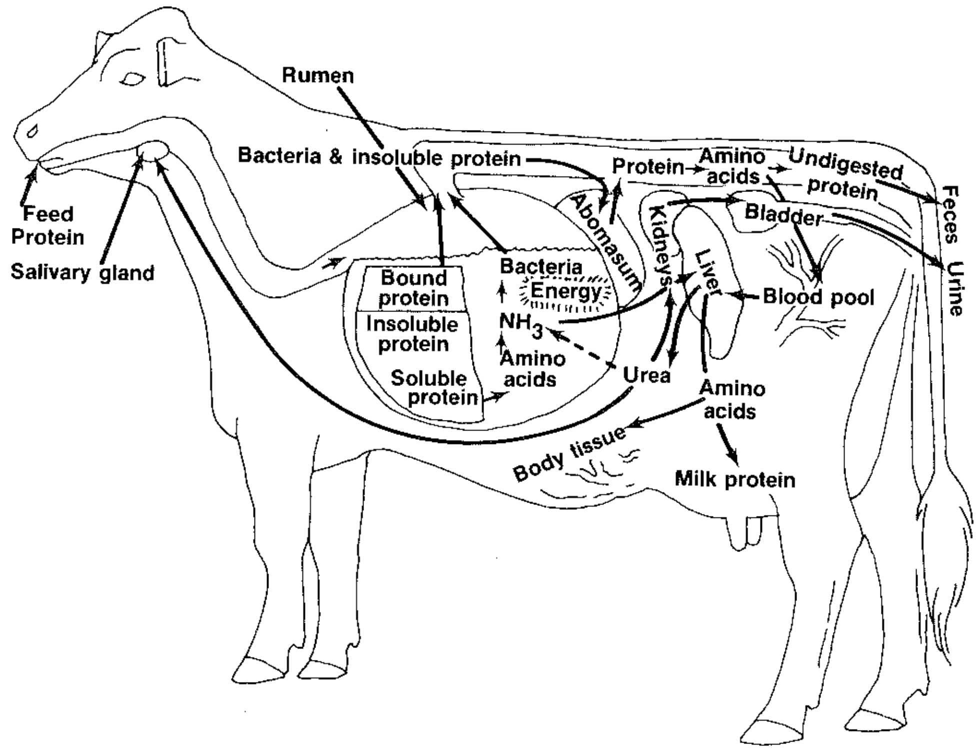

Figure 2. Protein metabolism in the cow

Figure 2 depicts the protein metabolism in the cow. Essentially, the bacteria in the rumen rapidly break down the soluble proteins to amino acids and ammonia. The ammonia is utilized by the bacteria to produce microbial protein. The insoluble available protein not degraded, plus bound protein and bacterial protein, passes down to the lower gut to be digested and absorbed. The bound feed protein is not digested and passes out in the feces.

The excess ammonia from rapid soluble protein breakdown in the rumen is absorbed from the gut, synthesized into urea in the liver, and excreted in the urine. To decrease the loss of soluble protein (excess ammonia), soluble energy is needed to supply the "fuel" necessary to help in the incorporation of ammonia into bacterial protein. The energy is best supplied by feedstuffs high in starch and sugars, such as corn, hominy, and oats. When the soluble energy is high, the amount of ammonia lost is decreased. The starch and sugars should be present at the same time as the soluble proteins, degrading at the same rate. The insoluble available protein being slowly degraded in the rumen is an important ammonia and amino acid source for the fiber-digesting bacteria, which grow at a slower rate.

Guidelines for Changing Ration Protein Degradability and Increasing Protein Utilization

- Feed lower-solubility ingredients or concentrates when feeding ensiled products.
- If possible, feed the urea in the bunk as a part of the ensiled product, or put the urea in the silo at ensiling time.
- In stanchion barn feeding (meal feeding), try feeding the high producing cows grain more than 2× per day, especially urea feeds.
- If feeding high soluble-protein grains or urea grains represents a potential dollar savings, feed only to mid- and (or) tail-end-lactation cows.
- Grain fed in the parlor should be a low protein solubility and degradability feed.
- Grain fed in gate or magnetic feeders with blended-ration situations should be of lower solubility and degradability.
- When mixing ingredients with ensiled forages for blended diets, use low-solubility ingredients such as soybean meal, dried brewer's grains, or distiller's grains. This is more important when urea is included in the mixed ration.
- If high solubility and (or) degradability ingredients or commercial supplements are to be used, feed them in a bunk in a blended ration. This ensures that the cow does not eat all the soluble and degradable nitrogen at one time and thus that the bacteria has time to assimilate the ammonia efficiently.
- If feeding high protein solubility ingredients or feeds, be sure to have higher soluble-energy ingredients such as corn.
- If hay is a part of the ration, use intermediate-solubility feeds and (or) ingredients.
- If corn silage is the major part of the ration, use a higher percentage of an intermediate-

degradability protein source in the 3–4 range. If hay crop silage is the major forage, use a higher percentage of proteins in the 4–5 range (table 2).

These guidelines may help you, generally, to solve problem cases. The new approach to ration formulation is to first feed the rumen and then feed the cow. Using this approach will maximize the utilization of forages in the diet and maximize microbial protein output to help meet the cow's protein requirement.

Table 3. Milk increase needed to break even for different grain and milk price differentials

Increased cost/ton of feed	*$11.00/cwt*			*$12.00/cwt*			*$13.00/cwt*		
	lb grain/cow/day			*lb grain/cow/day*			*lb grain/cow/day*		
	10	*20*	*30*	*10*	*20*	*30*	*10*	*20*	*30*
$	lb milk/cow/day								
10	.5	.9	1.4	.4	.8	1.3	.3	.7	1.1
20	.9	1.8	2.7	.8	1.7	2.5	.7	1.5	2.3
30	1.4	2.7	4.1	1.2	2.5	3.7	1.1	2.3	3.5
40	1.8	3.6	5.5	1.7	3.3	5.0	1.5	3.1	4.6

A Practical Approach to Protein Feeding

Send samples of feed to a laboratory for analysis. If you suspect a solubility or bound protein problem, be sure to request this analysis. Calculate the soluble protein level in the diet for your early lactation cows as shown previously.

The protein solubility should be 25–35%. The lower end of the range becomes more critical when feeding grain 2 times per day versus blended rations with the cow eating 11 to 14 times per day.

If the diets exceed the solubility limits, it may be worthwhile to feed a more insoluble available protein source. If the cow is not receiving adequate insoluble available protein, there will be an immediate response. If the solubility is too low (starving the bacteria), feed more soluble and (or) degradable protein. It is essential to keep the rumen functioning properly. The insoluble available protein in ingredients varies in rate of degradation in the rumen. The insoluble available protein in wheat middlings, oats, barley, and soybean meal is highly degradable. That in the following is very resistant: corn, corn gluten feed, corn gluten meal, distiller's and brewer's grains (see table 2). Solubility and degradability are not as critical in mid- and late lactation.

Economics of Protein Solubility

A considerable tonnage of commercial grain is being sold now on the basis of protein solubility. An increase in milk production is being claimed on about 80% of the farms where the method has been tried. Because of the type of ingredients used to lower protein solubility (distiller's grain, soybean meal, brewer's grain, corn gluten meal), the price per ton of feed is higher than that of regular feeds. The question is, How much extra milk must the cow produce to break even? Table 3 gives you this relationship. It can be seen that the pounds of milk needed to offset the increased cost in feed are small. For example, a dairy farmer who pays $30/ton more for feed, feeds 30 lb grain/cow, and receives $12/cwt for milk will need 3.7 lb of milk/cow/day to break even. A farmer buying a low-solubility feed, should take the following steps to test the economic feasibility of the higher-priced grain:

- Note number of cows in group being fed low-solubility feeds.
- Measure the milk in the tank for the group each day for a 3-week period (1 week before and 2 weeks after cows are put on grain). Calculate average increase in milk/cow/day.
- Use the following formula to calculate simple economics:

lb extra milk/cow/day needed =
[increased cost in grain, $/lb)
× (lb grain fed/cow/day)]
÷(price/lb milk).

To determine how much extra the farmer can afford to pay for grain, the following formula can be used:

$$\text{increased price/ton of feed} = \frac{2000 \times (\text{increased lb milk/cow/day}) \times (\text{price/lb milk})}{\text{lb grain fed/cow/day}}$$

Summary

Remember the following guidelines for good protein nutrition in the dairy cow:

1. Determine dry matter intake of cow or group.
2. Determine total protein requirement of cow.
3. Calculate total soluble protein in ration.
4. Make a protein adjustment, first on the basis of total and then, if necessary, on the basis of soluble protein. Do not forget that in addition to the quickly degradable protein (soluble), the bacteria need some slowly degraded protein for cellulose digestion.

Cooperative Extension, New York State College of Agriculture and Life Sciences, New York State College of Human Ecology, and New York State College of Veterinary Medicine, at Cornell University, and the U.S. Department of Agriculture cooperating. In furtherance of acts of Congress of May 8 and June 30, 1914, and providing equal opportunities in employment and programs. Lucinda A. Noble, Director.

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ENERGY IN DAIRY CATTLE NUTRITION

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Introduction

Energy is an integral part of all life processes and is required in large quantities for normal growth, production and reproduction. The daily requirement for energy is second only to water in terms of the actual quantity required per day. The cost of providing energy to the dairy cow may exceed the cost of providing other nutrients such as protein or minerals.

Unlike other nutrients, energy is not a specific chemical substance or compound. Energy is derived as a product of the digestion, absorption and metabolism of various feedstuffs ingested by the animal. The carbohydrate components of feeds are the primary energy sources in ruminant rations.

The actual design and evaluation of dairy cattle rations has traditionally been based upon meeting energy requirements. The balancing of the ration for protein, minerals and vitamins is normallly done after the balance of forage to concentrate has been achieved on an energy basis.

Energy Terminology

Energy can be best thought of as the ability to do work. A variety of units of measure and terms are used to quantify the energy content of feeds and the energy requirements of the animal.

A. Units of measure

1. Calorie (cal) = the amount of energy required to raise the temperature of 1 gram of water from 16.5 to 17.5 C. One calorie is equal to 4.184 joules (J) which is the common energy term used in Europe.

2. Kilocalorie (kcal) = 1,000 cal

3. Megacalorie (Mcal) = 1,000 kcal = 1 therm

B. Terms

1. Gross energy (GE) = The total amount of energy, measured as heat, that is released when a substance is completely oxidized to carbon dioxide and water.

2. Digestible energy (DE) = The apparently digested energy of a feedstuff. Measured as the difference between energy content of the feed consumed and the energy contained in the feces excreted by the animal. Fecal energy includes undigested feed, bacterial cells and energy from endogenous sources.

3. Metabolizable energy (ME) = The apparently metabolized energy. This is determined by subtracting the urinary energy and gaseous energy from the DE content of the feed. In ruminants, the ME content of the feed is usually about 80-85% of the DE value.

4. Net energy (NE) = This is the ME content of the feed minus the heat increment. The heat increment is composed of the heat of fermentation and the heat of nutrient metabolism.

   Net energy can be divided into a number of sub-categories. These include:

   NE_m - net energy used for maintenance

   NE_g - net energy used for growth

   NE_l - net energy lactation - includes NE used for both maintenance and the synthesis of milk

Figure 1 contains the overall scheme of energy utilization and the losses associated with the various energy terms.

Energy Systems

A major point of concern and confusion in dairy cattle nutrition is the number of different energy terms which are in use. In New York, the three common terms are ENE, TDN and NE_l. These can be described as follows:

1. ENE - Estimated Net Energy: This system was developed by Dr. F. B. Morrison at Cornell University. The values are commonly expressed in Mcal per 100 pounds of dry matter. This system was derived because Dr. Morrison believed net energy values to be more accurate than TDN. The ENE values listed by Dr. Morrison were derived by examining the

available data for the productive energy of feedstuffs. Adjustments were made if they were deemed necessary. An equation which is commonly used to estimate ENE values is (Moore et al., J. Dairy Sci., 36:93, 1953):

ENE (Mcal/100 lb DM) = 1.393 TDN - 34.63

2. TDN - Total Digestible Nutrients: This is an energy value which is similar to apparent DE and can be easily measured through the use of digestion trials. TDN is expressed as a percent of the total dry matter. One pound of TDN is equal to approximately 2000 kcal of DE. TDN is calculated by the following formula:

TDN = DP + DNFE + DCF + (DEE x 2.25)

where: DP = digestible protein
DNFE = digestible nitrogen free extract
DCF = digestible crude fiber
DEE = digestible ether extract

In comparison with the NE system, the TDN systen has some disadvantages. Since only fecal energy losses are generally considered, feeds with a high fiber content tend to be overvalued by the TDN system when compared with low fiber feeds. This is due to the higher gaseous and heat increment losses associated with the digestion of high fiber feeds.

3. NE_l - Net Energy Lactation: This is the system developed by Drs. Flatt, Moe and Tyrrell at the USDA Research Center at Beltsville, Maryland. This system is based upon determining the energy value of feeds and rations by indirect calorimetry. This technique involves an indirect measurement of total heat production in conjunction with nitrogen balance trials. As a result of their work, these investigators have proposed a single value, NE_l, to express the total energy requirement of the lactating cow. This decision is based upon the following information:

a. A lactating cow converts ME from body tissue reserves to milk with an efficiency of 82 to 84%.

b. A lactating cow converts ME from feed directly to milk with an approximate efficiency of 64%.

c. A lactating cow converts ME from feed to body tissue reserves with an efficiency of 72 to 75%.

d. A dry cow converts ME from feed to body tissue reserves with an efficiency of 58 to 60%.

e. Efficiency of utilizing feed ME for maintenance in cattle is between 60 and 75%.

Thus, in a lactating cow the efficiencies of utilizing ME for either milk production or maintenance are similar and separate values for maintenance and production are not required.

The NE_l system is theoretically the best system for expressing both the energy requirements of dairy cattle and also the energy value of feedstuffs. The primary disadvantage of the NE_l system is the difficulty and expense of determining NE_l values of feedstuffs. Thus, many current NE_l values on feeds have been derived by equations from established DE or TDN values.

Energy Requirements

The total daily energy requirement of a dairy cow is the sum of the energy needed for maintenance, growth, milk production and reproduction. The most commonly used source for energy requirements is the 1978 NRC publication. As an example, the daily NE_l requirement for a 600 kg cow producing 40 kg of milk with a 3.5% milkfat test would be:

Function	NE_l (Mcal/day)
Maintenance	9.7
Milk (.69 Mcal NE_l/kg)	27.6
Total	37.3

The above requirements assume a mature, nonpregnant cow. However, it is important to realize that a number of other factors can modify this requirement. Some of the most common modifiers are:

a. Growth - this is added for first or second lactation cows. The maintenance requirement is increased by 20% for first lactation cows and 10% for second lactation cows. This adjustment accounts for the fact that these animals have not reached mature body size.

b. Pregnancy - The maintenance requirement is increased by about 30% for cows which are in the last 2 months of gestation. This provides additional energy for the rapid fetal growth that occurs during this time.

c. Body weight change - The gain or loss of body tissue represents a change in energy status. For each kilogram of body weight loss, the daily energy requirement can be decreased by 4.92 Mcal of NE_l. For each kilogram of body weight gain desired, an additional 5.12 Mcal of NE_l should be added.

d. Activity - The current NRC requirement table values assume cows housed and fed in stanchions or drylot conditions. However, if cows are on pasture or must walk long distances, some additional energy is required. This is currently estimated as an increase in the maintenance requirement of about 3% for each additional kilometer walked.

e. Environment - Animals exposed to cold temperatures may require additional energy for maintenance. Even though not well quantified, it is suggested that an additional 8% total feed allowance be used for milking cows during the severe winter conditions found in the Northern U.S. This is due to a depression in dry matter digestibility during cold weather.

Level of Feed Intake and Energy Discount Factors

An important concept in energy utilization is the relatiolnship betwen the level of feed intake and the energy value of a ration or feedstuff. It must be remembered that the experimentally determined energy value of a feedstuff or ration is valid only at the specific level of intake used in the study. If the feedstuff or ration is then fed at a different level of intake, there will be an alteration of the energy value.

As a result of a large number of studies, the 1978 NRC publication uses a discount of 4% per unit of maintenance for NE_l values in the feed composition table. The impact of this on the actual energy value of a feed can be demonstrated as follows:

Level of Intake	NE_l Value (Mcal/kg)
Maintenance	2.0
2X Maintenance	1.92
3X "	1.84
4X "	1.76

The NE_l values for feedstuffs in Table 4 of the 1978 NRC publication on dairy cattle requirements are for cows consuming feed at 3 times the maintenance energy requirement. This is approximately equivalent to a 600 kg Holstein cow producing about 30 kg per day. An equation which can be used to convert maintenace TDN values to NE_l values at 3 times maintenance is (1978 NRC):

$$NE_l \text{ (Mcal/kg)} = -0.12 + (0.0245 \text{ TDN})$$

Estimating the Energy Value of Feedstuffs

The total energy content of a feedstuff can be determined by measuring the heat of combustion. This provides a gross energy value. A similar direct laboratory test for digestible or net energy is not available. The common approach is to estimate the energy content of forages from their ADF content. It is important to ascertain the level of intake represented by energy values predicted by individual forage testing labs.

Practical Aspects of Energy Utilization

The above concepts form the basis upon which energy requirements and ration formulation are built. However, there are a few specific areas of energy utilization which requires special attention in developing or evaluating dairy rations.

1. Negative energy balance and restoration of body tissue reserves

During early lactation, the dairy cow cannot consume adequate quantities of feed to meet energy requirements. Thus, during this time, the cow is said to be in a negative energy balance (energy output exceeds energy input). In an effort to partially counteract this situation, the dairy cow converts some body tissue reserves into an energy source for milk synthesis. The energy value associated with this is:

1 kg body tissue = 2.17 kg TDN = 4.92 Mcal's NE_l

This conversion provides enough energy to synthesize about 7 kg of milk. Thus, the loss of 100 kg of body tissue would provide enough energy for the synthesis of 700 kg of milk.

The next part of this process is to provide excess energy at some point in the lactation cycle to allow the cow to replenish these body tissue reserves. This is commonly done during either late lactation or the dry period. However, there is an energetic advantage to doing this during late lactation rather than during the dry period.

a. Condition put on during late lactation

- efficiency of converting feed ME to body tissue - 75%
- efficiency of converting tissue ME to milk - 82%
- overall efficiency (feed->tissue->milk) - 61.5%

b. Condition put on during the dry period

- efficiency of converting feed ME to body tissue - 60%
- efficiency of converting tissue ME to milk - 82%
- overall efficiency (feed->tissue->milk) 49%

2. Energy deficiency

A deficiency of energy in dairy cattle is usually due to limited feed intake or a ration which is too low in energy concentration. In growing heifers, an energy deficiency reduces the rate of gain and increases the age of the animal at either breeding or calving. Lactating cows respond to an energy deficiency by decreasing milk production and mobilizing body tissue reserves.

3. Excess energy intake

In general, excess energy intake results in an accumulation of body tissue or fat. Excessive energy feeding to dairy heifers may cause permanent damage to mammary development and may reduce fertility. Overconditioned cows are the result of excess energy intake. Fat cows have been reported to have the following problems:

- reduced fertility
- reduced milk production
- increased incidence of health problems such as ketosis and displaced abomasums
- reduced feed intake

In addition to the above problems, either underfeeding or overfeeding energy is expensive from an economic point of view.

Efficiency of Energy Utilization

The total daily energy requirements for a 1400 (635 kg) pound cow at different levels of milk production are in Figure 2. Note that the maintenance requirement is constant since the same bodyweight is assumed for all cows. The pregnancy requirement for the dry cow adds about 30% to the basal maintenance requirement. In addition, the total daily energy requirements are given for cows producing 40, 80 or 120 (18, 36 or 54 kg) pounds of milk with a fat test of 3.5%.

The relative efficiency of energy use for milk production can also be derived from Figure 2. The maintenance requirement, as a percent of the total daily requirement, is 45, 29 and 21% for cows producing 18, 36 or 54 kg of milk per day. Since the overhead (maintenance) cost is a smaller portion of the total for high producing cows, the potential profit is increased since more milk is produced per unit of feed consumed.

Energy Sources in Dairy Cattle Rations

The primary feed components from which the dairy cow derives energy are:

Type	Examples	Availability
1. Carbohydrates		
- sugars	Growing plant cells, molasses	Highly digestible
- starches	Primarily in grains as stored energy; corn, oats, barley, etc.	Highly digestible
- cellulose & hemicellulose	Structural portions of plants; legumes, grasses, corn silage	Partially digestible
- lignin	Cell wall of mature plants; mature alfalfa, straw	Almost indigestible
2. Fats	Concentrates energy source (2 1/4 times more than concentrates); tallow, soybean oil	High digestible in normal amounts

Figure 1. Scheme of Energy Utilization

Feed Energy (GE)

→ Fecal Energy
1. Feed Origin
2. Metabolic Origin

↓

Digestible Energy (DE)

→ Urinary Energy
1. Feed Origin
2. Endogenous Origin

→ Methane

↓

Metabolizable Energy (ME)

→ Heat Increment
1. Heat of Fermentation
2. Heat of Nutrient Metabolism

↓

Net Energy (NE)

NE_{m+p}

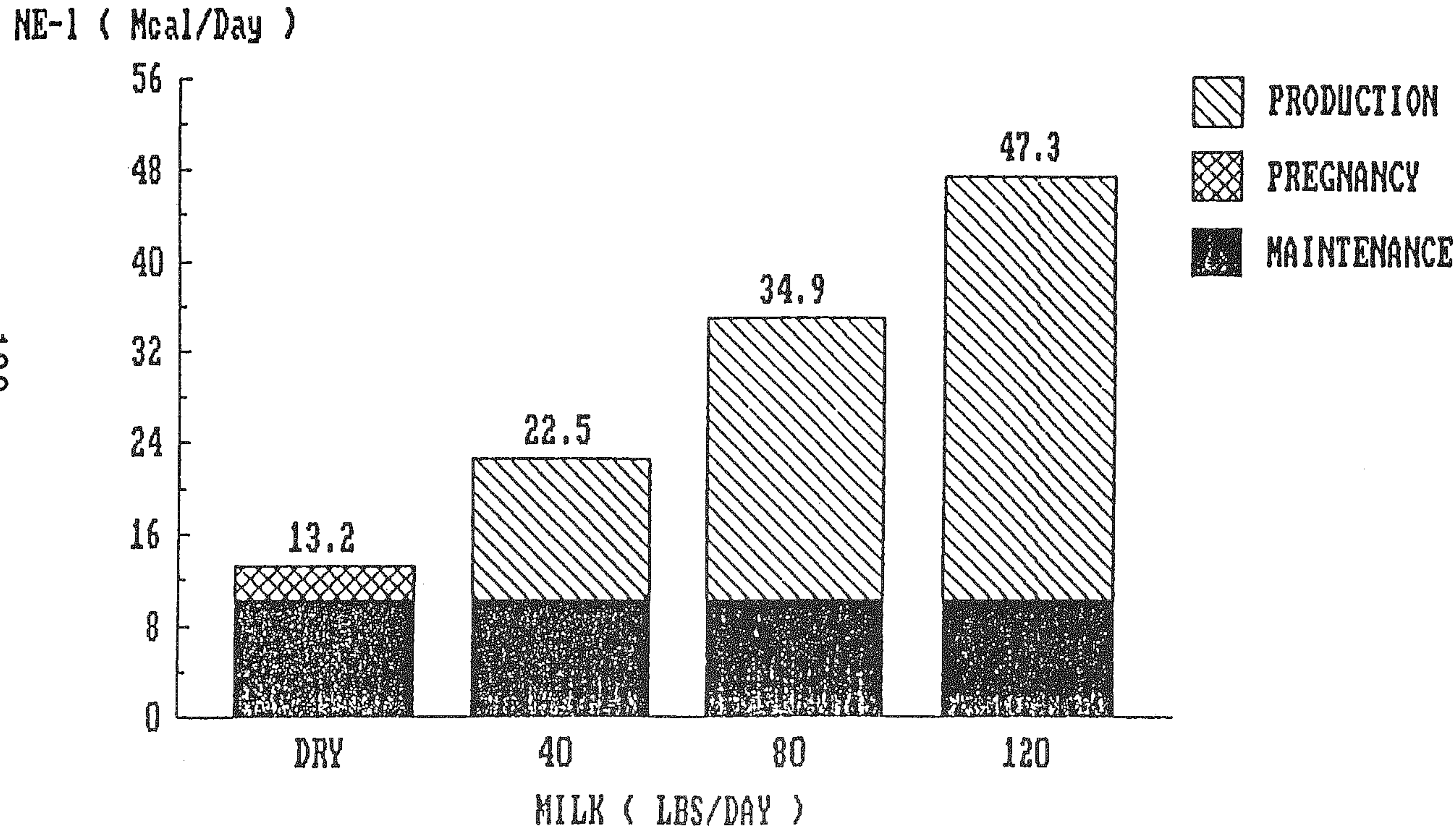
↙ NE_m

Fraction of total NE_{m+p} expended by the animal to keep in energy equilibrium; No gain or loss of weight
1. Basal Metabolism
2. Activity at Maintenance
3. Sustaining Body Temperature

↘ NE_p

Fraction of total NE_{m+p} available to the animal for productive use
1. Stored in <u>tissues</u>
   growth, fat, wool
2. Stored in <u>products</u>
   milk, fetus
3. Work

DAILY ENEREGY REQUIREMENTS
1400 LB COW



Balancing Rations for Carbohydrates for Dairy Cattle

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The management of carbohydrate feeding can have a great effect on herd performance. Imbalances cause a variety of problems. The author recently has observed various phenomena related to imbalanced carbohydrate rations with increasing frequency. These include

1. high-protein/low-fiber forages
2. low or fluctuating intake
3. low butterfat or high butterfat
4. increased feet and leg problems
5. large changes in body condition in early lactation
6. more corn in the manure
7. wet manure
8. no peak
9. no persistency
10. increased incidence of metabolic diseases
11. increased incidence of reproductive problems

In contrast, in some well-managed Holstein herds the herd averages 20,000+ lb of milk with a 3.8 to 4.0% fat test and 3.2 to 3.3% protein test. Common characteristics in these types of herds are

1. large-frame-size cows
2. good-quality forage
3. not much grain fed
4. forage particle size long
5. feedings many times per day
6. dry matter intake high and constant
7. cows peak high and persist (less than 10% drop/month)
8. small changes in body condition
9. low incidence of ketosis and displaced abomasum
10. few problems with reproductive performance

The central theme in these success stories appears to be that the carbohydrate feeding is managed well.

The dairy cow is a ruminant with a large microbial population in the rumen. The microbial population requires carbohydrates for growth, and these carbohydrates must be balanced or there can be a shift in the rumen population away from fiber digestion, causing some of the problems listed above. The challenge is to maintain the balance to ensure maximum fiber digestion while delivering maximum amounts of energy for milk synthesis.

Figure 1 outlines the important components of the carbohydrate. Broadley classified the carbohydrates in feeds into slowly digested fibers and rapidly digested nonfibers.[1]

Crude fiber is the current legal nomenclature for the fiber by which feeds are registered and guaranteed. Unfortunately, this definition of the total fiber in feed is completely inadequate in that all of the hemicellulose and part of the lignin are unaccounted for (Table I). Van Soest has developed improved methods for analyzing for the fiber in feeds.[1] He uses detergents to solubilize the nonfibrous fractions. Acid detergent fiber (ADF) is commonly known, so called because it is used to extract all of the cell solubles and hemicellulose (Figure 1 and Table I), leaving the cellulose and lignin. Although this is a significant improvement over crude fiber, it is not completely satisfactory. Van Soest meant ADF only to be an intermediate step in determining lignin and bound protein. The most appropriate value is neutral detergent fiber (NDF), which includes the hemicellulose. It can be seen from Table I and Figure 1 that the neutral detergent extracts cell solubles and the pectins that are associated with the cell wall. The solubilized carbohydrates are generally more rapidly digested than fiber in the rumen.

There are problems with the NDF procedure usually associated with feedstuffs high in starch. The original method has been modified to include an amylase enzyme to help solubilize the starch. Unfortunately, this has not resolved all of the problems. In many feedstuffs, it still is difficult to extract the starch. As technology develops, the

TABLE I

Detergent System

Fraction	*Chemical*	*Primary Digestant*
NDF	Neutral detergent	
Hemicellulose		Fiber bacteria
Cellulose		Fiber bacteria
Lignin		Unavailable
ADF	Acid detergent	
Cellulose		Fiber digesters
Lignin		Unavailable
Lignin	72% sulfuric acid	Unavailable
Solubles	Neutral detergent	Starch and sugar
Protein		Bacteria and protozoa
Lipid		
Minerals		
Starch		
Sugars		
Pectins		
Nonstructural carbohydrate and pectin	By calculation	

use of near infrared analysis will be more common—many analyses will be done in minutes. This method, however, depends on a good calibration set; and much work remains to be done on this aspect. For current purposes, it is suggested that book values be used for concentrate feeds (Table II) and NDF analyses on forages. Note the ranges in forage NDF analysis (Table III) and the ratios of ADF and lignin as a percentage of NDF (Table IV).

NDF is used as an indicator because studies at Rutgers, Pennsylvania State University, the University of Georgia, and the University of Wisconsin indicate that it is important to optimize NDF in a ration in order to maximize dry matter intake. Mertens' suggestions for NDF levels are presented in Table V.[2] This table illustrates the guidelines for both NDF and ADF.

NDF is used as the prime indicator instead of ADF basically for the following reasons:

1. The ratio of NDF and ADF in a feedstuff is not constant among feedstuffs (Tables III and IV).
2. NDF is a good estimate of the bulk of a diet.
3. A mat of large fibrous particles is required.

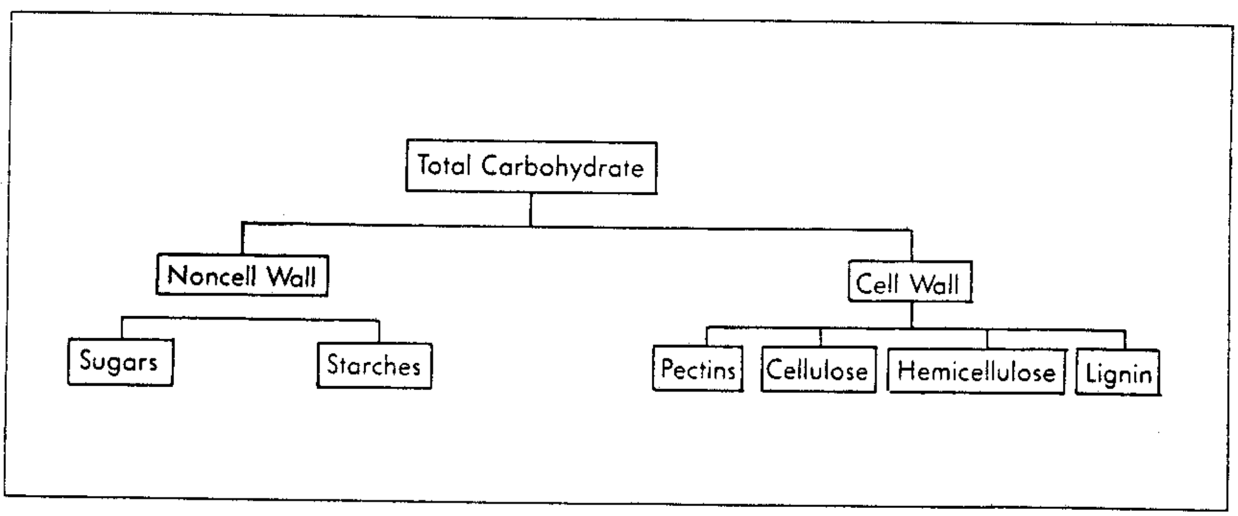

Figure 1—The components of the carbohydrate.

TABLE II

Carbohydrate Fractions of Selected Feedstuffs*

Feedstuff	Crude Protein (% DM)	Ether Extract (% DM)	Ash (% DM)	Total Carbohydrate† (% DM)	NDF (% DM)	NFC‡ (% DM)	TNC§ (% DM)
Forages							
Alfalfa hay, early vegetative	24.5	4.0	10.2	61.3	35.8	25.5	
Alfalfa hay, late vegetative	21.9	3.8	9.6	64.7	40.0	24.7	
Alfalfa hay, early bloom	19.6	3.4	9.2	67.8	43.7	24.1	
Alfalfa hay, mid bloom	17.6	2.6	9.1	70.7	46.9	23.8	
Grass hay, late vegetative	20.7	3.8	8.2	67.3	57.0	10.3	
Grass hay, prebloom	18.2	3.6	7.6	70.6	62.2	8.4	
Grass hay, early bloom	15.9	3.2	7.3	73.6	65.4	8.2	
Grass hay, mid bloom	13.9	3.1	7.1	75.9	67.2	8.7	
Corn silage, well eared	8.1	3.0	4.2	84.7	45.0	39.7	
Corn silage, few ears	8.4	3.1	4.5	84.0	55.0	29.0	
Concentrates							
Barley	11.9	1.5	2.9	83.7	28.3	55.4	
Beet pulp	9.7	0.6	5.4	84.3	54.0	30.3	10.6
Brewers grains	29.4	7.2	3.9	59.5	46.0	13.5	14.7
Citrus pulp	7.0	6.0	5.2	81.8	21.1	60.7	27.2
Corn and cob meal	9.0	3.7	1.9	85.4	26.0	59.4	
Corn distillers grains	29.6	10.6	5.0	54.8	42.5	12.3	11.5
Corn gluten feed	22.9	1.1	7.6	68.4	41.3	27.1	23.3
Corn gluten meal	65.9	2.4	3.4	28.3	14.0	14.3	18.4
Corn grain	10.9	4.3	1.5	83.3	9.0	74.3	73.8
Corn hominy feed	11.9	1.9	2.9	83.3	27.4	55.9	
Cottonseed meal	44.4	2.0	6.3	47.3	34.0	13.3	
Linseed meal	38.3	1.5	6.5	53.7	25.0	28.7	
Oats grain	15.6	2.1	3.0	79.3	32.2	47.1	56.8
Peanut meal	52.0	1.4	6.3	40.3	14.0	26.3	
Rapeseed meal	40.6	1.8	7.5	50.1		50.1	
Sorghum grain	12.4	3.1	2.0	82.5	8.7	73.8	
Soybeans	42.8	18.8	5.5	32.9		32.9	
Soybean meal (44% crude protein)	49.9	1.5	7.3	41.3	14.0	27.3	
Soybean meal (48% crude protein)	55.1	1.0	6.5	37.4	10.0	27.4	9.5
Soybean mill feed (hulls)	10.8	0.8	4.2	84.2	69.9	14.3	21.3
Sunflower meal	25.9	1.2	6.3	66.6	40.0	26.6	
Wheat grain	11.3	1.9	1.8	85.0	14.0	71.0	
Wheat bran	17.1	4.4	6.9	71.6	51.0	20.6	22.7
Wheat middlings	17.4	4.3	5.5	72.8	37.2	35.6	48.4

*From Mertens.[5]

†Total carbohydrate = 100 − crude protein − ether extract − ash. It contains some noncarbohydrate fractions such as lignin, cutin, and organic acids.

‡NFC = nonfiber carbohydrate. NFC = total carbohydrate − NDF.

§TNC = total nonstructural carbohydrate. This is determined by the method of Smith.[7]

4. Research at Georgia, Wisconsin, and Pennsylvania State University shows a correlation with intake.

Mertens recently indicated the importance of recognizing that the cow has a long-term energy requirement which impacts intake, and that as the energy density of the rations increases, dry matter intake will decrease.[3] In formulating diets for dairy cattle, fiber and forage should be maximized in the diet to minimize cost. These concepts are illustrated in Figures 2 and 3. Mertens demonstrates that these are unique solutions for maximizing intake for a given productivity level.[4]

As mentioned earlier, it is important that microbial balance in the rumen be maintained. To do that, it is necessary to maintain a minimum amount of fiber for the fiber digesters. The best way to estimate the minimum amount is by rumen volume, which is correlated with body weight. Mertens suggests that 1.2% of body weight be the maximum.[5] This number can be used instead of the numbers in Table V.

To expand on this concept, NDF is the slowly digested bulky component of the feed. Mertens found that when animals were fed diets ad libitum with different NDF contents, they consumed the dry matter to a daily NDF capac-

TABLE III

Protein and Fiber Composition of Forages (Mainly from New York State*)

Forage	Percent DM	Protein (% DM)	NDF (% DM)	ADF (% DM)	Hemicellulose (% DM)	Cellulose (% DM)	Lignin (% DM)
Legume haylage	56‡ 51-62	20 17-24	44 36-51	34 30-38	10 5-14	27 23-30	7.4 5.7-9.0
Legume silage	37 30-43	20 17-24	47 40-55	39 33-44	8.9 4.1-13.6	31 22-34	7.7 5.3-10.0
Mostly legume haylage	55 51-60	19 15-23	48 40-56	37 31-42	11.5 5.7-17.3	29 25-33	7.8 4.3-11.4
Mostly legume silage	35 27-42	17 13-22	52 45-59	39 35-42	13.4 7.8-18.9	32 20-35	6.8 5.4-8.3
Mostly grass haylage	59 52-65	15 11-18	54 46-62	38 34-43	15.7 10.8-21	31 27-34	7.7 5.5-9.9
Mostly grass silage	36 28-45	15 11-19	56 50-63	39 35-44	17.0 12-22	33 29-36	6.9 4.7-9.0
Grass silage	31 21-41	13 10-17	62 55-68	41 37-44	21 15-27	24 31-37	6.4 4.9-7.8
Corn silage	33 25-40	8.2 7.2-9.3	45 38-51	26 22-30	19 15-23	2.3 19-27	2.8 2.2-3.5

*Samples are from the New York Dairy Herd Cooperative Forage Testing Laboratory.
†Analysis was done by Robertson JB: Deptartment of Animal Science, Cornell University, 1984.
‡A mean of 1 standard deviation will fall within these values (the range indicated represents 67% of the samples received).

ity of 1.2% of body weight.[5] The cows studied were mature cows in mid lactation. (These concepts are graphically depicted in Figures 2 and 3.) Recent calculations by Mertens from a Brody study[6] show that growing dairy animals, first-calf heifers, and small second-calf heifers will eat NDF only to a capacity of 1.0% of body weight. Further calculations by Mertens suggest that dry cows and cows in early lactation might eat only to an NDF capacity of 0.8 to 1.0% of body weight. This is summarized in Table VI.

More research must be done to corroborate these numbers. The differences mean that forage quality and grouping animals by size can be most important in ration formulation considerations. It should be added that if dairy animals are small when they calve (undersized for expected calving weight for breed) and small as mature cows, the 3+ NDF capacities might be overestimated, suggesting that the second lactation numbers might be more appropriate.

Balancing rations for replacements is of extreme importance. Allowing heifers to achieve the genetic potential for their frame size will allow the formulation of rations containing maximum amounts of forage. If the NDF capacity of a group of animals is only 0.8 to 1.0% of body weight,

TABLE IV

Fiber Classification in Various Forage Types*

Forage	NDF (% DM)	ADF (% NDF)	Hemicellulose (% NDF)	Cellulose (% NDF)	Lignin (% NDF)
Legume silage	47	83.0	18.9	66.0	16.4
Mostly legume silage	52	75.0	25.7	61.5	13.1
Mostly grass silage	56	69.6	30.4	58.9	12.3
Grass silage	62	66.1	33.8	54.8	10.3
Corn silage	45	57.8	42.0	51.0	6.2

*From Robertson JB: Department of Animal Science, Cornell University, 1984.

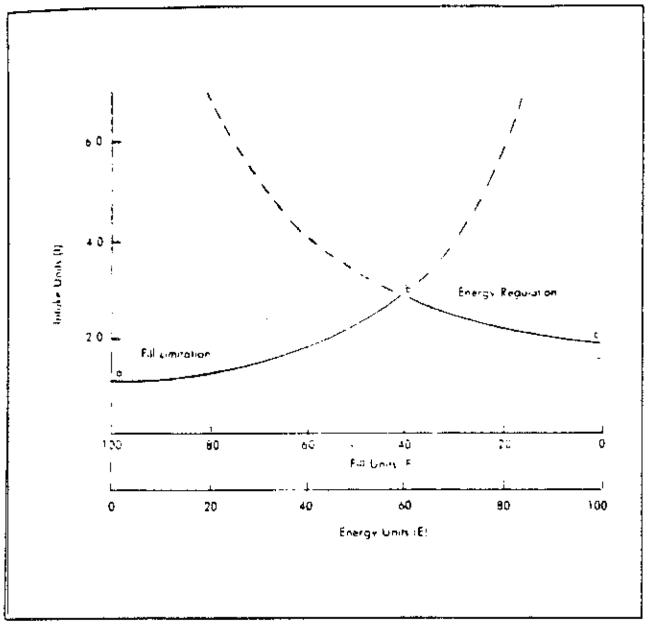

Figure 2—Illustration of the reciprocal nature of dietary characteristics on intake when I × F = C (constant capacity) along line a-b and I × E = R (energy requirement) along line b-c (From Mertens[4]).

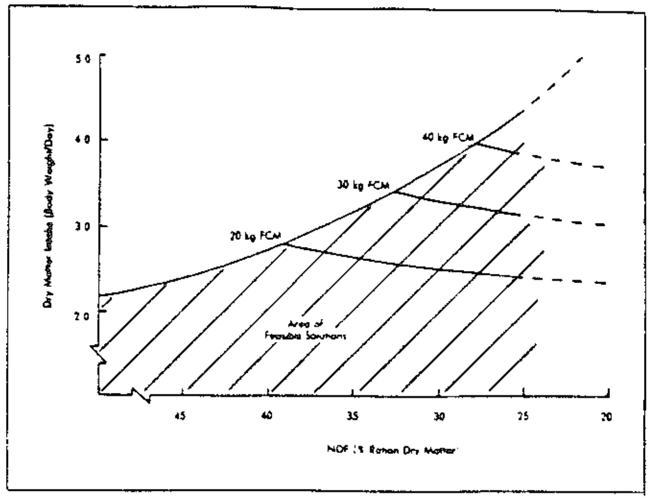

Figure 3—Theoretical equation solutions of dry matter intake for a 600-kg cow producing selected amounts of 4% fat corrected milk (FCM) showing that as the production level increases, the range of diets that can be formulated decreases. To obtain 75% of the fiber from forage, the NDF content of the forage must be below 40% to formulate rations for production in excess of 40 kg FCM. The minimum allowable NDF content of the total ration is assumed to be 25%. (From Mertens[4])

it will limit the total intake and will emphasize the importance of high-quality forages.

For example, if a group of early-lactation cows is 50% first-lactation animals and the rest an equal mixture of second, third, and more lactations, the average size in the group will be small. If the heifers are only 1100 lb and the others 1300 lb, the average weight for the group will be 1200 lb. If this group is only 50 days in milk, and a 55% NDF forage is being fed, the cows may have an NDF capacity of only 0.8 to 1.0% of body weight.

Some examples of formulating for NDF are presented in Tables VII and VIII. The types of problems that surface and also the problems that can be resolved can be seen from these. The main point that emerges is twofold: If NDF is balanced using high-quality forages, the nonprotein nitrogen level (protein solubility) in the ration will exceed that which can be adequately utilized by the bacteria. There are several possible solutions to this, none of which is totally adequate or suitable:

1. Partially substitute a high-NDF/lower-protein source such as grass haycrop silage or corn silage.
2. Feed several times each day and improve feeding strategy.
3. Decrease the protein degradability by substituting low-solubility/low-degradability protein sources (see Table VII).
4. Replace haycrop silage with hay.
5. Include some grass in the alfalfa mixture.

The examples demonstrate the importance of forage allocation and carbohydrate balancing to maintain the fiber bacteria in the rumen.

TABLE V

Optimal NDF and ADF Contents of Rations*

3.5% Milk Produced by 1320-lb cow (lb)	*Net Energy Lactation (Mcal/lb)*	*NDF (%)*	*AD (%*
<31	0.65	45	31
31–46	0.69	39	28
47–64	0.74	33	24
>64	0.79	27	21
Dry	0.61	49	34

*From Mertens.[2]

'These values correspond to National Research Council net energy recommendations.

There are two ways to calculate the NDF required in ration. The first is to use the values in Table V. For exam ple, cows producing over 64 lb of milk should have 28% of the dry matter as NDF. The NDF concentration is calcu lated by means used for other nutrient concentrations ex pressed as a percentage, using table values for the concer trates and analytical values for forages.

Another approach is to use an equation. The equatior which nearly fits the data in Table V, assuming the appro priate dry matter intake, is pounds of NDF = capacit Neutral Detergent Fiber Intake Capacity (NDFIC) = 0.011 × pounds body weight. (This can be used as an a erage or can be adjusted as shown above.) Examples are given in Table IX.

The estimated dry matter intakes should be close to accurate. This is one way of obtaining a quick estimate of dry matter intake. The other way is to use prediction equations for intake.

It should be borne in mind, as seen in Table II, that feeds like brewers have high NDF levels. This is small-particle feed. Forage NDF is what is needed.

NDF can be examined in another way. Mertens recommends that 70 to 75% of the total NDF consumed by the cow be from forage and the minimum total NDF in the ration be at least 25%.[5] This emphasizes an effective fiber. Mertens suggests that a method for measuring effective fiber be developed. The fraction of the particles retained on a 1.18 sieve may be a way of adjusting the NDF to an effective fiber in the feeds. This concept is illustrated in Table X.

TABLE VI
NDF Capacity as a Percentage of Body Weight

Animal	Lactation Number 0	1	2	3+
Growing	1.0	-	-	-
Dry cow*		0.8	0.9	1.0
Milking cow				
0–30 lb dry matter intake		0.85	0.95	1.05
30–60 lb dry matter intake		0.90	1.0	1.1
> 60 lb dry matter intake		1.0	1.1	1.2

*Starting lactation.

Nonfiber Carbohydrate

Finally, in balancing rations for carbohydrate (Table II), the nonfiber carbohydrate (NFC) must be examined. The NFC can be calculated by the following equations:

$$\text{Total carbohydrate} = 100 - \text{crude protein} - \text{ether extract} - \text{ash}$$

$$\text{NFC} = \text{total carbohydrate} - \text{NDF}$$

or

$$\text{NFC} = 100 - (\text{NDF} + \text{crude protein} + \text{ash} + \text{fat})$$

Note that total nonstructural carbohydrate measures the starch and sugars (Table II). NFC also includes pectins, which are found in feeds such as legumes, citrus pulp, and beet pulp. Pectins are rapidly digested.

Starches and sugar ferment very rapidly, mainly to propionic acid. If the starches and sugars are readily available, fermentation can change to lactic acid fermentation, which can lead quickly to acidosis and problems in cattle.

The recommendations for amounts of starch and sugars to be fed to cattle vary. Recommendations from The Netherlands are a maximum of 25% of the ration. Mertens suggests 1.1% of body weight as NFC, or about 30% of the ration dry matter as a maximum.[5] Others give 40 to 45% as maximum. A more logical approach might be to set a minimum and maximum for rations, and this maximum, as

TABLE VII
Rations for an Early-Lactation Cow* Formulated First on NDF and then on Protein

Forage Program	Balanced Forage: Concentrate DMI (%)	Forage (%)	NDF	Crude Protein	Soluble Protein**	Balanced for NDF Forage (%)	NDF	Crude Protein	Soluble Protein**
Alfalfa hay crop silage, high-moisture shelled corn, soybean meal	3.6	50	25.6	15.9	9.1(60)	66	39	16.2	11.1(68)
	4.0	50	25.8	14.5	7.4(51)	56	27.5	15.1	7.8(52)
Corn silage, high-moisture shelled corn, soybean meal	3.6	50	28.9	15.9	6.2(39)	53	30	15.9	5.6(35)
Grass silage, high-moisture shelled corn, soybean meal	3.6	50	37.2	15.9	6.6(41)	35	30	15.9	6.5(41)
Alfalfa hay crop silage (50)** Corn silage (50)** Soy/brewers, High-moisture shelled corn	3.6	50	31.1	15.9	6.4(40)	-	-	-	-

*1400 lb (based on producing 80 lb fat corrected milk; consuming 51 lb dry matter; and requiring 15.4 lb NDF (30% dry matter), 8.1 lb protein, and 40 Mcal net energy lactation.
**Numbers in parentheses represent % soluble protein.

TABLE VIII

Maximum, Minimum, and Recommended Percentages of Forages in Dairy Rations*

NDF (% DM)	Legumes (40% Forage in Ration DM)	Legumes (50% Forage in Ration DM)	Grasses (60% Forage in Ration DM)	Grasses (70% Forage in Ration DM)
1540-lb cow				
Maximum forage content (upper limit)†				
120 lb milk (3.5% fat)	54.2	39.1	-	-
100 lb milk (3.5% fat)	67.5‡	48.6	41.2	32.9
80 lb milk (3.5% fat)	83.9‡	60.3	51.6	41.0
60 lb milk (3.5% fat)	100.0‡	75.0‡	65.1	51.4
Recommended maximum forage content§				
120 lb milk (3.5% fat)	47.6	-	-	-
100 lb milk (3.5% fat)	60.3	43.5	36.7	29.4
80 lb milk (3.5% fat)	76.0	54.7	46.6	37.1
60 lb milk (3.5% fat)	96.3	68.9‖	59.5	47.1
Minimum forage content (lower limit)#	46.4	35.9	31.8	28.6
Expected milk production (lb/day)	121.8	116.3	112.0	102.3
1320-lb cow				
Maximum forage content (upper limit)†				
120 lb milk (3.5% fat)	43.2	-	-	-
100 lb milk (3.5% fat)	55.9	40.4	34.0	-
80 lb milk (3.5% fat)	72.0‡	51.8	44.0	31.5
60 lb milk (3.5% fat)	92.8‡	66.5‡	57.3	45.4
Recommended maximum forage content§				
120 lb milk (3.5% fat)	-	-	-	-
100 lb milk (3.5% fat)	49.3	-	-	-
80 lb milk (3.5% fat)	64.6	46.6	39.4	31.5
60 lb milk (3.5% fat)	84.6	60.7	52.0	41.3
Minimum forage content (lower limit)#	46.4	35.9	31.8	28.6
Expected milk production (lb/day)	103.9	99.6	95.6	87.6

*From Mertens.[5]

†Uses an NDF intake of 1.2% body weight/day and discounts net energy for level of intake. Some cows may be unable to maintain specified milk production levels when rations contain maximum forage.

‡Rations containing >65% forage may contain ruminally escapable protein or nonfiber carbohydrate inadequate for microbial protein synthesis.

§Assumes an NDF intake of 1.1% body weight/day and discounts net energy for level of intake.

‖Rations containing >65% forage should be fed with caution to ensure that nonfiber carbohydrate, protein, and mineral supplementation are adequate.

#To prevent milk fat depression and borderline ruminal acidosis, these rations may need supplementation with dietary buffers and/or high-fiber concentrates.

suggested by Mertens, is expressed as a percent of body weight. It would appear initially that the early lactation ration might be the one that should have constraints on it. The initial recommendation might be as follows: For a slow rate of NFC digestion, a minimum of 1.1% body weight and a maximum of 1.4%; for a medium rate of NFC digestion, a minimum of 1.0% body weight and a maximum of 1.1%; and for a rapid rate of NFC digestion, a minimum of 0.8% body weight and a maximum of 1.0%. The minimum is important to provide for microbial growth. The maximum will prevent acidosis.

It should be borne in mind that feeding management i: an important part of the carbohydrate feeding program Cows should be stimulated to consume feeds as evenly a possible. This means that if a herd is milked twice per da: with an early morning and late afternoon milking, the strat egy will be to regulate the eating pattern from early morn ing until 8 or 9 P.M. in the evening. The "quiet" time wil be after this until the morning milking. It is important t plan the feeding strategy around the milking and barn ac tivity times and to modify this depending on the source c carbohydrates and proteins.

Digestion of Carbohydrates

There are three major factors affecting digestion of carbohydrates in the rumen: carbohydrate availability (solubility, crystallinity, degree of lignification, and carbohydrate distribution); rumen protein and cofactor availability (the microbial mass requires ammonia, amino acids, iso acids, vitamins, and minerals) and passage (the rate at which material moves through the rumen to the lower tract). All types of carbohydrate are different, and it is a challenge to develop methods for assessing these variations. Carbohydrate availability is affected by many factors, mainly maturity, environment, processing, species, and feeding management. These are described below.

TABLE IX

Calculations of the NDF Required in the Ration

Cow Weight (lb)	NDF Intake	Dry Matter Intake (Pounds Production Level*) (64)	(41-64)	(31)
900	9.9	34	30	22
1000	11.0	39	33	24
1100	12.1	43	37	27
1200	13.2	47	40	29
1300	14.3	51	43	32
1400	15.4	55	47	34
1500	16.5	59	50	37
1600	17.6	63	53	39
1700	18.7	67	57	42

*Based on percent NDF in Table V (NDF intake 1.1% NDF).

Maturity

With forages, as the plant matures there is generally greater lignification of the cell wall and a decrease in rapidly available carbohydrate. Thus the rate of digestion, energy availability, and dry matter intake are reduced (Table XI).

With grains, as the grain matures a greater percentage of the carbohydrates (sugars) moves into storage carbohydrates, increasing energy density and reducing the rate of digestion.

Environment

Rainfall, soil temperature, fertility, and cloud cover all affect plant physiological response.

Processing

When particle size is reduced in processing, the result is an increased surface area. This allows more bacteria to attach to the starch.

Of particular importance in the grain industry, steam, extrusion, popping, and drying change the form of the starch and thus its availability.

During the ensiling process, the rapidly fermentable sugars are fermented to volatile fatty acids, leaving starches and cell wall. In extensive fermentations, some of the hemicellulose also may be fermented. Wetter materials are more rapidly fermented, and less carbohydrate is crystallized. Fermenting dry materials may result in increased heat, causing maillard reactions wherein the sugars and lignins condense with the protein.

TABLE X

Estimates of Roughage Value*†

Feed	Percent NDF Content	×	Fraction Retained on 1.18-mm Sieve	=	Roughage Value Unit
Standard	100		1.00		100.0
Grass hay	65		0.98		63.7
Legume hay	50		0.92		46.0
Legume silage, coarse chop	50		0.82		41.0
Legume silage, fine chop	50		0.67		33.5
Corn silage	51		0.81		41.5
Brewers grains	46		0.18		8.3
Corn, ground	9		0.48		4.3
Soybean meal	14		0.23		3.2
Soybean hulls	67		0.03		2.0
Rich mill feed	56		0.005		0.3

*From Mertens.[5]

†Estimates of roughage value assume that only NDF retained on sieves with 1.18-mm apertures contributes to chewing activity. This simple system also assumes that all fiber particle sizes above 1.18 mm yield the same chewing activity regardless of source or fragility.

TABLE XI

Digestion Kinetic Characteristics of Legume and Grass Forages Cut on the Same Date*

Forage	Days After Prebud	Stage of Maturity	Crude Protein (% DM)	NDF (% DM)	INDF† (% DM)	DNDF‡ (% DM)	DNDF Rate§ (per hour)
Legume hay	0	Prebud	24.5	35.8	14.9	20.9	0.103
Legume hay	7	Bud	21.9	40.0	17.4	22.6	0.098
Legume hay	14	Early bloom	19.6	43.7	19.8	23.9	0.093
Legume hay	21	Midbloom	17.6	46.9	22.1	24.8	0.088
Legume hay	28	Full bloom	16.0	49.5	24.4	25.1	0.082
Legume hay	35	Late bloom	14.6	51.6	26.6	25.0	0.077
Legume hay	42	Postbloom	13.6	53.2	28.7	24.5	0.071
Legume hay	49	Mature	12.9	54.2	30.7	23.5	0.066
Grass hay	0	Late vegetative	20.7	57.0	8.6	48.4	0.095
Grass hay	7	Prebloom	18.2	62.2	10.7	51.5	0.087
Grass hay	14	Early bloom	15.9	65.4	13.9	51.5	0.080
Grass hay	21	Mid bloom	13.9	67.2	17.7	49.5	0.073
Grass hay	28	Full bloom	12.0	68.0	22.0	46.0	0.066
Grass hay	35	Late bloom	10.5	68.5	26.4	42.1	0.061
Grass hay	42	Postbloom	9.3	69.0	30.5	38.5	0.056
Grass hay	49	Mature	8.3	69.8	34.0	35.8	0.051

*From Mertens:[5]
†INDF = indigestible NDF.
‡DNDF = digestible NDF.
§Rate of digestion of digestible NDF.

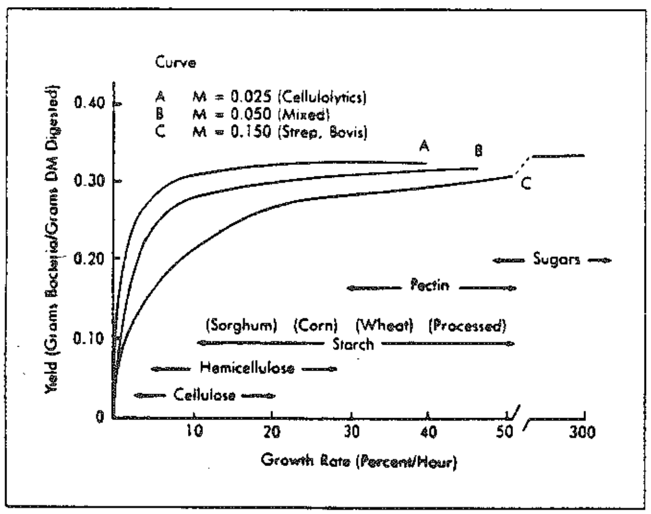

Figure 4—Effect of microbial growth rate on the yield of rumen bacteria from various feed components. These plots assume a 0.33 g bacteria/g organic matter fermented theoretical maximum yield for rumen bacteria. Three different maintenance energy coefficients (grams organic matter fermented/grams bacteria/hour) indicated as "M" are shown. The ranges of observed fermentation rates for various carbohydrates are given in the figure. While the maintenance cost of cellulolytics is low, the added advantage of this efficiency may be offset by poor-quality, slow-digesting sources. Quality of forage fiber is required to take advantage of the potential efficiency of cellulolytic bacteria. The same problems of quality also apply to sources of starch. Further limitations of certain substrates are shown in Figure 5.

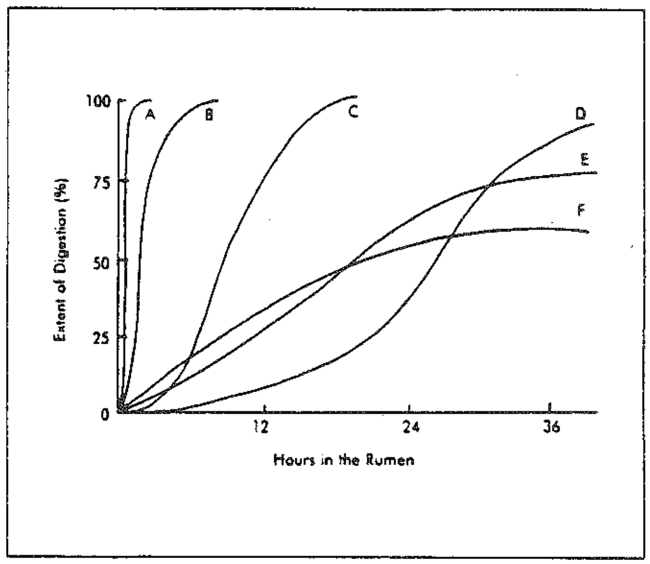

Figure 5—Effect of different rates of digestion upon cumulative extent and time. Curve A, soluble sugar, 300%/hour; Curve B, pectin, vegetable celluloses, and branched starches, 30-50%/hour; Curve C, more crystalline starch, 10-20%/hour (processing can have major effects on starch digestion); Curve D, crystalline cellulose 3-5%/hour with a 12-hour lag; Curve E, timothy cell wall 8%/hour; Curve F, alfalfa cell wall 12%/hour; Curves E and F asymptote at limited digestibilities due to lignification. Even though alfalfa is more lignified than grass, its cell wall digests at a faster rate and to a greater extent at early times than grass, crystalline starch, or cellulose.

Species

Forage

With legumes, NDF (cell wall) is rapidly fermented, as are the pectins and sugars. This yields high-lignin and less total carbohydrate available (Table XI).

With grasses, NDF is slowly fermented (more is available). Starches and sugars are rapidly fermented, especially corn silage high in starch (Table XI).

Grains

Carbohydrates in grains vary widely in terms of availability and rapidity of digestion in the rumen. Ranking from slow to fast are sorghum, corn, oats, barley, and wheat (Figures 4 and 5).

When the above factors are combined with the effects of rate of passage, it becomes quite complicated. First, as intake increases, feed particles move through the rumen at faster rates. The bacteria that digest fiber grow slowly, and thus at higher intake more of the fiber escapes digestion. Basically, it is a balance between rate of digestion and rate of passage. Reduced forage particle size can have devastating consequences. Not only is the escape of the fiber increased, but chewing time (eating and ruminating) is significantly reduced. It should be 10 to 11 hours/day; this will allow the production of adequate saliva and the natural buffering that is essential for the fiber bacteria and protozoa to survive. At least 10% of the particles must be over 1 inch long (Figure 5).

Finely ground or processed dry sorghum or corn increases digestibility: there is more surface area for bacteria and the particles are dense enough not to leave the rumen rapidly. The starch in high-moisture grains, however, ferments very rapidly, and thus the particle size must increase to where the corn is just cracked. Varieties within a species may have different rates. For example, waxy corn has more rapidly degraded starches than normal corn.

Feeding Management

As mentioned above, it can become important to feed more than once per day. This will reduce passage rate and even it out. In addition, if the cow has no feed or does not have access to it for any significant amount of time, there can still be surges of eating which could offset the positive aspects of increased feeding frequency.

The order of feeding also can become important. The rates of digestion should be sequenced in a manner that not only controls the fermentation but also provides saliva flow and a continuous stream of nutrients to the microbes and the cow.

Summary

The following recommendations are made for ration balancing:

1. Define the group of cows as to body weight and milk production and days in milk. Prorate the weight of heifers and cows.
2. Predict dry matter intake.
3. Use Table III or the NDF equation to determine the NDF required in the ration.
4. Balance for NDF
   a. Ensure that at least 75% of NDF comes from forage (discount NDF in concentrates of fine-particle feeds to less than 12% NDF).
   b. Check for protein balance and solubility.
      - Meet the NRC requirement for crude protein.
      - Check solubility (it should be 30 to 35% of the crude protein).
      - Try to have one-third of the total protein in early lactation from a mixture of oil seed protein and resistant proteins.
   c. If the constraints cannot be met, reformulate the ration with other forage fiber sources.
      - Some high-cell-wall by-products can replace about 25% of NDF (if forage particle length is adequate).
5. Check the energy concentration in the diet if it does not fall within the range of ±3 Mcal/day. Check dry matter intake calculations and other assumptions. Carefully study the starch and sugar sources. Balance with different sources and feeding management.
6. Balance minerals and vitamins.
7. Check the water.
8. Check the bunk management.
   a. Hours empty bunk
   b. Feeding frequency
   c. Feed sequencing
   d. Method of instituting change
9. After balancing and instituting a program, do the following:
   a. Measure milk volume by group if possible.
   b. Have each tank of milk checked at the milk plant for butterfat and observe changes.
   c. Observe the condition score change.
   d. Observe the manure condition change.
      - If the manure is wet, reduce degradable protein.
      - If the manure is dry, increase degradable protein.
      - If there is grain in the manure, check the particle size of the grain, feeding management, forage content of the ration, and protein fractions.
      - If there are long particles of forage in the manure, check forage particle size and rumen function parameters.
10. Adjust rations, bunk management, and degradability of carbohydrate.

There remains much to learn about balancing the carbohydrate in rations. We eventually will be balancing the degradability of the slowly and rapidly degrading carbohydrate and protein fractions. Balancing for NDF is a big step forward; there are many more to go.

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ADDED FAT IN DAIRY COW RATIONS

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ADDING FAT, an energy-rich nutrient source, to the diet of high-producing dairy cows can help maintain high milk yields by balancing the animal's energy intake and output.

If the diet does not provide sufficient nutrients, the energy demands of lactation force the animal to burn body fat, with weight losses of 2 to 3 pounds a day common during the first 100 days of lactation. If energy needs are not met, milk yields and fat tests will drop, ketosis may develop, and reproductive performance may decline.

Researchers at Ohio observed the following benefits from adding fat to the diet: (1) an increase in milk yield of 5 to 8 percent, (2) enhanced ability to meet energy needs while maintaining optimum levels of starch and fiber in the ration, and (3) greater metabolic efficiency (less energy needed to incorporate dietary fat directly into milk fat than if the cow synthesized fat from other feed sources).

FAT DIGESTION AND USE

Dietary fat begins to be broken down into usable form by two processes that occur in the rumen. First, the process of lipolysis splits the fat into free fatty acids and glycerol. Then the unsaturated fatty acids combine with hydrogen molecules (hydrogenation) to produce saturated fat.

Attached to bacteria and feed particles, the fatty acids enter the small intestine, where pancreatic juice and bile stabilize the fat particles. The fat can now be absorbed; and, in absorption, fatty acids are converted into triglycerides and incorporated into lipoproteins--forms that can be transported by the lymphatic system. In these forms, the absorbed fat can be used as an energy source by tissues, stored as body fat, or used in the synthesis of milk fat.

FAT SOURCES

Both animal fats and vegetable oils contain fatty acids and are comparable in energy value, but they differ in composition, affecting how the body is able to use the energy. The difference in form also affects their handling characteristics as feed additives. Most simply, however, at room temperature an oil is a liquid and a fat is a solid or semisolid.

Animal fats such as tallow and lard contain relatively large amounts of saturated fatty acids that are more efficiently used by dairy cattle than are unsaturated fats. Vegetable oils such as soy and corn contain unsaturated fatty acids that can alter production of volatile fatty acids (VFA) in the rumen and decrease fiber digestibility, which can lower fat test and feed utilization.

Protected fats contain fatty acids in forms that are unavailable in the rumen and that are digested in the small intestine. Vegetable oil that is coated with protein and treated with formaldehyde is an example of a protected fat that remains an insoluble complex in the rumen. After the formaldehyde-protein that covers the oil is broken down in the abomasum (fourth part of the stomach), the oil can be digested in the small intestine. The Food and Drug Administration has not approved formaldehyde-treated feed, but a protected-fat product that is an insoluble calcium salt is being tested. Similarly, fish oils are highly unsaturated and can lower fat test and rumen digestion, but these are not commonly used in the Midwest.

Adding 5 percent fat to a conventional grain mix (100 pounds per ton) or 10 to 20 percent to a protein supplement (200 to 400 pounds per ton) can supply extra calories to high-producing cows. To reduce the rancidity problem associated with feeding added fat, especially in the summer, feed whole oilseeds (Table 1), a fat source that is readily available in the Midwest.

Suggested feeding levels for oilseed supplements are listed below:

Raw soybeans .... 3 to 4 pounds per cow per day
Heat-treated soybeans ..... 5 to 6 pounds per cow per day
Whole cottonseed .... 6 to 7 pounds per cow per day
Sunflower seed .... 2 to 3 pounds per cow per day
Rapeseed .... 2 to 3 pounds per cow per day

Although researchers at Nebraska have used whole soybeans as an added fat source, heat treatment of soybeans and cottonseeds decreases rumen degradation of protein, increases protein digestion by destroying trypsin inhibitors, and slows enzymatic rancidity. Wisconsin researchers reported that extruded soybeans are 10 percent lower in protein degradability than raw or unprocessed soybeans.

COST FACTORS

Both cost and handling characteristics should be considered when adding fat to dairy rations.

Although animal fat usually costs less than vegetable oils, tallow and grease prices vary from 15 to 30 cents per pound—considerably higher than corn prices. But because fat contains 2.25 times as much energy as corn, it can cost

Table 1. Nutrient Value of Selected Oilseeds, Expressed on a Dry Basis

Type of seed	Crude protein	Fat	Total digestible nutrients (TDN)	Calcium	Phosphorus	Acid detergent fiber
	percent					
Soybean	41	20	94 (0.99)[a]	.28	.66	11
Cottonseed	25	25	98 (1.04)[a]	.15	.73	29
Sunflower						
Oil type	19	42	...	.17	.52	...
Confectionery	24	25	82	.17	.52	33

[a]Values in parenthesis are megacalories of net energy-lactation per pound of dry matter.

2.25 times as much as corn and be a cost-equivalent energy source. For example, if corn costs 6 cents per pound and supplies 0.92 megacalories of energy, the break-even price for fat is 13.5 cents per pound.

To figure the value of oilseeds, use Morisson feed constants, given here for soybeans and cottonseed:

	Energy constant	Protein constant
Soybean seed	.352	.746
Cottonseed	.656	.303

To use these values, multiply the energy constant by the price of 100 pounds of shelled corn, multiply the protein constant by the price of 100 pounds of soybean meal, and add these values together. If you can purchase 100 pounds of oilseed for less than this calculated price, it is a good buy as an energy and protein source when compared with corn and soybean meal. And, because additional protein, fiber, and minerals are also added when oilseeds are fed, their cost per pound of fat is usually more economical.

Spray-dried fat products have excellent flow characteristcs and blend easily with conventional dry grain mixtures. These fat products contain from 40 to 80 percent fat and range in price from 40 to 80 cents per pound. To calculate the cost per pound of added fat, divide the price per pound by the level of fat. For example, if an additive that contains 80 percent fat costs 60 cents per pound, the cost per pound of fat is 75 cents.

If fat is added to commercial grain mixtures or protein supplements, estimate the value of the grain source and subtract that cost from the cost of the fat added to the commercial grain. For example, if wheat midds cost $5 and the feed costs $6.50 per 100 pounds, the difference is $1.50. Therefore, if 3 percent fat was added to the feed, the dairy producer is paying 50 cents per pound for the fat.

To summarize, check feed tags carefully and figure the cost-benefit ratio for fat sources. Add fat to the feed of the top group of cows or topdress it to high-producing cows. If you feed extra fat to all cows, you lose the economic advantage because low producers can gain excess weight in late lactation.

MANAGEMENT CONSIDERATIONS

In a high-producing cow, about 5 percent fat in the ration dry matter should produce optimum results. Because most forages contain 2 to 3 percent ether extract, which is 80 percent fat, the recommended 5 percent fat can be reached by adding one pound of fat, which makes up 2 to 3 percent of the ration dry matter.

In early lactation, a high-yielding cow that is producing over 70 pounds of 4 percent fat-corrected milk will show the greatest response to added fat in the ration. During this phase, through approximately 120 days after calving, body fat is heavily utilized and energy demands remain high. At this time, one pound of supplemented fat—which replaces 2 to 3 pounds of grain—can supply the energy needed to produce 7 pounds of milk.

When fat is added to dry rations, several other adjustments to the ration may be needed:

1. Feed adequate amounts of fiber to maintain rumen digestion; check forage level and form in the ration.
2. Maintain higher levels of calcium, 0.8 to 1.0 percent, and magnesium, 0.25 to 0.30 percent, in the total ration dry matter because they can form soaplike products with the fat, thus lowering their availability as nutrients.
3. Add 1 percent of a low rumen degradable protein source for each 3 percent additional fat in the ration dry matter. Because fat does not influence energy levels in the rumen, supplemental protein must be made available to the cow itself rather than to the microbes in the rumen.
4. Gradually increase the fat in the ration, allowing 2 to 3 weeks to reach recommended levels. To avoid a decline in milk production, remove the fat gradually because abrupt withdrawal can alter feed acceptability.

MILK COMPOSITION

In some studies, adding fat to dairy rations lowered the level of both solids-not-fat and milk protein (casein). Dairy producers selling milk on a protein basis should be aware of this possible effect, but any changes in milk protein level should be small if recommended levels of fat and adequate fiber are fed. When extra fat is added, milk fat tests may increase from 0.2 to 0.3 percent. Milk fat tests increase if energy was limiting, if more circulating blood lipid was provided, or if a lower percentage of grain was fed when fat was added. Sometimes, though, no change in fat test occurs because the fat level would have dropped without the increased fat in the ration. However, if the ration is low in dietary fiber level or form, adding fat can lower fat test results from 0.5 to 1 percent.

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Body Condition Scoring: A Useful Tool for Dairy Herd Management

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Recent research and field experience indicate that body condition (degree of fattening) can influence a dairy cow's production, reproduction, and health. This fact sheet describes a system for monitoring body condition and provides recommendations for optimum body condition scores at various stages of lactation.

The Importance of Body Condition

Almost everyone is familiar with the "fat cow syndrome" and all the problems that can accompany it: calving problems, milk fever, retained placentas, metritis, ketosis, displaced abomasum, and downer cow syndrome. Most of these problems can be avoided if cows are fed balanced late-lactation and dry-cow rations and calve at an optimum body condition. Fat cow syndrome results from cows being overfed during late lactation and (or) the dry period when their energy requirements are very low.

On the other hand, a cow must calve with adequate body condition so that she can "milk some fat off her back." The reason for this is simple. During early lactation, milk production increases at a faster rate than feed intake. As a result the cow uses more energy to produce milk than she is taking in through the feed, creating a condition known as *negative energy balance.* The cow responds to this negative energy balance by using her stored fat as an energy source in an attempt to meet the energy requirement for producing large quantities of milk. If she calves in an underconditioned state, she will not have this fat reserve to call on for extra energy; and consequently, she may not produce to her genetic potential.

Recent research at Cornell indicates that changes in body condition after calving are also important. Rapid loss of body condition has been associated with a higher incidence of metabolic disorders and impaired reproductive performance such as a delay in the onset of heat cycles after calving. This rapid loss of condition may also be related to the development of fatty liver, a condition that has been associated with decreased fertility and an increased incidence of health disorders. Thus, it is important for the dairy farmer to strike a balance between allowing cows to be too fat or too thin at calving and also to monitor body condition changes after calving. A body condition scoring system has been developed to aid in achieving this balance.

Body Condition Scoring System

The scoring system currently being used at Cornell was originally developed in Scotland and recently modified to its present form by E. E. Wildman of the University of Vermont. The system is based on feeling the back and hindquarters of the cow to determine the amount of tissue covering these areas. Particular attention is given to the loin, rump, tail head, hook, and pin bone regions (figs. 1 and 2). All these areas must be considered for each cow, because using one or two alone can be misleading. For accurate scoring, cows must be standing on a level surface. Visual appraisal must be minimized, and frame size, stage of lactation, milk production, and health status must be ignored for accurate scoring. Reserve the use of these factors to help interpret what the scores mean.

Cows are scored on a scale of 1 to 5. A score of 1 indicates severe underconditioning; a score of 5 is assigned to overconditioned, obese cows. Pluses and minuses can be added to refine the system.

Condition score 1. Individual short ribs have limited flesh covering. Bones of the chine, loin, and rump regions of the backbone are prominent. The hook and pin bones are sharp with almost no flesh covering, and there are deep depressions between the hook and pin bones. The area below the tail head and between the pin bones is severely depressed causing the bone structure of the area to appear extremely sharp and the ligaments and vulva to be prominent.

Condition score 2. Individual short ribs can be felt, but are not prominent. The ends of the ribs are sharp to touch, but have greater flesh covering. The short ribs do

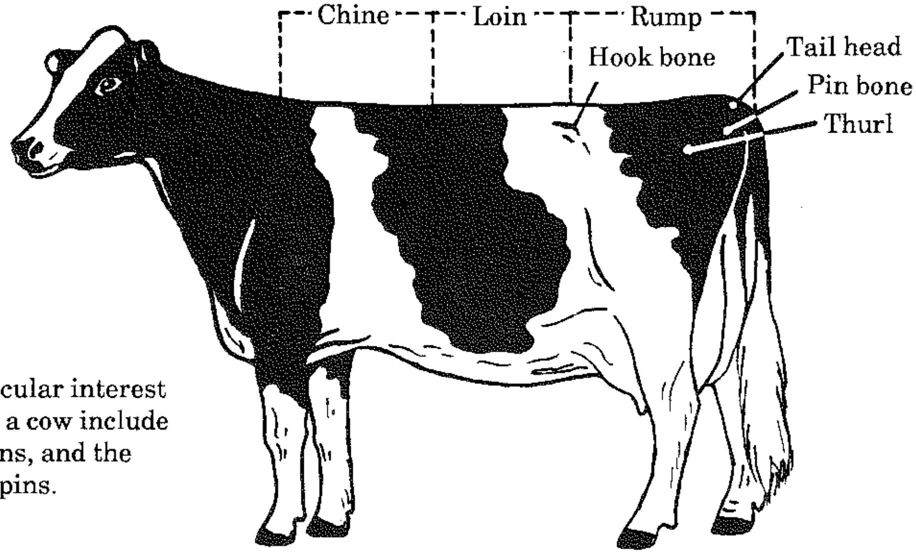

Figure 1. The areas of particular interest when body condition scoring a cow include the loin, backbone, hooks, pins, and the area between the hooks and pins.

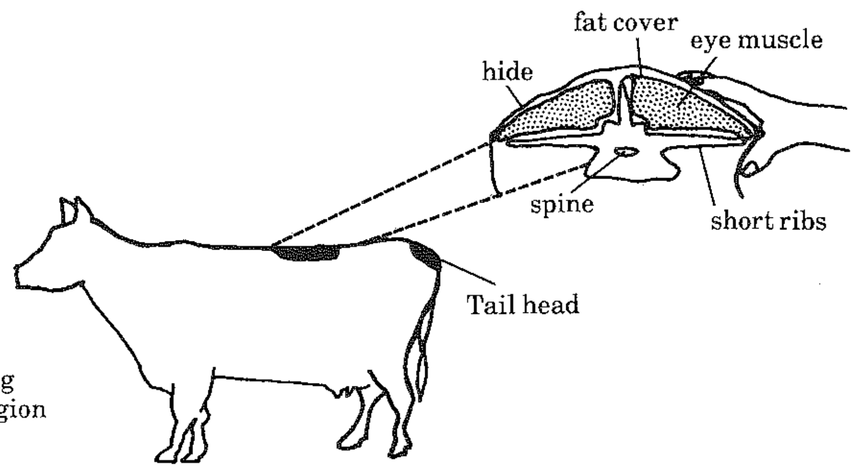

Figure 2. The amount of flesh covering the bony structures such as the loin region is estimated by palpation.

not have as distinct an overhanging shelf effect. The individual bones of the chine, loin, and rump regions of the backbone are not visually distinct, but are easily distinguished by touching them. The hook and pin bones are prominent, but the depression between them is less severe. The area below the tail head and between the pin bones is somewhat depressed, but the bone structure has some flesh covering. See figure 3.

Condition score 3. Short ribs can be felt by applying slight pressure. Together, the short ribs appear smooth and the overhanging shelf effect is not noticeable. The backbone appears as a rounded ridge, with firm pressure being necessary to feel individual bones. The hook and pin bones are rounded and smooth. The area between the pin bones and around the tail head appears smooth without signs of fat deposition. See figure 4.

Condition score 4. The individual short ribs are distinguishable only by firm palpation. The short ribs appear flat or rounded with no overhanging shelf effect. The ridge formed by the backbone in the chine region is rounded and smooth. The loin and rump regions appear flat. The hooks are rounded, and the span between the hooks is flat. The area around the tail head and the pin bones is rounded, with evidence of fat deposition. See figure 5.

Condition score 5. The bone structure of the backbone, short ribs, and hook and pin bone region is not apparent, and subcutaneous fat deposits are very evident. The tail head appears buried in fatty tissue.

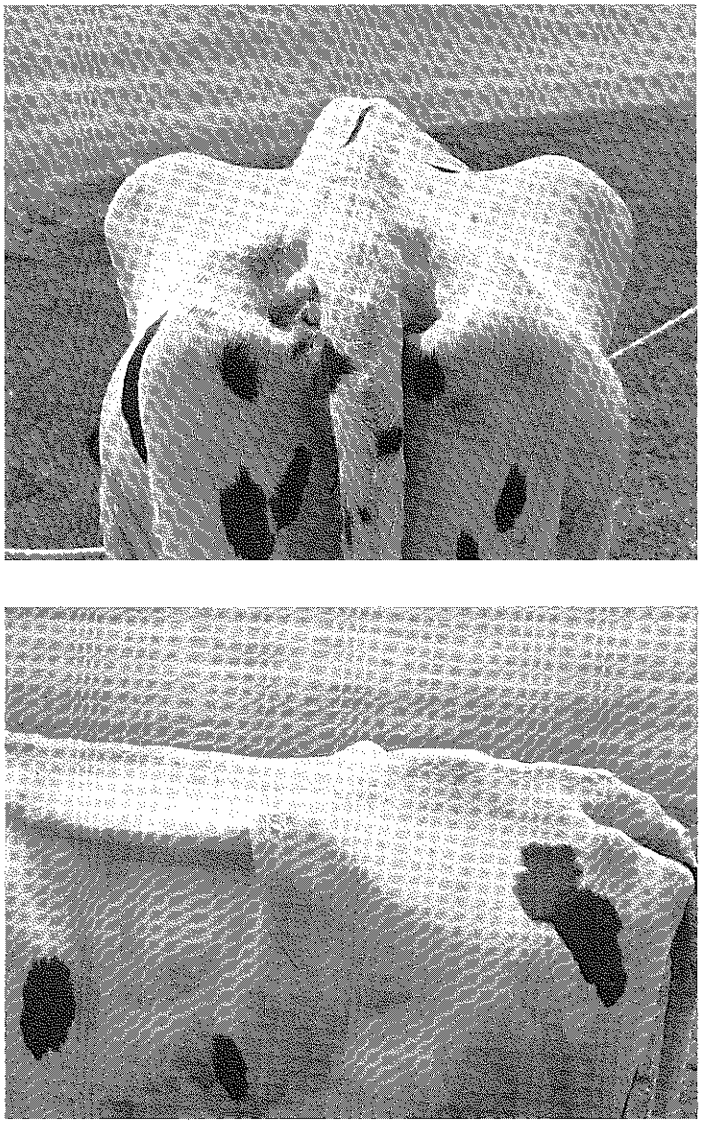

Figure 3. Thin cow resulting from extreme negative energy balance. Condition score 2.

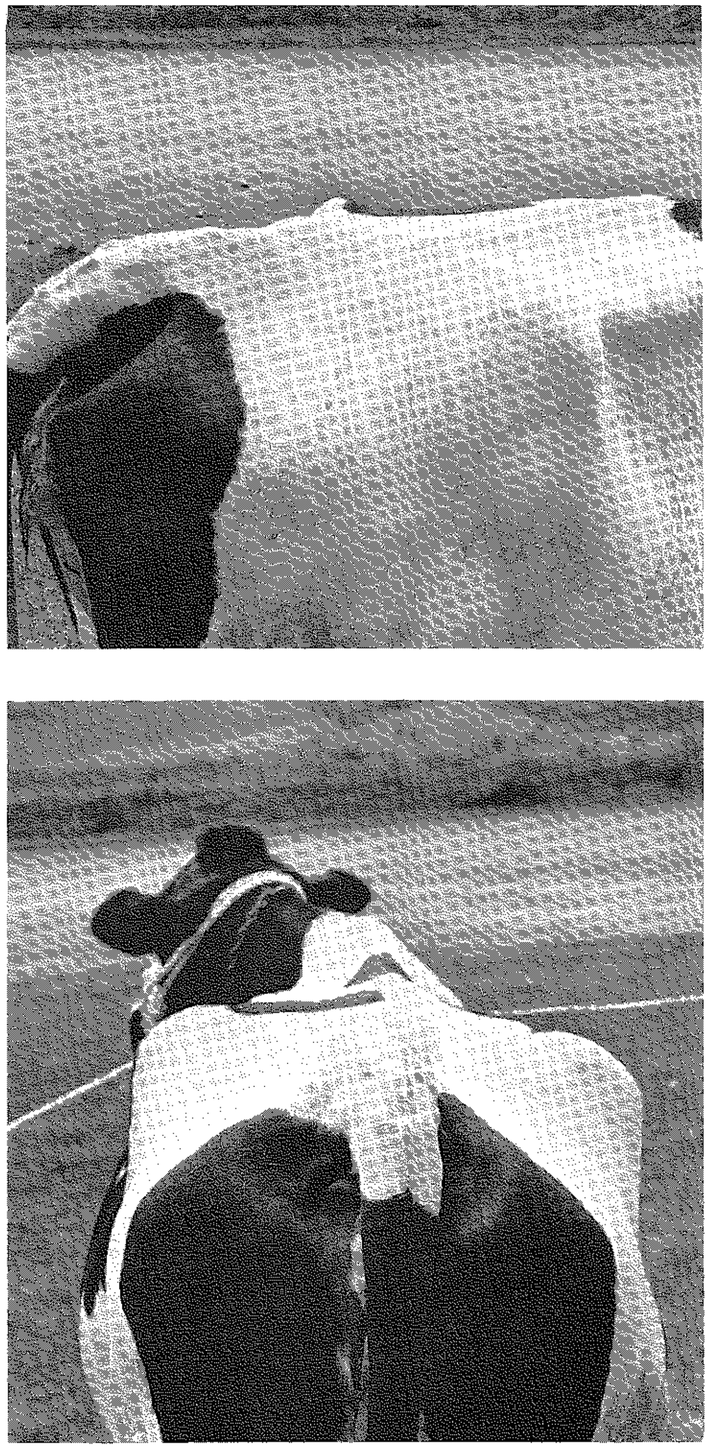

Figure 4. A healthy, high-producing cow in good body condition. Condition score 3.

"Typical" Body Condition Scores

As a guide to learning the scoring system and interpreting the results, examples of "typical" condition scores are listed. There will be a range of condition within each score; so it is sometimes convenient to assign +'s and -'s or talk of "high 2" or "low 3" scores.

Score 1	Skin and bones.
Score 2 to 2^- (low 2)	Severe negative energy balance in an early-lactation cow. A problem exists or may be developing.
Score 2^+ (high 2)	High-producing, early-lactation cow.
Score 3	Milking cow in good nutrient balance.

Score 3^+ to 4^-	Late lactation and dry cow in good condition.
Score 4	Overconditioned; an inefficient milk producer if milking and a potential problem at calving if dry.
Score 5	Severe overconditioning; a candidate for fat cow syndrome.

Using this system, dairy farmers can score cows on a regular basis as an aid in fine-tuning rations, determining group changes, maximizing milk production, and preventing health and reproductive problems. Fact Sheet 151.00 describes specific applications of the system and gives recommendations for optimum scores at various stages of lactation.

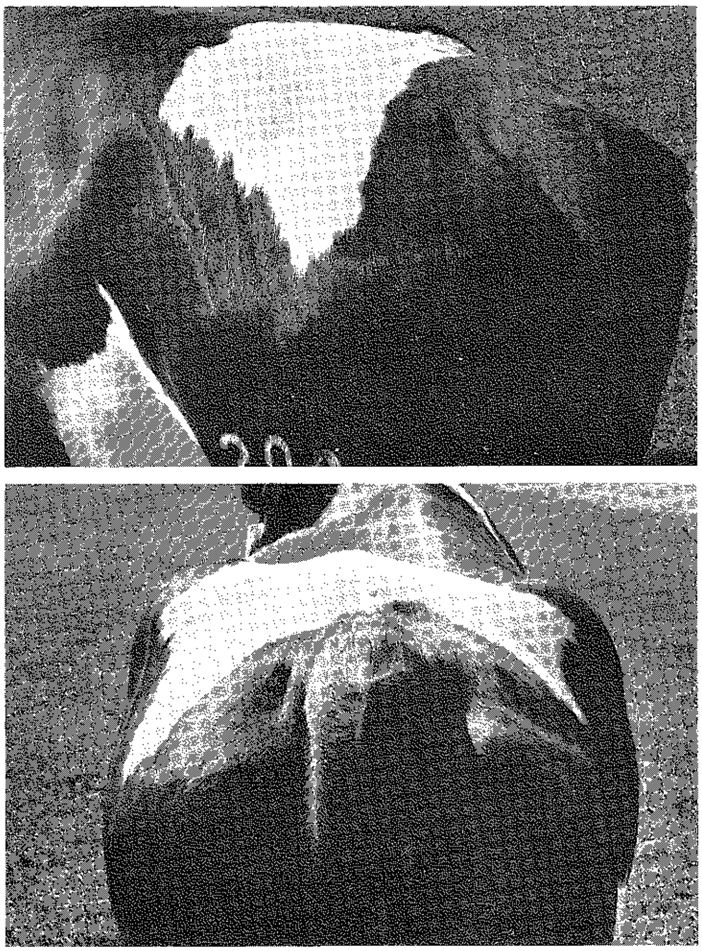

Figure 5. A moderately overconditioned dry cow. Condition score 4.

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DAIRY HEALTH
Body Condition Scoring
Fact Sheet
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DAIRY MANAGEMENT

CORNELL COOPERATIVE EXTENSION

Troubleshooting Your Herd with the Body Condition Scoring System

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Dept. of Animal Science
Cornell University

The body condition scoring system described in Fact Sheet 150.00 can be used as a tool for monitoring body condition changes in your herd and for fine-tuning rations or making group changes. To accomplish this, cows must be scored on a regular basis, and records must be kept so that body condition score patterns can be observed over a period of months. A sample scoring sheet is attached to this publication.

The cows should be divided into four groups for scoring: early lactation (up to 90 days), mid-lactation (90 to 180 days), late lactation (180 days to dryoff), and dry. We recommend scoring all cows at freshening and as many cows as possible on a monthly basis during lactation. If your herd is so large that you cannot score all the cows in each lactation group, score at least 20 cows in each group so that you can score a representative sample. Make sure you score a representative sample. Include first, second, and third and later lactation cows. Take care to score cows that have just entered the group as well as those that have been in the group for several weeks. In dry groups, score cows that have recently entered the dry group and those that are nearing the end of their dry periods.

It takes less than one minute to score each cow; the time commitment is minimal. Calculate an average score for each scoring group and compare it with the recommendations given here. If the average score for a group is very far from the recommended score, perhaps a change in ration balancing or feeding strategy should be considered. Of course, there will be a range of scores due to individual cow variation. If the range within a lactation group is very broad (more than one condition score unit), adjustments should be made in the way the cows at the fringes of the range are being fed or grouped.

The following outline gives target scores for each stage of lactation and also provides hints for troubleshooting rations and feeding strategies. The suggested targets are applicable to most herds that are milked twice daily. There is some indication, however, that in high-producing herds milked three times daily, recommended scores at dryoff, during the dry period, and at calving should be one step higher (4- to 4, instead of 3+ to 4-). Make these adjustments if herd performance suggests they are needed. Note, however, that scores greater than 4 are **never** recommended.

Cows at Calving

A. Recommended scores: 3+ to 4-

B. Nutritional objective: to allow cows to calve with adequate, but not excessive, body fat reserves.

C. Red flags

1. Scores below 3+
   a) Cows have received inadequate energy during late lactation and/or the dry period. Failure to replenish energy reserves will limit milk production during the upcoming lactation.
2. Scores above 4-
   a) Energy intakes were too high during late lactation and/or the dry period.
   b) Separate dry cows from the milking herd and feed them a low-energy ration containing adequate, but not excessive, protein, minerals, and vitamins.

Early Lactation

A. Recommended scores: 3- to 3

B. Nutritional objective: maximize intake of a high-energy ration so that body-condition changes and negative energy balance will be minimized.

Ration must contain adequate protein to support peak milk production.

C. Red flags
  1. Scores below 3-
     a) Very high producers may drop to 2+ and are not a problem.
     b) Thin cows that are not high producers are not getting enough energy. Be sure that all nutrients are balanced properly and that dry matter intake and water intake are adequate.
  2. Cows show good body condition (3 to 3+), but production does not peak as high as expected.
     a) Check for inadequate protein, mineral, or water intake.

Mid-Lactation

A. Recommended score: 3

B. Nutritional objective: To maintain body condition in 3 range and maximize milk production

C. Red flags
  1. Scores below 3
     a) Cows are receiving inadequate energy. Check early lactation ration, because problem probably began there.
  2. Scores above 3+
     a) Reduce energy intake to avoid overconditioning and fat cow problems.

Late Lactation

A. Recommended score: 3
  1. Aim for 3+ to 4- at time of dryoff.

B. Nutritional objectives
  1. Replenish energy (fat) reserves to prepare cow for next lactation.
  2. Avoid overconditioning.

C. Red flags
  1. Scores below 3+ at dryoff.
     a) Cows are receiving inadequate energy. Check to see that early- and mid-lactation groups are receiving enough energy, because problem may have begun there.
     b) In high-producing herds and those milked 3 times daily, a change in grouping strategy may be required. Keep cows in mid-lactation groups or feed rations formulated for mid-lactation levels of production for longer periods of time to allow them to replenish reserves.
  2. Scores above 4- at dryoff.
     a) Reduce energy intake during late lactation.

Dry

A. Recommended scores: 3+ to 4-

B. Nutritional objectives
  1. Maintain body condition in recommended range.
  2. Feed low-energy ration that provides adequate, but not excessive, amounts of protein, vitamins, and minerals.

C. Red flags
  1. Scores below 3+
     a) Increase energy intake. Inadequate body-fat reserves can decrease milk production in upcoming lactation.
     b) Increase energy content of late-lactation ration. Body fat reserves should be replaced at that time.
  2. Scores above 4-
     a) Reduce energy intake of dry cows while maintaining adequate levels of protein, vitamins, and minerals.
     b) Reduce energy intake of late-lactation cows, because the problem may have begun there.

Remember, the important goals should be to allow cows to develop adequate, but not excessive, body condition during late lactation and the dry period and to maintain adequate energy intake during early lactation so that milk production is maximized and body condition loss is minimized.

Keep written records of body condition scores, so that average condition scores for each group of cows can be calculated and so that you can refer back to a particular set of condition scores at a later date. A sample score sheet has been included as an aid in record-keeping. Keep your score sheets in a separate notebook, by group, so that you can compare the scores over time.

Cornell University—Body Condition Score Report **Stage of Lactation Group*** ______________

Date__________ Date__________ Date__________ Date__________ Date__________

Cow Name/Number	Score	Cow Name/Number	Score	Cow Name/Number	Score	Cow Name/Number	Score	Cow Name/Number	Score
Average score									
Range									

* Fresh, early, mid, late, or dry

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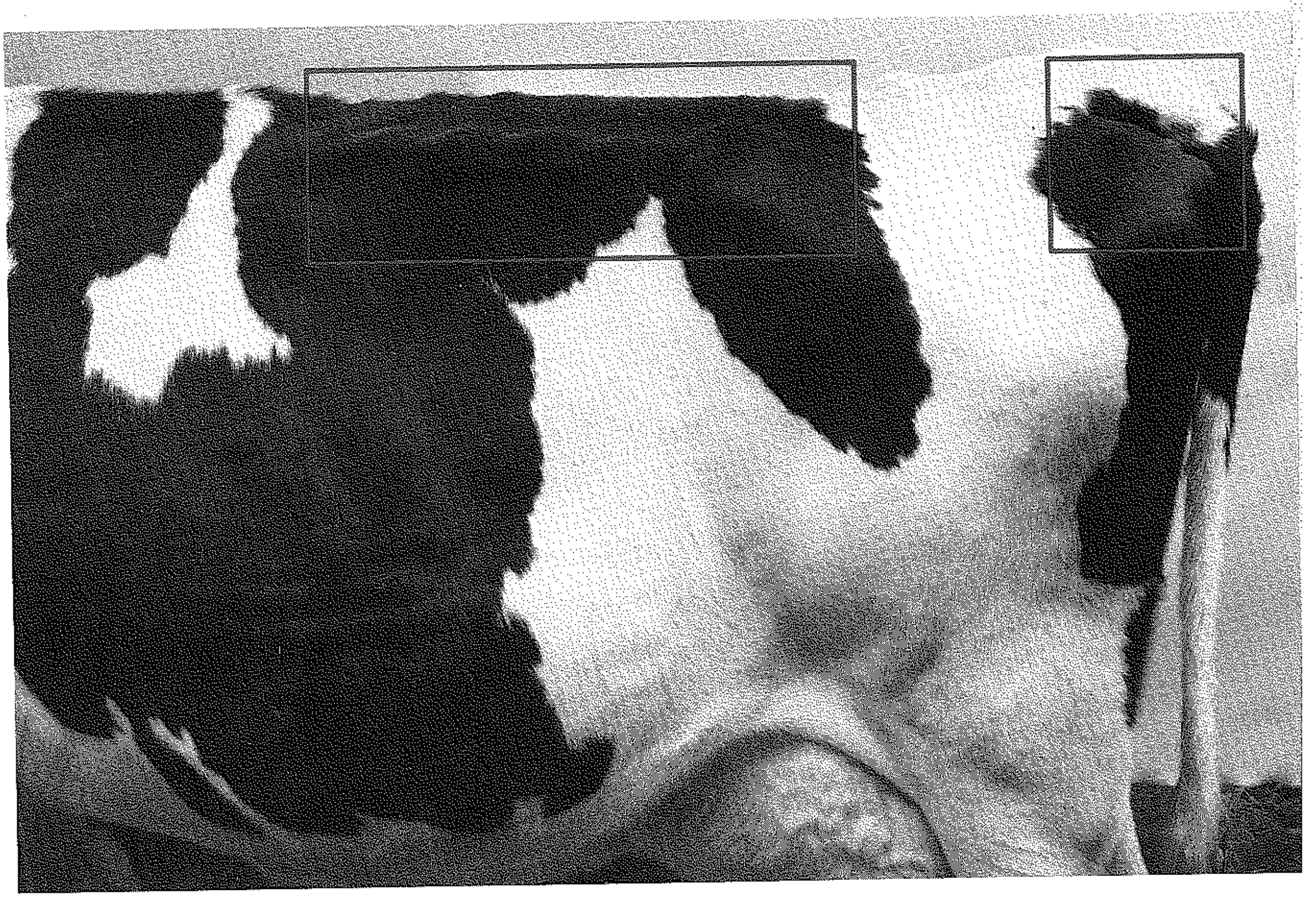
Body-Condition Scoring as a Tool for Dairy Herd Management

College of Agriculture
Cooperative Extension

Extension Circular 363



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Introduction

Body-condition scoring is a method of evaluating fatness or thinness in cows according to a five-point scale and using the score to fine-tune dairy herd nutrition and health. Research and field experiments have shown that body condition influences productivity, reproduction, health, and longevity. Thinness or fatness can be a clue to underlying nutritional deficiencies, health problems, or improper herd management. If done on a regular basis, body-condition scoring can be used to troubleshoot problems and improve the health and productivity of the dairy herd.

Overconditioning, or fatness, may result from poor nutrition or reproduction management. A fat cow is more susceptible to metabolic problems and infections and is more likely to have difficulty at calving. Overconditioning usually begins during the last three to four months of lactation, when milk production has decreased, but grain and total nutrient levels have not been reduced accordingly. Other causes of overconditioning are prolonged dry periods or overfeeding during dry periods.

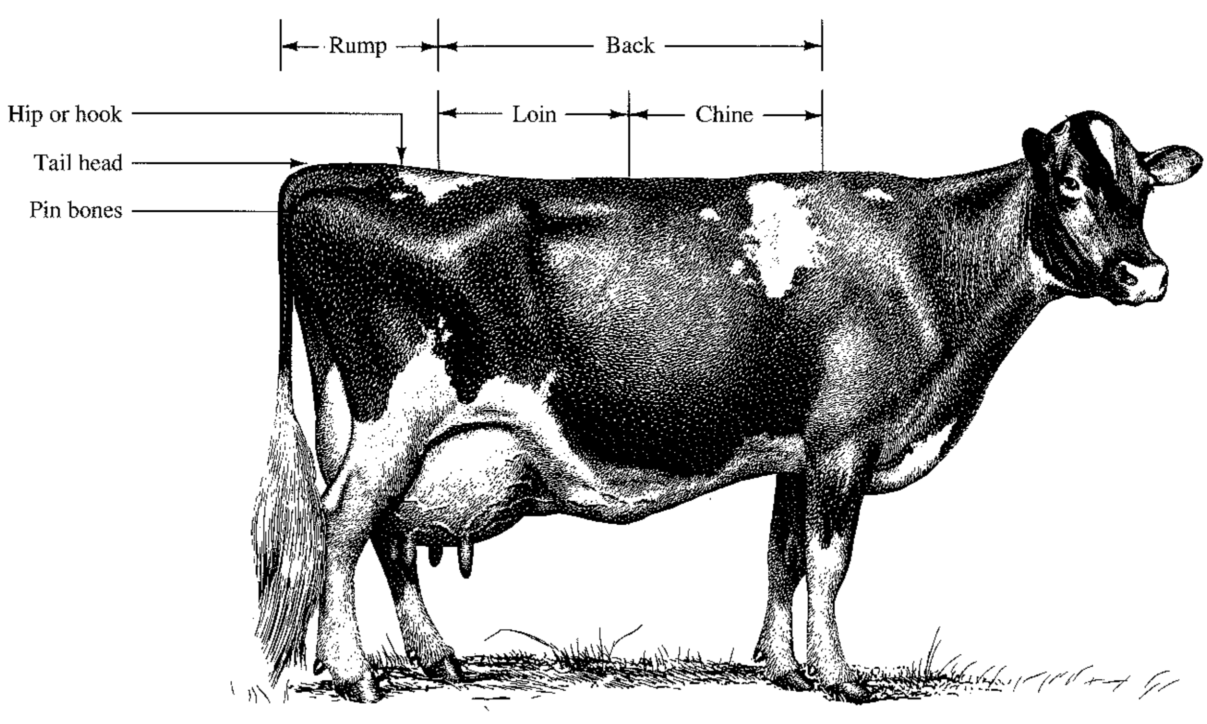
Underconditioning, or thinness, can frequently lower production and milkfat levels because of insufficient energy and protein reserves. Thin cows often do not show heat or conceive until they start to regain—or at least maintain—body weight. In feeding these animals, care must be taken to maintain production while increasing body reserves.

Body-condition scoring is also useful in dairy heifer feeding management. Thin heifers may not grow rapidly enough to reach puberty by 13–15 months of age. They may also be too small to calve at 23–25 months or to carry enough weight to maintain a normal first lactation. On the other hand, fat heifers have been shown to produce less milk when they enter the milking herd, especially if they have been fat at puberty.

Body-Condition Scoring Scale

On a five-point scale, a score of 1 denotes a very thin cow, while 5 denotes an excessively fat cow. These are extreme scores and should be avoided. The average, 3, is the most desirable for the majority of the herd. A score with a plus or minus indicates a borderline body condition.

For accurate scoring, both visual and tactile appraisals are necessary. The following diagram illustrates the dairy cow's major bone and muscle groups and shows the areas of concern in scoring.



Score of 1

- Individual short ribs have a thin covering of flesh.
- Bones of the chine, loin, and rump regions are prominent.
- Hook and pin bones protrude sharply, with a very thin covering of flesh and deep depressions between bones.
- Severe depression below tail head and between pin bones. Bony structure protrudes sharply, and ligaments and vulva are prominent.

Score of 2

- Individual short ribs can be felt but are not prominent.
- Ends of ribs are sharp to the touch but have a thicker covering of flesh.
- Short ribs do not have as distinct an "overhanging shelf" effect.
- Individual bones in the chine, loin, and rump regions are not visually distinct but are easily distinguished by touch.
- Hook and pin bones are prominent, but the depression between them is less severe.
- Area below tail head and between pin bones is somewhat depressed, but the bony structure has some covering of flesh.

Score of 3

- Short ribs can be felt by applying slight pressure.
- Altogether, short ribs appear smooth and the overhanging shelf effect is not so noticeable.
- The backbone appears as a rounded ridge; firm pressure is necessary to feel individual bones.
- Hook and pin bones are rounded and smooth.
- Area between pin bones and around tail head appears smooth, without signs of fat deposit.

Score of 4

- Individual short ribs are distinguishable only by firm palpation.
- Short ribs appear flat or rounded, with no overhanging shelf effect.
- Ridge formed by backbone in chine region is rounded and smooth.
- Loin and rump regions appear flat.
- Hooks are rounded and the span between them is flat.
- Area of tail head and pin bones is rounded, with evidence of fat deposit.

Score of 5

- Bony structures of backbone, short ribs, and hook and pin bones are not apparent; subcutaneous fat deposit very evident.
- Tail head appears to be buried in fatty tissue.

Related Research

Recent research demonstrates the relationship of body condition to health, reproduction, feed intake, and milk production. In a 1986 study at Cornell University, three groups of dry cows were monitored to determine the effect of body condition during the dry period on subsequent reproductive performance. Scores for the three groups represented typical below-average, average, and above-average body conditions for dry cows:

Group 1	3.7
Group 2	4.1
Group 3	4.5

Cows were monitored closely through the dry period and into the following lactation. It was found that Group 3 cows, the fattest, had a longer interval to first ovulation, a higher number of days to first heat and conception, and the lowest first-service conception rates (Table 1). For the farmer, these factors mean lost dollars.

Table 1. Effect of body condition in dry cows on subsequent reproductive performance.

	Group 1	Group 2	Group 3
Intervals between calving and			
▪ first ovulation (days)	27	31	42
▪ first heat (days)	48	41	62
▪ conception (days)	74	90	116
First-service conception rate	65%	53%	17%

Source: J. Dairy Sci. (Supplement 1), p. 245, 1986.

The study also showed that body condition affects dry-matter intake (Table 2). Of the three groups, fat cows had the lowest dry-matter intake. Although milk production appears unaffected by body condition, a lower dry-matter intake can lead to ketosis, a displaced abomasum, or other consequences of nutritional stress. Such problems are more common in fat cows because they must use more body fat to meet their energy needs. Body-fat mobilization, in turn, produces ketones and fatty acids, which can have damaging results. Ketones build up in the blood and, if not broken down rapidly, cause ketosis. Fatty acids in the blood aggravate the problem because they tend to reduce appetite.

Table 2. Effects of body condition on dry-matter intake and milk production.

	Group 1	Group 2	Group 3
Dry-matter intake (lb)	44.2	43.6	40.9
Daily milk production, first 14 weeks of lactation (lb)	63.1	66.2	67.1

Source: J. Dairy Sci. (Supplement 1), p. 245, 1986.

Researchers in England studied the effect of body condition at calving on dairy cow health. The study involved two groups of cows, one in desirable condition and the other overconditioned. As before, results showed a lower dry-matter intake among the fat group. Lower dry-matter intake is often the result of metabolic problems, and weight losses in fat cows following calving can set the stage for additional infections and noninfectious health problems. In fact, the fat group had more cases of disease than the desirable group (Table 3). An increase in metabolic problems—5 to 10 percent or more—is a signal to check body condition.

Table 3. Cases of disease recorded during lactation.

	Group[a]	
Disease	Desirable	Fat
Mastitis	3	11
Retained placenta	1	2
Endometritis	2	2
Cystic ovaries	0	1
Ketosis	2	5
Milk fever	1	2
Hypomagnesemia	0	1
Lameness	4	7
Total	13	33

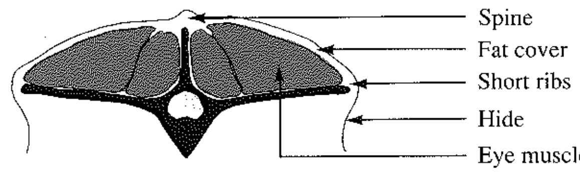
Source: Anim. Prod. 43, pp. 1–6, 1986.
[a]Each group consisted of nine cows.

How to Score for Body Condition

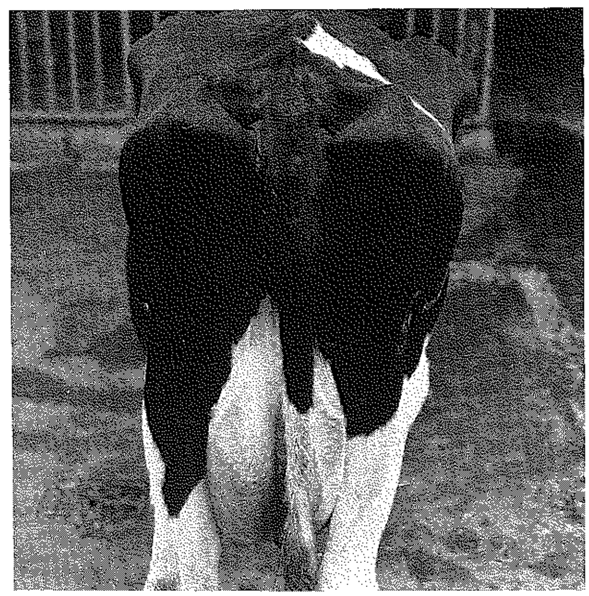
In scoring a cow, the areas to examine are the tail head and loin. The following cross-sectional views illustrate the lack or overabundance of fatty tissue for each score. Photographs of the tail head and loin show how these areas should look for each animal.

Score	1
Body condition	Very poor
Tail head	Deep cavity under tail and around tail head. Skin drawn tight over pelvis, with no tissue detectable in between.
Loin	No fatty tissue felt. Pins, hooks, and short ribs can be seen; edges feel sharp. Animal appears emaciated.

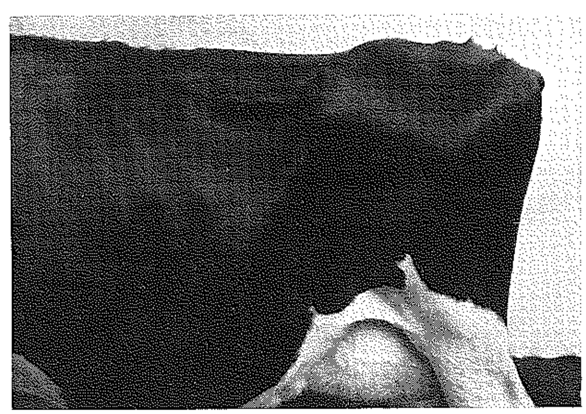
Cross-section, score 1



Back view, score 1

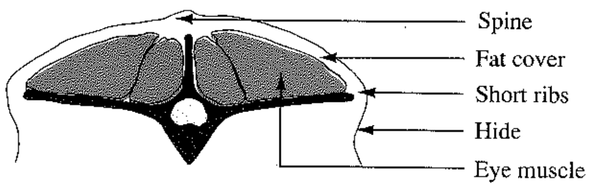


Side view, score 1

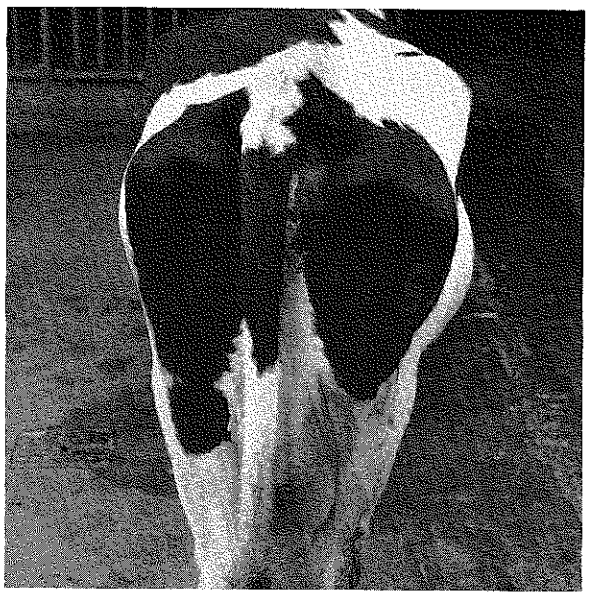


Score	**2**
Body condition	Poor
Tail head	Cavity evident around tail head but less prominent. No fatty tissue felt between skin and pelvis, but skin is supple.
Loin	Ends of short ribs are sharp to the touch, but individual ribs can no longer be seen. While bones are less prominent, they are still angular and can be easily distinguished by touch.

Cross-section, score 2



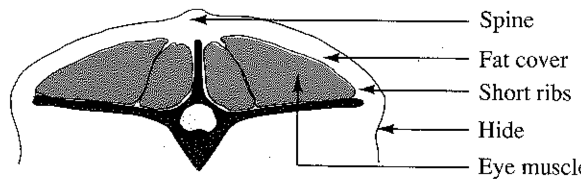
Back view, score 2



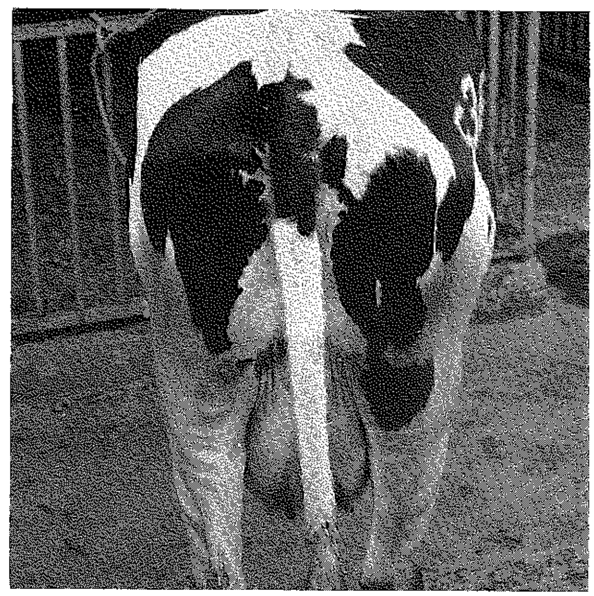
Side view, score 2

Score	**3**
Body condition	Good
Tail head	Slight cavity lined with fatty tissue apparent at tail head. Area between pins has smoothed out.
Loin	Ends of short ribs can be felt with moderate pressure. Slight depression visible in loin area. Hooks and pins can be felt but have some covering of flesh. Hook, pin, and back bones have lost angularity and appear smooth.

Cross-section, score 3



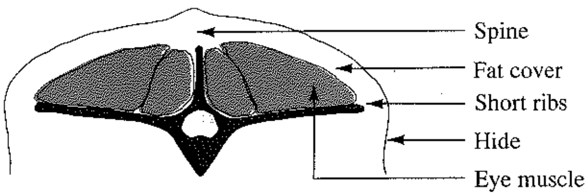
Back view, score 3



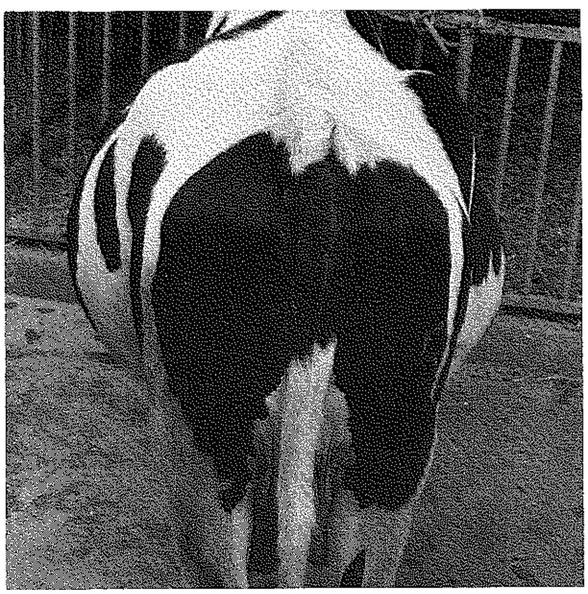
Side view, score 3

Score	**4**
Body condition	Fat
Tail head	Depression between pins and tail head filling in. Patches of fat apparent under skin. Pelvis felt only with firm pressure.
Loin	Short ribs cannot be felt even with firm pressure. No depression visible in loin between backbone and hip bones. Back and area between hooks and pins appear flat.

Cross-section, score 4



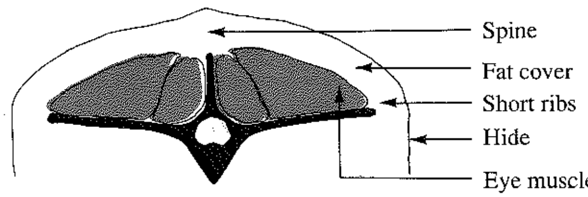
Back view, score 4



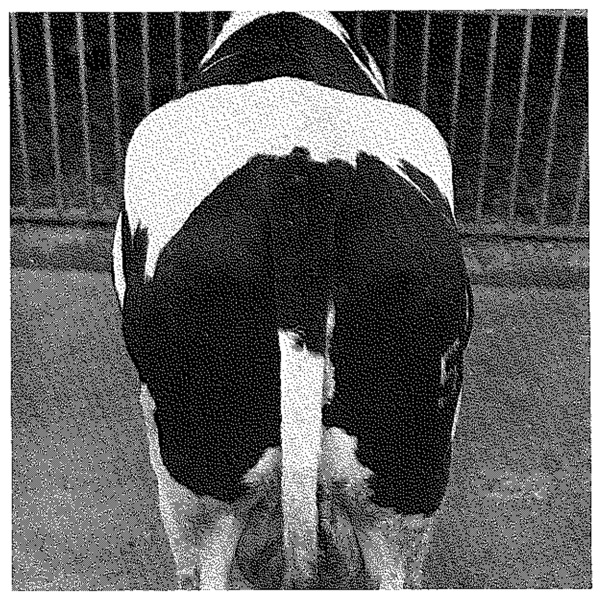
Side view, score 4

Score	**5**
Body condition	Grossly fat
Tail head	Tail head buried in fatty tissue. Area between pins and tailbone rounded, skin distended. No part of pelvis felt, even with firm pressure.
Loin	Folds of fatty tissue over short ribs. Bony structure cannot be felt. Hooks, pins, and backbone almost disappear.

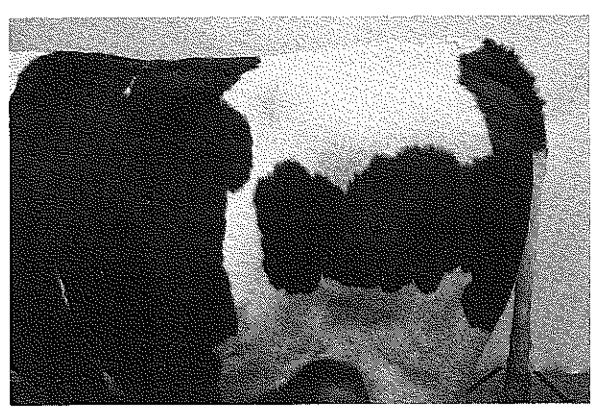
Cross-section, score 5



Back view, score 5



Side view, score 5



Target Scores for Stages of Lactation

Below are target scores for each stage of lactation and hints for troubleshooting by altering rations and feeding strategies.[1] Pluses and minuses indicate borderline body conditions.

Cows at Calving

Recommended score: 3+ to 4-

Nutritional objective:
Allow cows to calve with adequate, but not excessive, body-fat reserves.

Red flags:
- Scores below 3+ indicate that cows received an inadequate energy supply during late lactation and/or the dry period. Failure to replenish energy reserves will limit milk production during the upcoming lactation.
- Scores above 4- indicate that energy intake was too high during late lactation and/or the dry period. Separate dry cows from the milking herd and feed them a low-energy ration with adequate, but not excessive, protein, minerals, and vitamins.

Early Lactation

Recommended score: 3- to 3

Nutritional objective:
Maximize intake of a high-energy ration to minimize changes in body condition and counteract negative energy balance. Ration must contain adequate protein to support peak milk production.

Red flags:
- Scores below 3-

a. Very high producers may drop to 2+ and are not a problem.
b. Thin cows that are not high producers are not getting enough energy. Be sure that all nutrients are balanced properly and that dry-matter and water intakes are adequate.
- Cows have good body condition (3 to 3+), but production is not as high as expected. Check for inadequate intakes of protein, minerals, or water.

Mid-Lactation

Recommended score: 3

Nutritional objective:
Maintain body condition at this score to maximize milk production.

Red flags:
- Scores below 3 indicate that cows are receiving inadequate energy. Check early lactation ration, because problem began there.
- For scores above 3+, reduce energy intake to avoid overconditioning.

Late Lactation

Recommended score: 3
Aim for 3+ to 4- at time of dryoff.

Nutritional objectives:
- Replenish energy and fat reserves to prepare cow for next lactation.
- Avoid overconditioning.

Red flags:
- Scores below 3+ at dryoff mean cows are receiving inadequate energy. Check to see that early- and mid-lactation cows are receiving enough energy, since problem may have begun there.
- For scores above 4- at dryoff, reduce energy intake during late lactation.

Dry

Recommended score: 3+ to 4-

Nutritional objectives:
- Maintain body condition in recommended range.
- Feed low-energy ration that provides adequate, but not excessive, amounts of protein, vitamins, and minerals.

Red flags:
- Scores below 3+

a. Increase energy intake. Inadequate body-fat reserves can decrease milk production in upcoming lactation.
b. Increase energy content of late-lactation ration. Body-fat reserves should be replaced at that time.
- Scores above 4-

a. Reduce energy intake of dry cows while maintaining adequate levels of protein, vitamins, and minerals.
b. Reduce energy intake of late-lactation cows, because the problem may have begun there.

Heifers

Recommended score: 3- to 3+

Nutritional objectives:
- Maintain body condition in recommended range.
- Feed a balanced ration that provides adequate but not excessive amounts of energy, protein, vitamins, and minerals.

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1. Adapted from Perkins et al., *Body Condition Scoring,* New York Dairy Management Fact Sheet, 1985.

Red flags:

■ Scores below 3- may indicate a nutritional problem. If heifers are allowed to become too thin, they will not grow at the proper rate and may have reproductive problems later on.

■ Scores above 3+ have been shown to be associated with a greater fat infiltration in the mammary glands of heifers at puberty. When these heifers freshen, they will not produce to their full genetic potential.

Table 4 summarizes dairy cow body-condition scores and potential problems. By scoring cows on a regular basis, producers can adjust rations, determine group changes, maximize milk production, and prevent reproductive problems.

Table 4. Body-condition scores for dairy cows.

Score	Condition
1	Skin and bones.
2 to 2- (low 2)[a]	Severe negative energy balance in cow in early lactation. A problem either exists or may be developing.
2+ (high 2)[b]	High producer in early lactation.
3	Milking cow in good nutrient balance.
3+ to 4-[c]	Late lactation and dry cow in good condition.
4	Overconditioned; an inefficient milk producer; a cow with an extremely long lactation if milking and a potential calving problem if dry.
5	Severely overconditioned; a candidate for fat cow syndrome.

[a]Borderline 1. Indicates potential problem.
[b]Borderline 3.
[c]Borderline 4. Check your feeding program to avoid a future problem.

Troubleshooting

When metabolic problems occur because animals are not in proper condition, the first thing to check is the feeding program. The following nutritional checklist may help diagnose certain problems.

■ First, check dry-matter intake, especially of forage. Forage should account for at least 45 percent of a cow's total dry-matter intake. Check feeding sequences, fiber level, feeding frequency, and ration palatability. Problems in these areas are easily overlooked.

■ Second, check protein, energy, mineral, and vitamin levels by testing forage and balancing rations for each group of cows. Examine feed quality by checking forage and grain for fineness of chop or grind, smell, acceptability, and pH level. Check rations for amounts of bypass and soluble protein and for levels of starch, fats, and oils.

Once the cause of the problem has been determined, the next step is to keep it from reoccurring. Avoid rapid fluctuations in body condition. Pay close attention to cows during lactation, especially the later part, and during the dry period.

When large amounts of forage are consumed or if grain is not fed properly, animals may become overconditioned and are more susceptible to health problems. In dry-cow rations, these factors are more often overlooked.

To keep dry cows in proper condition, feed a daily hay-equivalent intake of 1.8–2.0 pounds per hundred pounds of body weight. This is the minimum intake of forage, and it should be maintained even in times of a forage shortage or high forage prices. Some long, dry hay should be incorporated into the diet, especially if silage or haylage is being fed. A complete ration of forages and grain for dry cows should be between 85 and 88 percent forage dry matter. If necessary, control feed intake to hold dry-matter intake to 2 percent of body weight.

The main objective during the dry period is to get the animal properly conditioned, starting in the previous three to four months of lactation. Once the cow is dry, her condition should be maintained through a balanced feeding program so that she freshens in good condition. Upon entering the milking herd, a cow can lose from 100 to 150 pounds during the first 60-80 days (1-2 pounds per day), but a weight loss of 3-4 pounds per day may lead to metabolic disorders. A cow should start replenishing her fat reserves 80-120 days after calving, at .75-1.0 pounds per day. (A few cows, about 5-10 percent, either never put on much flesh or usually tend to be obese.) Proper conditioning, then, can be accomplished by body-condition scoring, paying close attention to the animals, and ensuring that their nutrient requirements are being met, but not exceeded.

Summary

Research demonstrates that a cow's body condition relates to the animal's overall performance and that body-condition scoring can be an important tool in dairy herd management. In scoring a cow, the tail head and loin are the major areas to evaluate. Target scores help determine what condition to aim for during the different stages of lactation. If done on a regular basis, body-condition scoring can improve dairy herd nutrition, health, and production.

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An Ounce of Prevention: Dry Cow Feeding Management

By: Mary Beth Rymph

The dry period is often viewed as down time for a cow, but it is actually the start of her next lactation and should be treated as such. The goals of dry cow management are:

1. To maintain the cow and meet the needs of her growing calf;
2. To keep the cow in good health;
3. To prepare the cow for her next lactation.

Close attention to the dry cow is critical as both neglect and excess can lead to a number of metabolic disorders at calving and during early lactation. The impact of these problems on herd productivity can be quite serious, but generally, they can be easily prevented.

The first task in the effort to meet dry cow goals is to separate the dry cows from the milking herd. A milking cow's diet is far from balanced for a dry cow (Table 1). Dry cows mixed with lactating cows place limitations on the milk cows as they compete for feed and space. Whether they are relocated to stalls at one end of a tie stall barn, to another barn, or to a dry group in a free stall barn, separating dry cows from milkers is essential. Separation does not mean forgetting. They must still be observed and fed a well balanced diet.

Proper dry cow body condition is critical in its effect on production in the next lactation. It usually is not possible to meet a fresh cow's energy needs for production solely from dietary sources, so it is vital that cows have adequate energy stores of their own to draw upon. Cows should enter the dry period with the same body condition desired at freshening. Drying a cow off with a body condition score of 3+ to 4- and maintaining that condition during the dry period will help minimize the metabolic problems that can result from excessive condition gains or losses during the dry period.

Table 1. Comparison of dry cow ration nutrient levels as filled by diets balanced for levels of 3.8% butterfat milk production. *

	Ration Milk Support Levels					
	50 lb.		70 lb.		90 lb.****	
Dry Cow Nutrients Consumed	lb.	%DCR**	lb.	%DCR	lb.	%DCR
Dry Matter***	23.4	100%	23.4	100%	23.4	100%
Crude Protein	3.6	128%	3.8	137%	4.0	143%
NEL, Mcal	16.4	132%	17.3	139%	18.2	147%
Calcium	0.145	153%	0.152	160%	0.172	181%
Phosphorus	0.093	162%	0.097	170%	0.109	190%

* Milking rations balanced for a mature 1300 lb. cow, based on 1989 NRC recommendations using 110% of mineral recommendations (typical in field situations).

** Percent of dry cow recommendations.

*** NOTE: Estimated dry cow Dry Matter Intake in the table is 1.8% of body weight for a 1300 lb. cow. When dry cows have access to milking cow rations, they may consume considerably more DMI. This would further accentuate the imbalance of nutrients consumed by the dry cow relative to her requirements.

**** It may be difficult to practically balance a ration for energy at this production level.

Late lactation is the time to add restore condition because a lactating cow is approximately 27% more efficient at converting feed energy to body tissue than is a dry cow. To gain 1 pound of body tissue, a lactating cow would have to consume the metabolizable energy from 2.6 pounds of corn meal, while a dry cow would have to consume the energy from 3.3 pounds of corn meal. That's just 7-tenths of a pound of corn. However, one pound of a cow's tissue energy reserve equals about 7 pounds of milk and a cow may lose 100 pounds of body condition in the first 60 days of lactation to support milk production. By restoring on body condition in late lactation, the equivalent feed cost of 70 pounds of corn is saved through improved efficiency. Production is more cheaply bought by putting body weight on a lactating cow than on a dry cow.

Balance is the key to a healthy dry cow ration. No particular grains, forages or minerals are outlawed. The feeds need only be fed in amounts that will meet but not drastically exceed the cow's requirements. Frequently, these requirements are discussed in terms of percentages -- 12% crude protein, 0.40% calcium, etc., but cows eat pounds, not percentages (Table 2). For percentages to work, cows must consume the predicted amount of dry matter. If animals consume more or less dry matter, overfeeding or underfeeding of nutrients will result. Periodically, the dry cows' feeds should be weighed and dry matter intake calculated: **(Pounds of Feed Consumed x % Dry Matter)/Number of Dry Cows.** The ration can then be formulated to ensure that the pounds of nutrients the dry cows require are getting to them in a package they can consume.

Table 2. Dry Cow Daily Nutrient Guidelines*

Body weight, lb Nutrient	800	900	1000	1100	1200	1300	1400	1500
Intake, 1.8% of body weight								
Dry Matter, lb	14.4	16.2	18	19.8	21.6	23.4	25.2	27
Crude Protein, lb	1.73	1.94	2.16	2.38	2.59	2.81	3.02	3.24
Energy,								
NEL, Mcal	8.65	9.45	10.22	10.98	11.72	12.45	13.16	13.86
TDN, lb	8.43	9.21	9.97	10.71	11.43	12.14	12.83	13.51
Fiber,								
ADF, lb	3.89	4.37	4.86	5.35	5.83	6.32	6.80	7.29
NDF, lb	5.04	5.67	6.30	6.93	7.56	8.19	8.82	9.45
Calcium, lb**	0.058	0.065	0.073	0.079	0.087	0.095	0.101	0.109
Phosphorus, lb**	0.035	0.040	0.044	0.048	0.053	0.057	0.062	0.066
Magnesium, lb**	0.024	0.026	0.030	0.033	0.035	0.038	0.042	0.044
Potassium, lb**	0.096	0.108	0.120	0.132	0.144	0.156	0.168	0.180
Sulfur, lb	0.023	0.026	0.029	0.032	0.035	0.037	0.040	0.043
Sodium, lb	0.014	0.015	0.017	0.018	0.020	0.022	0.024	0.025
Chlorine, lb	0.020	0.023	0.025	0.028	0.030	0.033	0.035	0.038
Salt, lb	0.034	0.038	0.042	0.046	0.050	0.055	0.059	0.063
Selenium, mg	1.96	2.21	2.45	2.70	2.94	3.19	3.44	3.68
Vitamins, A, IU	27,579	31,026	34,474	37,921	41,368	44,816	48,263	51,710
D, IU	10,886	12,247	13,608	14,969	16,330	17,690	19,051	20,412
E, IU	101	113	126	139	151	164	176	189

* With the exceptions of intake and crude protein, guidelines are based on 1989 NRC requirements for 3rd lactation cows, 240 days pregnant. Intake estimates are conservative. Crude protein = 12% of dry matter intake to provide a margin of safety to cover varying forage quality and protein degradabilities.

** Calcium, phosphorus, magnesium and potassium levels are at 110% of 1989 NRC suggested levels calculated on a dry matter intake of 1.68% of bodyweight. Additional increases in calcium (by 7 grams = 0.015 lb) and phosphorus (by 4 grams = 0.009 lb) in the two weeks before freshening have been suggested (Gerloff, 1988). Other adjustments to nutrient guidelines may be warranted in specific ration situations.

Aiming for the highest dry matter intake possible has its benefits. It allows dry cows to depend more on forages than on grain for meeting their needs which can help lower ration costs. Maintaining dry cows' rumen capacity at its highest level by feeding longer chopped forages may also make it easier to bring them on to full feed when they freshen. Having a high dry matter intake at freshening can help avert cases of ketosis or displaced abomasum. To obtain maximum dry matter intake, the ration should be balanced for all nutrients, forages should be of good quality and palatable, and clean, free-choice water should be available. The environment should be dry and well ventilated. In other words, they should be treated as the milking herd is treated.

There are a number of nutritional imbalances or deficiencies that can occur in the dry period that may induce early lactation health problems. Through proper management, these problems can be largely avoided.

<u>Milk Fever</u>

Milk fever, or parturient paresis, is caused by excess calcium (Ca) and/or a phosphorus (P) deficiency or excess. The problem primarily the amount of mineral consumed, not the Ca to P ratio. If Ca exceeds a safe range of 70 to 80 grams (absolute maximum of 100 grams)(454 grams per pound) or if P exceeds 40 grams, there is a greater likelihood that milk fever will occur. Because of the upper limit on P, increasing P when Ca is high in an attempt to improve the Ca:P ratio may actually increase the chance of milk fever. To avoid milk fever, supply adequate Ca and P, but don't exceed the limits. Cows that have milk fever run a greater risk of coming down with other disorders (figure 1). Although milk fever may be relatively easy and cheap to treat, the problems that follow it are neither.

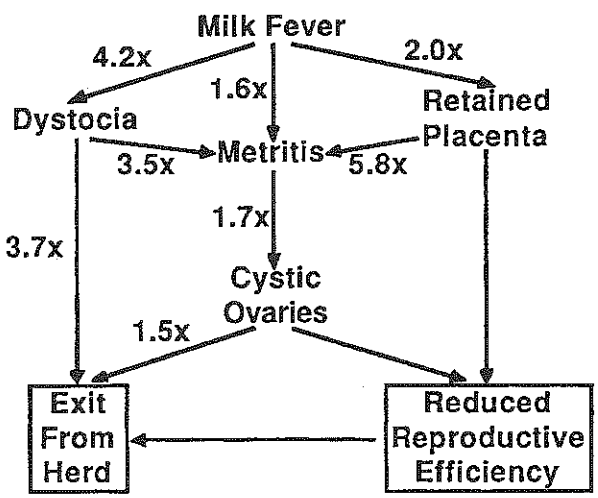

Figure 1. Relationships among health and reproductive disorders, reproductive performance and culling in mature cows. A number on an arrow indicates the number of times greater chance a cow had of having the next problem if she had suffered from the first (eg. 4.2 times greater chance of having dystocia if she had milk fever). Reduced reproductive efficiency includes Increased Days to First Service (Cystic Ovaries: +10 days, Metritis: +4, Retained Placenta: +5), Decreased Chance of Conception at First Service (only 60% and 70% as likely for cows that had metritis or cystic ovaries compared to unaffected cows), and increased total services (33% more for cows with cystic ovaries). Source: Erb, H.N., *et al.* 1985. J. Dairy Sci. 68:3337-3349.

Ketosis

Ketosis, or acetonemia, usually is seen in high producers in the first 6 weeks following calving. Over-conditioned cows are especially prone to ketosis. The cow may initially maintain milk production and have an exceptionally high fat test, but then goes off feed, appears nervous, loses weight and drops in production. The cow mobilizes large amounts of body fat in an attempt to meet energy needs. The underlying cause of ketosis is a low energy intake unable to meet the demands of early lactation. There are two types of ketosis: primary and secondary. Primary ketosis occurs without any other predisposing disease. Secondary ketosis, which accounts for about one-third of all cases, results when another disorder such as milk fever causes the cow to go off feed, triggering the ketotic condition. Secondary ketosis is often accompanied by an elevated body temperature while primary ketosis is not. Although ketosis can be treated with propylene glycol or niacin, prevention is a far preferable route.

To minimize the herd's ketosis problems:

1) avoid over-conditioning late lactation and dry cows

2) introduce dry cows to the milking herd's forages and grains at least 2-3 weeks before freshening to help to keep them on feed after freshening

3) rapidly but carefully increase ration energy levels after calving to meet requirements;

4) balance the ration for all nutrients

5) include at least one-third high quality roughage in the milking ration

6) minimize abrupt ration changes

7) feed palatable feeds

Dividing the dry cows into a dry group and "transition" group may decrease ketosis problems. Two to three weeks prior to freshening, cows would be moved to the transition group where they would be fed a diet balanced for them using the milking herd's feeds. This grouping system would accustom them to their future feeds, limit the chance of metabolic disorders due to an unbalanced diet, and decrease the likelihood that they would go off feed after freshening.

Displaced Abomasum

Another early lactation disorder, displaced abomasum (DA) occurs when the cow's fourth stomach floats or twists out of its normal position. The entrance and exit to the abomasum are then restricted, feed can no longer pass through and the stomach bloats up with gas. A suggested cause for DA is the increased freedom of movement organs have in the void created after calving because there is no calf taking up space, and/or when the rumen takes up less space due to decreased intake or a low bulk/high grain diet. Work by Coppock et al. (1972) showed that as the amount of grain fed increased during the dry period, the incidence of DA also increased. The lowest incidence was seen on the 75% forage, 25% concentrate diet. The cows on the high forage ration consumed 25% more dry matter than cows in other groups on the day before calving. Maintaining rumen fill with a ration high in forage can help prevent DA. Any disorder that decreases intake, especially in early lactation, can make a cow prone to DA.

Fat Cow Syndrome

Fat Cow Syndrome (FCS) is seen in cows that are over-conditioned when they freshen. Fat cows are more susceptible to milk fever, ketosis, digestive disorders such as displaced abomasum, retained placenta, metritis, and infectious diseases such as mastitis and salmonellosis. The animals show depression, lack of appetite and a suppressed immune system. Affected animals do not respond well to treatment. The only good way to deal with FCS is to keep the cows from getting over-conditioned in the first place. Recommendations suggest that cows calve at a body condition score 3+ to 4 (on a scale of 1 to 5). The cow can most efficiently put that weight on during the tail-end of her lactation. Ideally, the dry period should be used to maintain a cow's body condition. A small amount of condition can be put on in the dry period, but large gains or losses will only encourage problems at calving. Managing the herd so that the calving interval is between 12 and 13 months and the dry period is 40 to 70 days will control the time a cow spends in a situation where she can easily become over-conditioned.

Retained Placenta

Retained placenta, where a cow doesn't "clean" or eject all afterbirth within 8 1/2 hours after calving, has a variety of causes. A cow that has had milk fever or fat cow syndrome, or has had calving artificially induced is more likely to have a retained placenta. Retained placenta due to birth of twins and dystocia may be minimized to some extent through careful sire selection. Selenium and vitamin E deficiencies have been related to this problem as well. Since soils in various areas, including the Northeast, are low in selenium, forages grown there will also have a low selenium content. Supplementation of selenium and vitamin E in the feed or by injection during the dry period will eliminate retained placenta cases brought on by these deficiencies. Producers should be careful not to over-supplement selenium as it can be toxic. Retained placenta can lead into metritis, a uterine infection, which can greatly impair reproductive performance.

Udder Edema

Udder edema or caking is seen when an excess amount of fluid is retained between the cells in the udder tissues. Its causes are not fully understood, but there are factors that may increase the chance of it occurring. According to the 1989 NRC's, dry cows only need about an ounce of salt per day to meet their sodium and chlorine requirements (0.25% of ration dry matter). Feeding high levels of salts (sodium chloride or potassium chloride) in the dry period may increase the incidence of edema. Considering that cows are fairly good at regulating salt intake without greatly exceeding their requirements, making a salt block available and minimizing the force feeding of salt (ex., through grain) could help cut back on udder edema in the herd.

Downer Cow Syndrome

Downer Cow Syndrome (DCS) seems to be a variety of disorders lumped under one heading. The final result is a cow that goes down after freshening, is still alert, and may be difficult if not impossible to treat. The causes of DCS are not clearly defined, but they can include overfeeding protein in the dry period, feeding a magnesium (Mg) deficient ration, feeding a ration high in potassium (K), or injury due to pressure on nerves and muscles.

A study by Julien et al.(1977) that examined the apparently protein-based DCS, showed that cows overfed protein (ration crude protein raised to 15% from 8%) demonstrated a tremendous rise in metabolic disturbances (increased from 7% of all cows to 69%). Out of 53 cows, 8 came down with DCS, and 6 of those died. The exact level at which overfeeding protein became a problem was not defined, but great caution was urged.

A second type of DCS is apparently caused by inadequate ration Mg levels or a K and Mg interaction. As forages have been more heavily fertilized with manure and potash, K contents of forages have risen. High levels of K can depress the absorption of Mg by the cow, effectively resulting in an Mg deficiency. Cows suffering from this type of DCS may take many bottles of a Ca/Mg milk fever preparation, show some response after each and then go back down -- they are responding to the small amount of Mg in the treatments. The best way to avoid DCS caused by a K and Mg interaction is to maintain sufficient Mg in the dry and fresh cow's diets, and limit the ration's K. It can get to a point where no amount of added Mg will overcome excessive levels of K. The only alternative is to purchase forages known to be low in K (based on analysis). This apparently mineral based form of DCS can affect cows in later lactation. Careful attention to Mg and K in the milking ration is necessary.

Another possible cause of Mg deficiency is feeding high levels of "unprotected" fats (vegetable) without additional Mg supplementation. The fats may form soaps which pull some of the Ca and Mg out of the available pool. Dry cows usually are not fed high (1 lb) levels of added fats, so this usually is not a problem.

The type of DCS caused by injury may occur in any cow that is down for 6 or more hours. According to work by Cox and Onapito (1986), the pressure exerted by body weight in the cow's hindquarters may injure nerve and muscle tissue if a cow is down in excess of 6 hours. The cow will still have full function of her front end and may sit up like a dog, unable to coordinate the movement of her hindquarters to stand. The damage is likely to be permanent.

In the two to three weeks before freshening, properly accustoming cows to the feeds they'll be on in the milking herd can enhance intake after calving and head off some early lactation problems. Lead feeding, or feeding up to 6 to 12 pounds of grain in the two to three weeks before freshening has long been recommended to get the cow on feed. Actually, the main players that need to be adjusted to the ration are the rumen microbes, not the cows. Including some portion of milking herd feeds in the dry ration allows the rumen microbes to adjust to digesting them. This is especially important if the feeds in the dry and milking diets are very different. The milking herd's forages, as well as their grain at a rate of 0.5% of the cow's body weight, should be fed. Six to 8 pounds of grain should be more than sufficient because the aim is to adjust the rumen microbes, not to stuff the cow on grain. Even on the milking herd's feeds, the ration must still be balanced to avoid overfeeding minerals and underfeeding fiber or the metabolic disorders so carefully averted in the rest of the dry period may still crop up. For this reason, feeding large amounts of grain, which usually is the major source of calcium and salt for the milking herd, can encourage problems. After calving, grain should be increased at the rate of about 1 lb per day to avoid intake problems.

Careful monitoring of the dry cow ration will enable producers to meet the goals of dry cow feeding management. The net result will be a healthy cow at calving that is prepared to produce. The variety of problems that come to call at calving and in early lactation can be prevented. A little effort and careful formulation of the dry cow ration can help to make metabolic disorders a part of a dairy herd's past, not its future.

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Special thanks to Stuart J. Rymph for his editorial assistance.

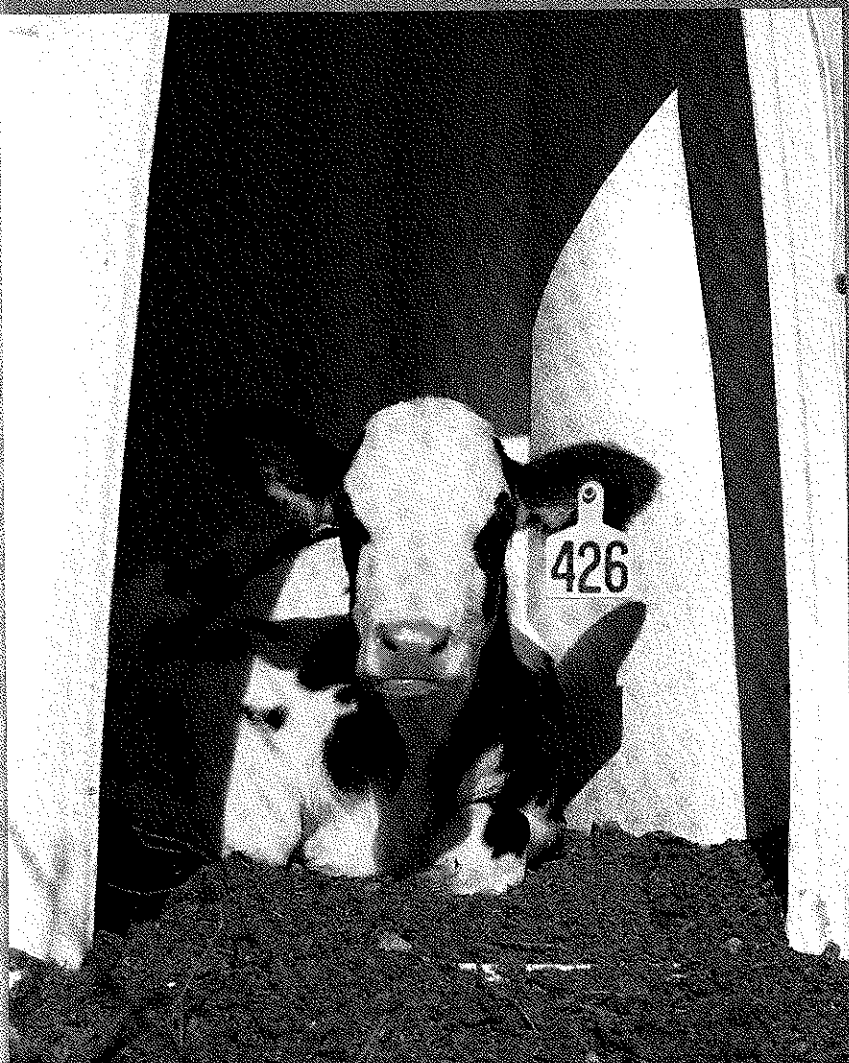
Dry Cow Nutrient Guidelines

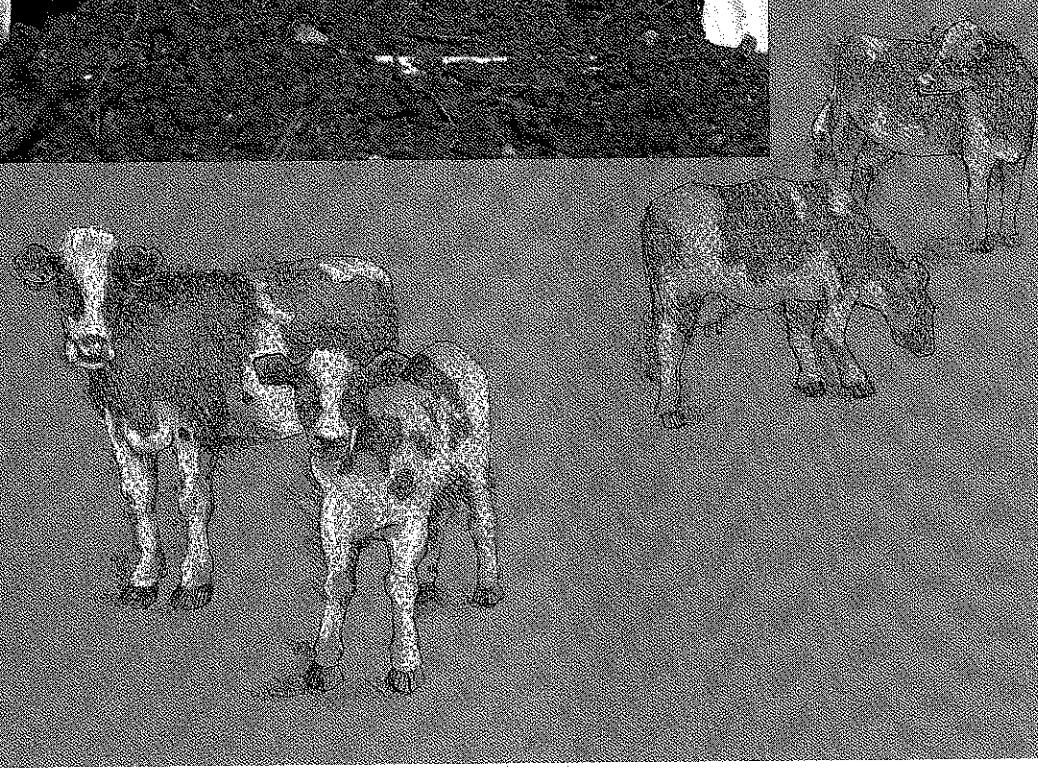
Nutrient	% of DMI	lbs
Dry Matter Intake	1.8% of BW	23.4
Crude Protein	12%	2.81
NEL	0.53 Mcal/lb	12.45 Mcal
ADF	27%	6.32
NDF	35%	8.19
Calcium	0.41%	0.095
Phosphorus	0.24%	0.057
Magnesium	0.16%	0.037
Potassium	0.67%	0.156
Selenium	0.3 ppm	3.19 mg
Vitamin A	1,915 IU/lb	44,816 IU
Vitamin D	756 IU/lb	17,690 IU

1300 pound mature cow.
Except for intake and crude protein, requirements based on 1989 NRC for Dairy Cattle. Calcium, phosphorus, magnesium and potassium levels are 110% of 1989 NRC.

RAISING DAIRY REPLACEMENTS

James Crowley, Neal Jorgensen, Terry Howard,
Patrick Hoffman and Randy Shaver





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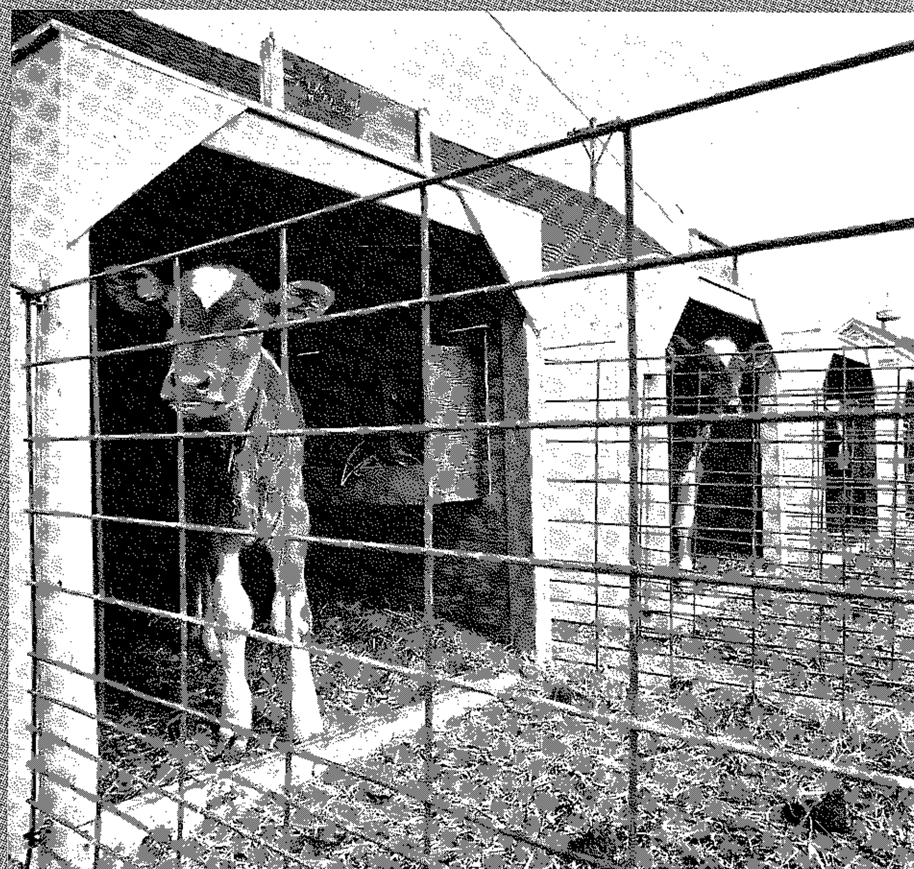
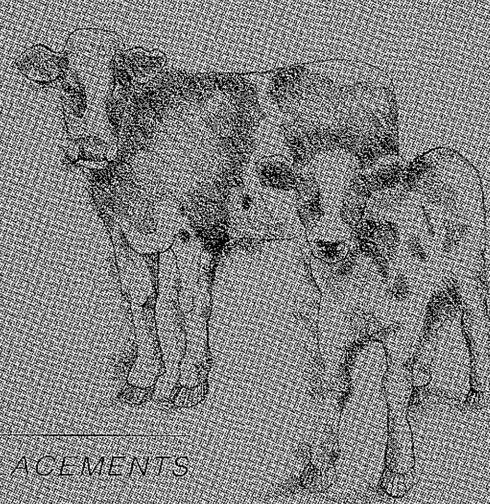




RAISING DAIRY REPLACEMENTS

HEIFERS ARE YOUR FUTURE

What kind of cows will you milk 3, 4, or 5 years from now? Their size, milking ability, temperament, reproductive performance, disease resistance and type are influenced by current breeding decisions, care of pregnant cows and management of heifers from birth to freshening. Replacements should be raised rather than purchased. It is generally less expensive to raise your own replacement heifers, especially when home-grown forages and grain are available. In addition, you know the genetic ability and health history of home-raised replacement heifers.

The suggestions and recommended practices in this publication are based on research trials and the experience of successful dairy farmers. Properly fed, housed and managed calves and heifers can improve your future success in dairying.

Heredity A Key Factor

Quality herd replacements begin with the genetic ability of calves. The best feeding and management program will not increase production beyond the inherited (genetic) potential of a calf. Choosing the right bull is the first step in a successful replacement program.

Proven Sires — The Best Bet Everyone has the opportunity to purchase semen from sires whose transmitting abilities have been carefully estimated. Use AI sires with high Predicted Transmitting Ability-Dollars (PTA$) to increase the odds of producing offspring with superior genetic potential for production. Not all the daughters from a higher PTA$ sire will be superior to the daughters of a lower ranked sire. But on average, 8 of 10 daughters from a +$180 bull will be higher producers than daughters from a +$100 bull.

Sons of High PTA Bulls Next Best Bull studs continually add young sires to maintain a future supply of proven sires. Although the transmitting ability of these young sires has not been completely evaluated, they are carefully selected sons of bulls with high predicted transmitting abilities and from highly selected cows. The chance of getting a good heifer from a young sire or from any unproven bull increases if he is the son of a high PTA bull.

A North Carolina geneticist found that a bull with a PTA of +1,267 pounds milk sired 72 sons with an average PTA of +437 pounds milk. A bull with a PTA of -2,072 pounds sired 59 sons with an average PTA of -1,181 pounds.

Sons of bulls with high PTAs are likely to become the next generation of high PTA sires, especially when the dams also have high PTA values. New bulls are continually evaluated to ensure continued genetic improvement. Semen from young sires is less expensive. At least 25% of the herd can safely be bred to young, unproven bulls. The rest of the herd should be bred to the highest PTA bulls your semen budget will allow. Select cows **randomly** from the herd to breed to young sires. Be sure that young sires are the sons of bulls and cows with high PTA values.

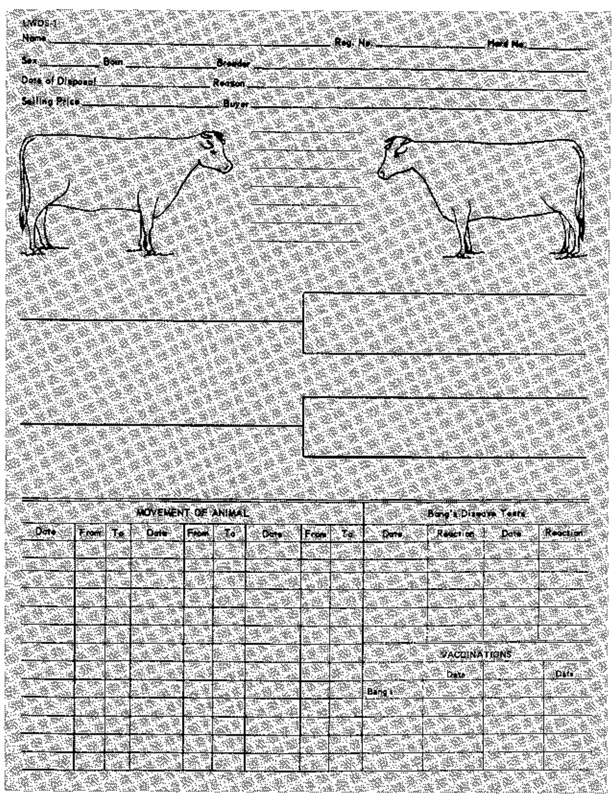
For various reasons, some rely on natural breeding. They too should use sires that are the sons of high PTA bulls and cows if they expect to improve the genetic ability of their herds.

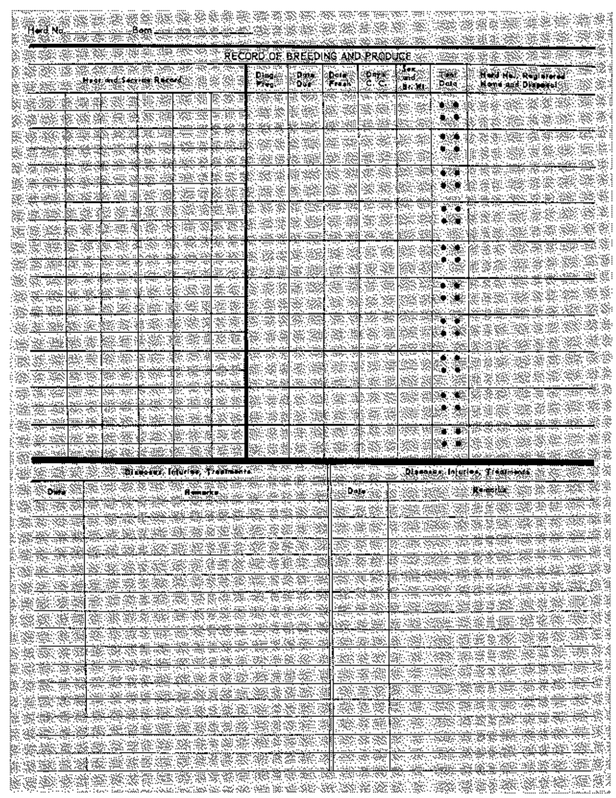
The cost of purchasing and maintaining a bull for natural service is usually greater than the cost of semen available from A.I. organizations. When only one unproven young sire is used, there is high risk that the bull has a low PTA. This is less likely to occur if several unproven young sires are used. For these reasons, those relying on natural service usually make less genetic progress than those who use several top A.I. sires.

Selection Essential for Genetic Gain

Genetic progress requires careful selection of parents. The best cows from that generation of calves are then selected as parents of the next generation. Poor reproductive performance of cows and/or high calf losses obviously limits the number available for selection or culling. If most of the replacements are needed to maintain herd size, you have a limited opportunity to select and less chance to improve the genetic ability of a herd.

Unless replacement calves are the progeny of parents with good genetic ability, you may be forced to select the "least worst" calves among a crop of poor calves, a strategy that almost guarantees no improvement in genetic ability. Simply raising more calves does not improve the genetic ability of the herd unless you **keep the best and cull the rest.**





Keep permanent records as soon as a calf is born.

Accurate selection for genetic improvement must be based on actual performance as determined by individual cow records. The feeding and management program must provide cows with an opportunity to show their genetic potential.

Two essentials for genetic progress are:

1. **A good breeding program**
   - Use high PTA sires.
   - Young sires with a high pedigree PTA value may be used on 20% to 30% of the cows and heifers in the herd.
   - If you use natural service, select a son of a high PTA sire and dam.
2. **A good selection program**
   - Keep complete records (feeding, reproduction, health, production and service sire) on each cow. Dairy Herd Improvement records are recommended.
   - Keep complete records on each calf, including the identity of sire and dam.
   - Raise all heifers possible, including daughters of first-calf heifers bred to good dairy bulls.

Number of Replacement Heifers Needed The annual culling or replacement rate in a milking herd is about 30%. This means that 30 good 2-year-olds are needed each year in a 100-cow herd. In an average 100-cow herd, at least 40 heifer calves would be required annually to provide 30 fresh 2-year-olds. About 25% of the heifer calves are lost from birth to freshening. Death from birth to 6 weeks of age is 15% to 20%; another 5% are lost due to accidents or gross abnormal type traits; and about 5% are nonbreeders (Tables 1 and 2).

When only older cows are bred to good bulls, most of the heifers are needed to maintain herd size (Table 3). As noted previously, selection is the key to genetic improvement. If all or most heifers are needed to maintain herd size, some heifers added to the herd will have similar or less genetic ability than cows already in the herd. To increase the genetic ability of herds, breed all cows and heifers to good A.I. bulls and raise all of the heifer calves possible. Breeding heifers to good A.I. bulls increases genetic progress in your herd and the sale of surplus dairy replacements increases income.

Table 1. **Heifer calves needed for one replacement heifer with varying mortality and culling rates.**[1,2]

Heifer calf mortality rate, %	Heifer culling rate, %				
	4	6	8	10	12
5	1.10	1.12	1.15	1.17	1.20
10	1.16	1.19	1.21	1.24	1.27
15	1.23	1.26	1.28	1.31	1.34
20	1.30	1.33	1.36	1.39	1.43
25	1.39	1.42	1.45	1.49	1.52

[1] For example, with a 15% calf mortality rate and a 12% heifer culling rate, 1.34 calves must be started to provide one 24-month-old replacement heifer.

[2] A.J. Brannstrom, University of Wisconsin-Madison, based on 1976 Dairy Update No. 22, R.D. Appleman, University of Minnesota.

Table 2. **Effects of calving age on size of replacement herd.**[1,2]

Age at freshening, months	% change from 24 months
22	-8.4
23	-4.2
24	0
25	+4.2
26	+8.4
27	+12.6
28	+16.8
29	+21.0
30	+25.2

[1] Each additional month after 24 months (2 years), increase replacement herd by 4.2%(1.00 / 24 months = 4.2%)

[2] For example, if 50 replacement calves and heifers are needed when freshening age is 24 months, then 58 replacements will be required when the freshening age is 28 months [50 + (50 x 16.8%)].

In a 100-cow herd, breeding 2-year-olds to good A.I. bulls lets you cull ten additional poor cows or undesirable heifers. Such selection makes a substantial difference in the pace of genetic progress. Good heifers not needed in the herd sell for two or three times more than dairy calves from beef bulls.

Table 4 shows the increased milk production possible when cows and heifers are bred to good A.I. sires. Clearly, the 825-pound increase in milk production indicates the benefits of breeding selected A.I. sires to heifers as well as cows.

For genetic improvement, calves from 2-year-olds cannot be "sacrificed." This will occur if heifers are bred to beef bulls or poor dairy bulls. The genetic potential a 2-year-old transmits to her first calf is the same genetic potential transmitted to her later calves. Since a good breeding program will continually increase genetic potential, daughters of heifers should have more genetic potential than daughters of older cows. Some dairy producers use beef sires, "jumper" bulls or other non-proven bulls for the convenience of getting heifers bred and to reduce calving problems. The following management practices are more effective in reaching these goals . . . and more profitable as well.

- Instead of using beef bulls to sire smaller calves, rely on good rations that add growth to heifers and breed heifers at the right size and age.
- To reduce calving difficulties, select A.I. bulls with good calving-ease ratings.
- Hormones that induce heat and enable breeding at desired times are now available. Their use makes artificial insemination of heifers more convenient. Consult a veterinarian about this management program.
- If you must use pasture breeding or natural service, use a son of a high PTA dairy sire and dam.

Management of Cows From Breeding to Calving

The genetic ability of a calf is determined at conception. Proper management of a cow during her 280-day pregnancy, especially during the 2 months before calving, also affects the future productivity of a replacement.

Table 3. Surplus heifers in a 100-cow herd

Heifers born[1]	Survival rate, %[2]	No. heifers raised, birth to freshening	Replacement rate 15%	25%	35%
			(Heifers for voluntary culling, herd expansion or sale)		
Calves saved from cows only					
45	90	40	25	15	5
45	80	36	21	11	1
45	75	34	19	9	1
Including calves from freshening heifers[3]					
55	90	50	35	25	15
55	80	44	29	19	9
55	75	41	26	16	6

[1] In a 100-cow herd, about 90 calves are born per year, half of which are heifers.

[2] Average survival rate from birth to freshening.

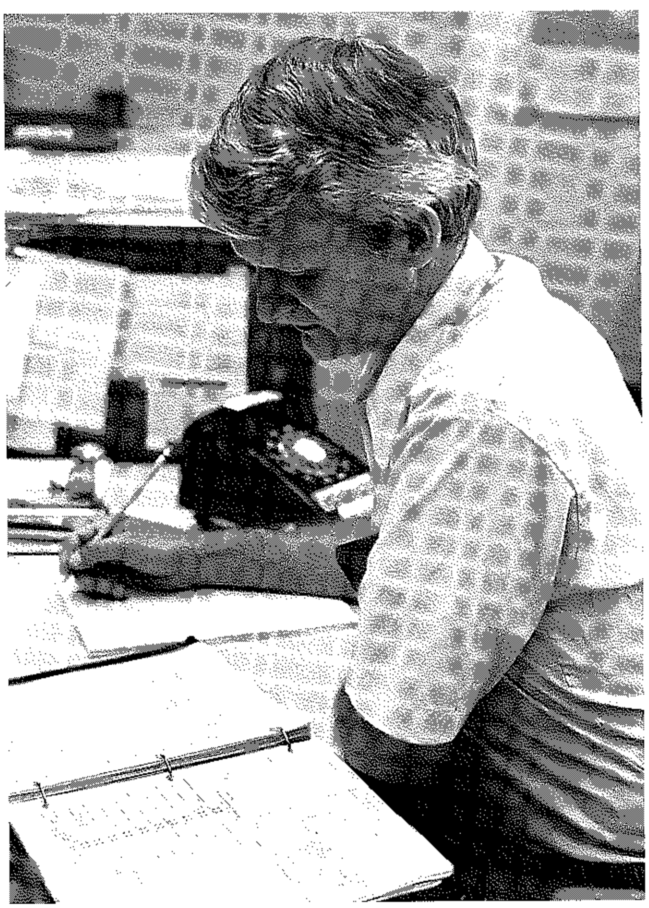
[3] With twenty 2-year-olds and 100 cows, total calf crop is 110 calves, half of which are heifers.

While the cow is pregnant, you should:

1. Keep accurate records (breeding dates, service sire, health and production);
2. Follow a herd health program (pregnancy diagnosis and disease prevention);
3. Feed a balanced ration that is adequate for milk production and additional growth and which will restore any weight the cow has lost in early lactation; and
4. Provide a 6- to 8-week dry period.

Cows need a dry period of at least 45 days to efficiently produce milk in their next lactation (Table 5). However, extending the dry period beyond 65 days offers no advantage in milk production. Long dry periods cost money and produce cows that are prone to metabolic problems, especially if fed excessive energy (Table 6).

Dry cow management is crucial to the health of the calf and performance of the cow. Body condition is a major concern, as under-conditioned cows will not milk to their genetic potential, and fat cows will have health problems. Feed adequate nutrients in late lactation to restore the cow's body condition to a condition score of 3.5 (Figure 1).



Accurate records must be kept on all animals in the herd.

Dry cow rations should provide the nutrients recommended by the National Research Council (Tables 7-8). Pay careful attention to the amount of energy, calcium and phosphorus in the diet. Feeding too much energy to dry cows can increase the incidence of ketosis, displaced abomasum, calving difficulty, and reproductive problems. Too much calcium or phosphorus will increase the incidence of milk fever.

Table 9 shows four example rations that rely heavily on forages plus limited amounts of supplements. These rations meet N.R.C. requirements and utilize feeds that are usually available on Wisconsin dairy farms. Dry cows also require bulky feeds in the ration to maintain rumen function. A ration containing only finely chopped silage or high-moisture silage may lack adequate bulk. Bulk can be provided by dry hay, corn stover, straw or good-quality silage.

Table 4. Degree of artificial insemination and effect on milk production.[1]

Amount of A. I.	Increase in milk production above herds using all natural service (lb/year)
All natural service	—
All cows artificially inseminated	1,282
All cows and heifers artificially inseminated	2,107

[1] North Carolina State University

Table 5. Effect of dry period on milk production in next lactation[1]

Days dry	Difference in milk production from herdmates (lb/year)
10-19	-2050
20-29	- 959
30-39	- 159
	Recommended range[2]
40-49	+ 313
50-59	+ 632
60-69	+ 734
70-79	+ 610
80-89	+ 534
90-99	+ 503

[1] Iowa State University

[2] Varies with cow condition and level of production. A 6-week dry period is adequate for average producers. Young cows and high producers need 8 weeks.

Table 6. Increase in incidence of metabolic problems with fat cow conditions[1]

	Percent cows calving	
	With fat cow conditions	After preventive practices
Ketosis	38	3
Retained placenta	62	13
Mastitis	6	2
Milk fever	5	2
Deaths	25	3

[1] Michigan State University.

Dry cow rations should be balanced as carefully as rations for lactating cows. In free stall barns or other free-choice feeding systems, dry cows should be separated from the milking herd. Utilize laboratory tests of forages, grains and other available feeds and ration-balancing programs to formulate economical rations for dry cows.

The dry period is the time to prepare the cow for calving and the next lactation. Proper management and feeding during this period will also produce a vigorous calf. DO THE JOB RIGHT.

Care at Calving Time

Approximately 5% of calves are born dead (stillbirths). Many of these calves can be saved if you are present at birth to render proper assistance.

Too often cows get assistance only after the cow or calf is in critical condition. The increased value of cows and calves makes it profitable to frequently check cows at calving time. Attend the cow while she is in labor and during birth. Monitoring the birth process ensures that the cow and the unborn calf receive assistance if it is required.

Maternity Stalls Isolate the cow a week or 10 days before she is expected to calve. The cow and the newborn calf need protection from other cows. Put the cow in a clean, dry, nearly square box stall

Table 7. Nutrient requirements of dry, pregnant cows[1,2]

Weight	Energy		Crude protein	Calcium	Phosphorus
	NEl	TDN			
Lb	Mcal	Lb	Lb	Grams	Grams
1,200	11.7	11.4	1.9	36	22
1,400	13.2	12.8	2.1	42	25
1,600	14.5	14.1	2.3	47	29
	Mcal/ lb		%		
Ration composition	0.57	55-60	12-13	.39	.24

[1] 1989, National Research Council, Nutrient Requirements of Dairy Cattle. Increase by 20% to provide for growth of 2-year-olds. For a group of dry cows, feeding 12% crude protein and increasing TDN to 63% will provide for growth and conditioning.

[2] Dry matter basis and average intake for dry cows.

that provides about 150 to 200 square feet of space. The box stall should be well lighted and airy but free from drafts.

Apply lime or other granular material to the floor before covering it with adequate amounts of a dry, comfortable bedding such as fresh, clean straw, ground corn cobs or shredded corn stalks. A good non-slip base and adequate amounts of dry, comfortable bedding can prevent stifle injuries, ruptured adductor muscles and udder trauma during calving.

Do not use wet sawdust, moldy hay, moldy, damp silage or spoiled haylage for bedding. Many cases of environmental mastitis can be traced to contaminated bedding, especially wood shavings and sawdust. Moldy hay and silage and manure-contaminated bedding contain organisms that can infect the uterus and udder of the cow. These organisms can also infect calves.

A well-drained paddock of small pasture with shade is a good calving area during mild, dry weather.

Be Available to Assist with Difficult Calvings Most cows calve without assistance. However, you never know beforehand which cows will need help. Heifers and younger cows are more likely to require assistance than older cows. Assistance is more likely to be required for bull calves and multiple births.

As shown in Table 10, calf mortality rates increase dramatically with the difficulty of birth. North Carolina University researchers estimate that each difficult birth costs $40 to $75 due to increased calf and cow

Table 8. Suggested vitamin and micromineral levels in dry cow diets.

Vitamin	Suggested Level
A	40-80,000 IU/Day
D	25-40,000 IU/Day
E	100-300 IU/Day
Microminerals	**PPM**
Cobalt	.1
Copper	10
Iodine	.6
Iron	50
Manganese	40
Selenium	.3
Zinc	60

Table 9. Example dry cow rations[1]

Feedstuff[2]	Alfalfa plus corn silage	Alfalfa plus oatlage	Alfalfa plus grass hay	Alfalfa plus cornstalks
	Lb dry matter			
Alfalfa (17% CP, 58% TDN)	11.5	6	7	13
Corn stalks (6% CP, 55% TDN)				10
Corn silage (8% CP, 68% TDN)	11.5			
Oatlage (12% CP, 57% TDN)		20		
Grass hay (8% CP, 52% TDN)			18	
Corn[3](10% CP, 88% TDN)				3
Protein supplement (49% CP, 84% TDN)			1	
Total	23	26	26	26
	Oz.			
Mineral				
(20-24% Ca, 18% P)[4]	1.5	1.0	1.0	1.0
Trace mineral salt[5]	1.0	1.0	1.0	1.0

[1] These rations meet minimum requirements. Increase protein and energy to provide for growth of young cows and to condition thin cows.

[2] Forages are fed as air-dried or silage (lbs. as fed x %DM = lbs. DM).

[3] Corn dry matter can be supplied from air-dry or high-moisture corn.

[4] A supplemental source of vitamins A, D and E is recommended.

[5] In selenium-deficient areas, provide selenium in salt, mineral or grain supplement.

mortality, reduced milk production, rebreeding problems and the cost of additional labor required in delivery. Proper management of dry cows and heifers and using sires with good calving-ease ratings can reduce economic losses associated with difficult births.

Check cows every 2 hours after labor begins. You can determine how the birth process is progressing by the following timetable:

Stage I.

Restlessness. A cow will often roll feed around in her mouth but will not swallow it. She gets up and lies down frequently and doesn't seem to be comfortable. Visible labor begins when the water bag breaks. The slippery and viscous material found in the water bag is essential for a normal, trouble-free birth.

For mature cows, the calf should be in the pelvic inlet **within 2 hours** after the water bag breaks.

For heifers, **as long as 4 hours may elapse** after the water bag breaks before the calf enters the pelvic inlet. It takes longer for the muscles in the pelvic inlet of heifers to relax.

Stage II.

Fetus delivered. For cows, the fetus should be delivered **1/2 to 1 hour** after it appears in the pelvic inlet.

For heifers, the fetus should be delivered **within 2 hours** after it appears in the pelvic inlet.

Stage III.

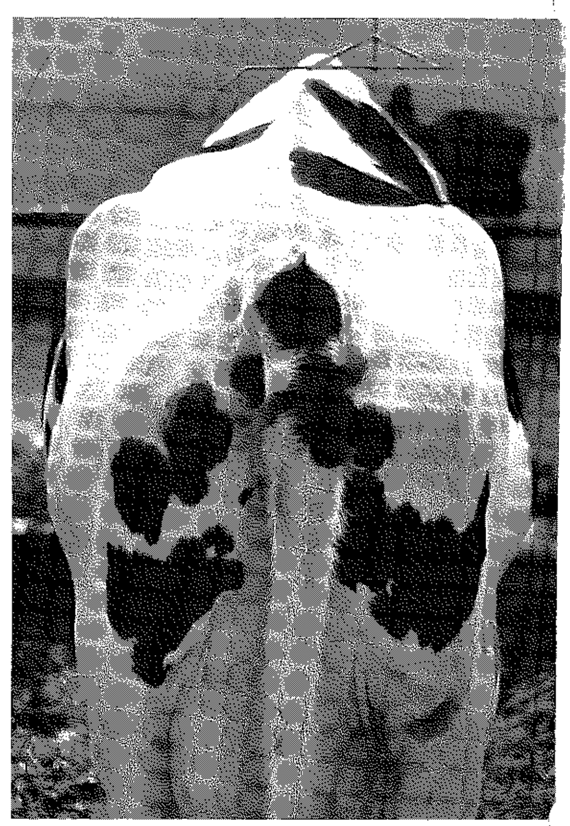
The placenta (afterbirth) is passed 1/2 to 8 hours after the fetus is delivered.

Stage IV.

The uterus returns to normal 15 to 30 days after birth.

Figure 1.

Body condition score 1.5



Body condition score 3.0

Some cows show noticeable signs of calving and will give birth in a few hours while others may not calve until the next day or may calve earlier than expected. Calving has definitely started, however, when the water bag breaks. **Continually monitor the progress of the cow during calving. If the cow does not progress according to the schedule discussed, she should be examined to check for abnormal position or other problems.**

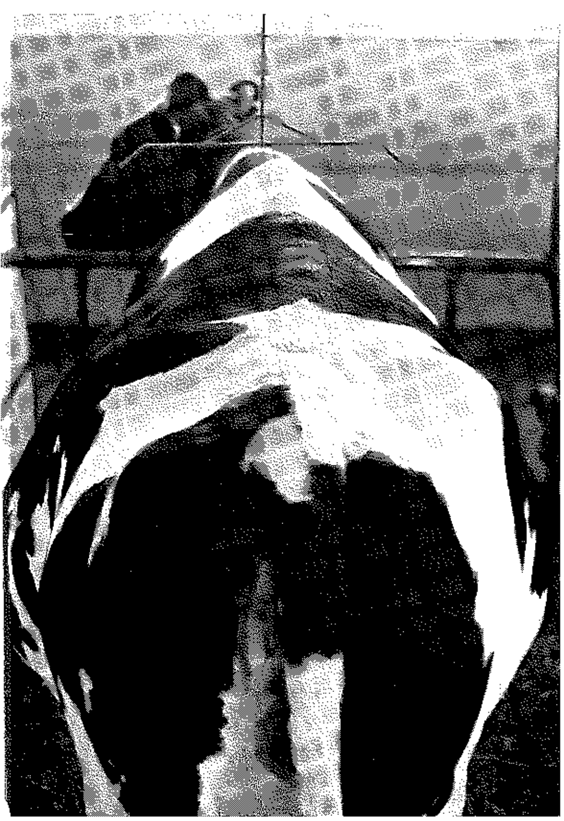
A calf is normally born head first with its head placed on both front legs (Figure 2). Backward deliveries are fairly common and cause no problem if both rear legs and the tail are presented. Professional help is required if a calf is delivered in any other position, such as with a breech presentation. A calf in a backward delivery will suffocate if there is any delay in final calving after the umbilical (navel) cord breaks.

When Help Is Needed The earlier you determine that an abnormal condition is delaying the birth process, the easier it is to correct the problem and to ensure the well-being of the dam and calf.

If the position of the calf is normal, experienced herdsmen usually provide the assistance the cow needs during birth. An inexperienced person should work closely with a veterinarian or experienced person to obtain experience and confidence. The following guidelines give general directions but are no substitute for actual experience.

Always wash the cow and your hands with detergent before examining her. Use disposable plastic sleeves. Have on hand a set of obstetrical chains and soap and water. Two 6-foot lengths of 3/8-inch nylon rope can be used instead of obstetrical chains.

Sterilize the nylon ropes or chains by boiling them for 15 minutes or by placing them in a small paper sack and heating them in an oven for 30 minutes at 300 degrees F. Sealing the sack with masking tape when the bag is removed will keep the contents relatively sterile for about 30 days. Never leave these tools in the barn since dust and manure could be the source of infectious organisms if introduced into the uterus.



Body condition score 4.5

Table 10. Calf mortality by difficulty of birth category[1]

Calving category	% of calvings in category		Calf mortality (%) within 48 hours	
	Heifers	Cows	Heifers	Cows
Unassisted	45	79	8	6
Easy pull	30	15	10	8
Hard pull	14	3	35	24
Jack needed	7	1	55	66
Veterinarian	4	1	48	65
Total	100%	100%	17%	8%

[1] North Carolina State University

If a cow requires assistance during a normal delivery, tie either the obstetrical chains or the nylon rope **above** the pastern of the calf — not below the pastern. Once the head and feet (or the hind feet and tail) are outside the uterus, pull **parallel** with the cow's hind legs. Pull directly down if the cow is standing. Pull parallel to her hind legs if she is lying down.

Be gentle. Do not use excessive force. Work with the cow as her abdominal muscles contract. When she relaxes, merely keep the "ground" you have gained and pull again as her abdominal muscles contract again. Working with the animal makes delivery much easier.

Remember, however, that you should never attempt to pull a calf unless either the calf's two front feet and its head or its two back feet and the tail are in the pelvic inlet.

Supplies needed in the calving facility include a stainless steel pail, disinfectant, disposable plastic gloves, lubricant and obstetrical chains.

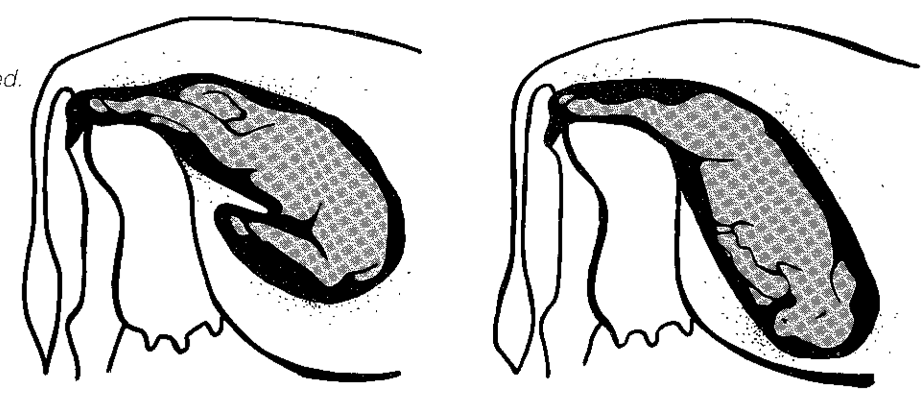
Retained Placenta The cow should expel the afterbirth within 8 hours after birth. Cows that have a difficult time calving, those with infections, and overconditioned cows are more likely to retain their placentas. Even in a well-managed herd, 5% to 10% of the cows will have retained placentas. If more than 10% of the cows have problems with retained placentas, poor feeding, management or sanitation may be the cause.

Feeding or injecting supplemental selenium and vitamin E three weeks before calving reduces the incidence of retained placentas if rations are selenium-deficient. However, selenium will not correct problems caused by other improper feeding or management practices. If a cow retains her placenta for more than 12 hours, has an excessive discharge from her vagina, has a high body temperature or goes off-feed, get advice and assistance from a veterinarian.

Figure 2.

Normal delivery presentations —
(1) Normal anterior presentation
(2) Normal posterior presentation.

Abnormal presentation —
(3) All four feet and head presented. Do not apply traction before correcting presentation.
(4) Posterior presentation without feet. Correct position before applying traction.
(5) Feet presented but head in back. Correct position of head before applying traction.



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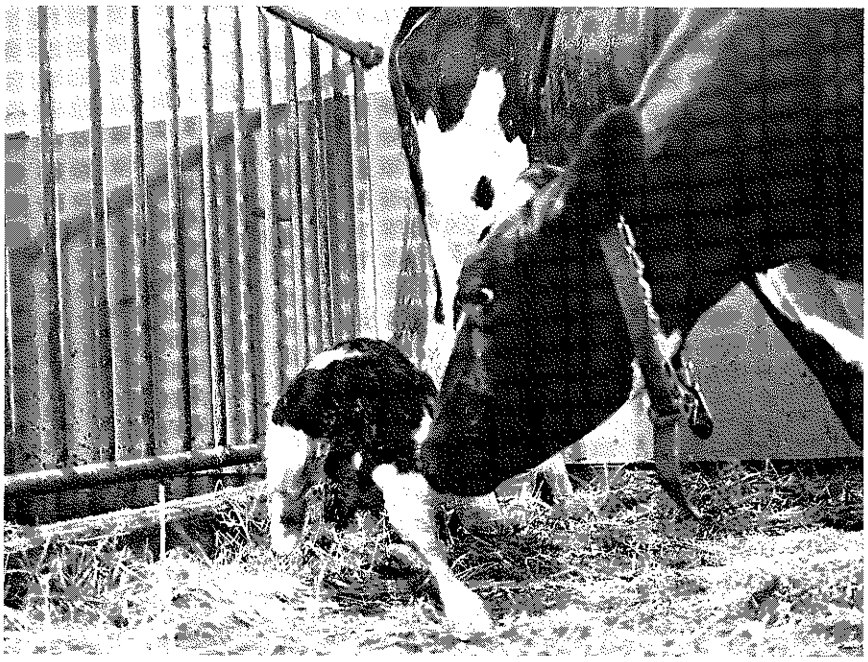
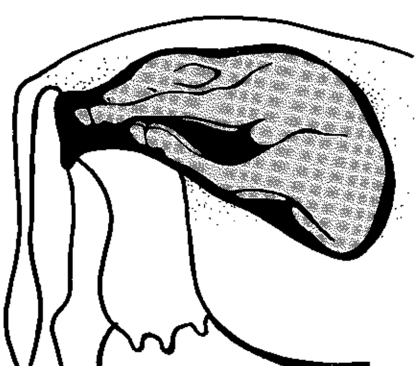
Immediately After Calving The cow should get up and assist the calf within 1/2 hour after giving birth. If she does not get up soon after birth, get advice and assistance from a veterinarian. Provide good, slip-free footing in the pen and adequate amounts of bedding so the calf and cow are dry. The cow should pass manure and drink water.

Feeding warm water and bran mash to a cow is a good "old time" treatment used by many herdsmen. A normal cow will be alert, have a normal body temperature and be willing to eat and drink within an hour or two after calving. Let the cow lick the calf after delivery. Licking stimulates the calf's blood circulation and may increase absorption of immunoglobulins in colostrum.



A healthy calf born in a clean, draft-free box stall is off to a good start.



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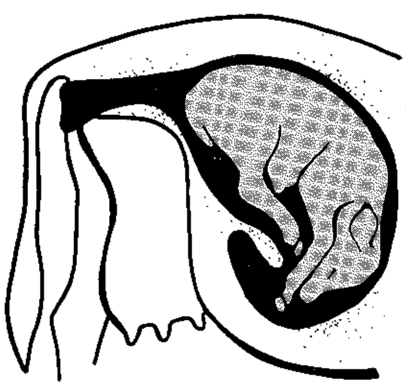

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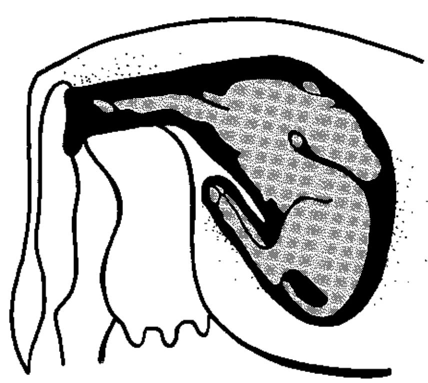

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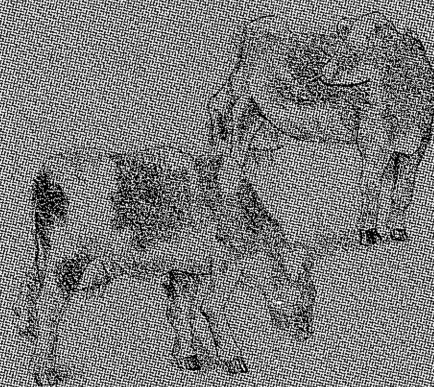
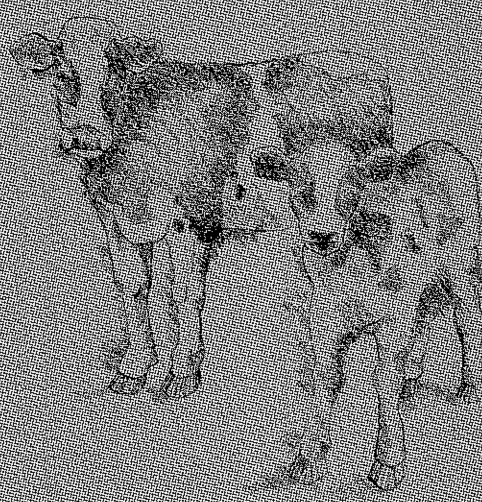




RAISING DAIRY REPLACEMENTS

THE NEWBORN CALF

The calf must start breathing as soon as the umbilical cord breaks. Remove mucus from the calf's nostril and rub the calf vigorously with a clean towel. If the calf fails to start breathing, stimulate the breathing mechanism by inserting the handle of a small, clean spoon up its nostrils about 2 inches. Use your finger if no spoon is available. Rotate vigorously. This stimulates a nerve in the nostril that initiates breathing. **Do not pound the calf on the chest or shake it by its hind legs.** This usually does more harm than good.

Immediately tie off the navel cord about 2 inches from the body line to prevent bacteria from entering the broken umbilical cord. Use common household string kept in a clean glass jar with a solution of 70% rubbing alcohol or use special plastic clips available from veterinary suppliers. Use only the large clips and place them 2 inches from the body line. Tying or clipping too close to the body may cause a hernia.

After tying the navel, remove the excess cord and any foreign material. Thoroughly disinfect the umbilical stump with a 7% tincture of iodine solution. Be sure the disinfectant gets into every crack and under any hair or other material. It is better to "soak" the umbilical stump in the iodine solution rather than a quick "dip" in the solution. Common household aqueous 1% to 2% iodine solutions are not strong enough to be effective disinfectants.

If possible, let the cow dry the calf. Otherwise, dry the calf with clean cloths or paper towels. Make sure the bedding is dry and do not expose the calf to drafts.

Feed the proper amount of good-quality colostrum within ½ hour after birth

Feed Calf Promptly

Immediate feeding of colostrum is one of the most important steps to increase survival and health of newborn calves. Colostrum is the best source of nutrients for the newborn calf. It is also important — and irreplaceable — in providing calves with the antibodies for resistance to diseases and infections.

Milk out and feed colostrum within 30 minutes after birth. This first feeding should be equal to 4% to 5% of the birth weight of the calf. Weigh or measure the colostrum. One quart weighs about 2 pounds.

Colostrum and Transitional Milk

The first feeding of colostrum plus the next two feedings during the first 24 hours should equal 12% to 15% of the calf's birth weight.

Although colostrum is commonly defined as the secretions from the first 6 to 10 milkings, true colostrum is obtained only from the first milking. The secretions after the first milking for 4 to 5 days after calving are transitional milk.

Colostrum contains more total solids and immunoglobulins — antibodies that help newborn calves fight infections — than does transitional milk. The composition of transitional milk is similar to that of whole milk by the sixth milking although milk is not legally saleable until after the fifth day (usually the 11th milking).

Bovine colostrum consists of a mixture of udder secretions and constituents of blood serum, notably immunoglobulins and other serum proteins. Colostrum accumulates in the mammary gland during the dry period.

If the cow is milked before calving, leaks milk before she calves or the colostrum appears abnormal, feed the newborn calf good-quality colostrum saved from another cow. Freeze a supply of good-quality true colostrum to feed when a mother's colostrum is poor.

Length of the dry period may influence the concentration of immunoglobulins in colostrum. The dry period should be at least 40 days in length. An adequate dry period appears necessary for immunoglobulins to accumulate in colostrum.

Whole milk contains about 0.1% immunoglobulins. The immunoglobulin content of colostrum varies from 2% to 23% and is directly related to the percentage of solids in true colostrum, which varies from 17% to 36%. In other words, colostrum containing more solids also usually contains a higher percentage of immunoglobulins.

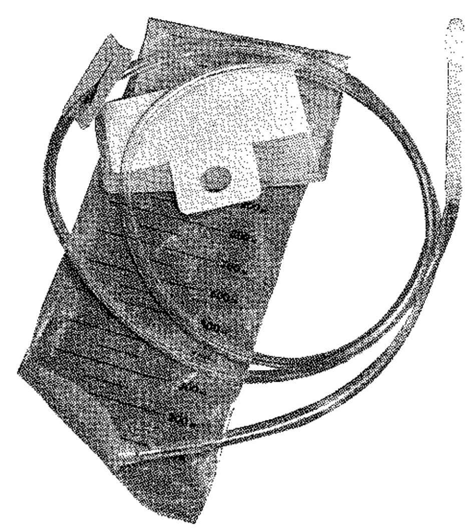
Table 11. Composition of colostrum, transitional milk and whole milk[1]

	Milking number (cows milked twice daily)					
	1	2	3	4	5	11
Item	**Colostrum[2]**		**Transitional milk**			**Whole milk[3]**
Total solids, %	23.9	17.9	14.1	13.9	13.6	12.9
Total protein, %	14.0	8.4	5.1	4.2	4.1	4.0
Casein, %	4.8	4.3	3.8	3.2	2.9	2.5
Immunoglobulins, %	6.0	4.2	2.4	0.2	0.1	0.09
Fat, %	6.7	5.4	3.9	4.4	4.3	4.0
Lactose, %	2.7	3.9	4.4	4.6	4.7	4.9
Minerals, %	1.11	0.95	0.87	0.82	0.81	0.74
Specific gravity	1.056	1.040	1.035	1.033	1.033	1.032

[1] University of Minnesota

[2] Colostrum also contains more vitamins than whole milk

[3] Milk is legally saleable after 5 days



An esophageal feeder should be available to force-feed colostrum to weak calves.

Although Table 11 shows colostrum containing about 24% solids and 6% immunoglobulins, the solid and immunoglobulin content of colostrum from different cows can vary considerably. **The appearance of colostrum is an indication of its quality.** Good colostrum containing a high percentage of solids, and thus a high percentage of immunoglobulins, will be thick and creamy. Thin and watery colostrum should not be fed to newborn calves since it is low in solids and immunoglobulins. Meters are available to measure the specific gravity of colostrum, an indication of the quality of colostrum. Do not feed excessively bloody or mastitic colostrum. Colostrum and transitional milk contain several types of immunoglobulins. Table 12 shows the major types of immunoglobulins and their functions.

The immunoglobulin content of the second milking is largely determined by how completely the cow was milked the first time. On average, the second milking contains 60% to 70% as much immunoglobulins as the first milking (Table 11). Immunoglobulins in both the first and second milkings help a calf develop passive immunity (Table 13).

All unsaleable milk (colostrum and transitional milk) should be used to raise dairy calves.

Passive Immunity

A calf is born essentially without any immunity (resistance) to infections and diseases. A newborn calf acquires passive immunity when it absorbs intact (whole) immunoglobulins through the intestinal wall during the first 24 hours of life.

Each form of immunoglobulin gives a calf some immunity against a specific disease or infection. The immunoglobulins in the colostrum are determined by the disease organisms or vaccinations a cow has encountered. A calf born and raised on the same farm as its dam is usually better protected against diseases on that farm than a purchased calf or a calf from a cow purchased shortly before calving.

Additional exposure of older cows to disease organisms and infections also means that the percentage of immunoglobulins in colostrum from mature cows may be more than twice that in colostrum from first-calf heifers. Good true colostrum from older cows can be frozen and used for all calves from 2-year-olds.

Immunoglobulin concentration is highest at calving and begins decreasing soon after calving. A long delay between calving and first milking reduces the amount of immunoglobulins as colostrum is diluted with newly synthesized milk.

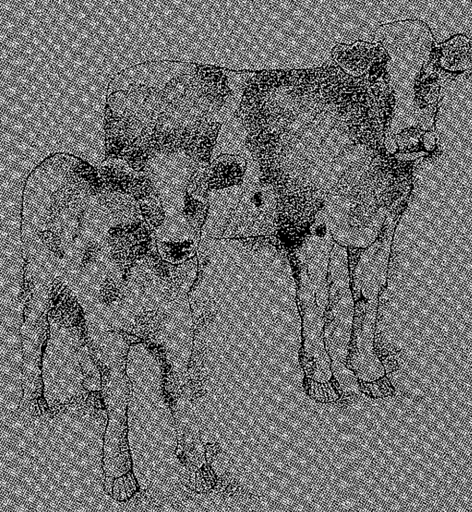
Table 12. Major types of immunoglobulins (Ig) and their functions

Type	% of total Ig	Provides immunity against:
IgG	80-86	Systemic infections
IgA	7-10	Intestinal infections
IgM	7-10	Systemic infections

Table 13. Typical immunoglobulin absorption by a 90-pound calf at the first two feedings

Milking	Lb/feeding	% Ig	Grams of Ig	% absorbed	Grams absorbed
1	4.5	10	204	20	40.8
2	4.5	5	102	20	20.4
Total Ig absorbed					61.2

Elevate a calf's head slightly when feeding it from a nipple pail.



Newborn calves can be fed colostrum and transitional milk continuously until they are weaned. Feed an amount equal to 4% to 5% of birth weight per feeding twice daily. It is not necessary to dilute fresh colostrum or transitional milk if it is fed continuously from birth until calves receive whole milk or milk replacer.

Fermented (Sour) Colostrum or Milk

There is usually enough excess colostrum and unsaleable milk from the first 10 milkings to feed calves through 21 to 35 days of age. This extra milk from the fresh cow may be stored economically at room temperature as fermented or sour milk.

Fermented or sour milk is an economical source of feed for raising calves. Use the following guidelines **when storing and feeding fermented milk:**

1. Feed newborn calves fresh or frozen colostrum for the first two feedings. Then feed transitional milk for at least the next four feedings (48 hours) at a rate equivalent to 4% to 5% of a calf's birth weight at each feeding. **Do not feed soured milk for the first 48 hours after birth.** Fermentation reduces the immunoglobulin content of colostrum and the acid in fermented milk may cause digestive upsets in newborn calves.

2. Store any excess colostrum and transitional milk in a clean plastic garbage container or other plastic-lined container. Keep containers covered to avoid contamination with dirt or disease-causing material. Do not store fermented milk in old milk cans or other metal containers because the acid produced during fermentation quickly corrodes metal.

Freeze extra good-quality colostrum in amounts needed for a single feeding.

3. Slowly mix the contents every time any fresh colostrum or transitional milk is added. Do not add extremely bloody or antibiotic-treated milk to the container. Antibiotics may prevent bacterial growth and prevent the proper fermentation.

4. Start feeding the fermented milk at the fifth feeding (third day). Always stir before removing from the container. Average solids content of pooled colostrum and transitional milk is 15% to 17%. Adding 1 part warm water to 3 parts fermented milk results in a mixture containing about 12% solids.

5. Store fermented milk at a relatively cool temperature (less than 70°F or 21°C).

6. Use a chemical additive to preserve milk if natural fermentation is not likely, such as when milk is stored at temperatures warmer that 70°F. Chemical additives can be used instead of relying on natural fermentation. Use propionic acid, a propionic-acetic acid mixture, or a commercial product. Add the acid at the rate of 1% to the fresh product. Mix fresh milk and acid before pouring it slowly into the container. Use commercial products according to label directions.

7. Feed fermented or acid-preserved milk within 3 to 4 weeks after it has been collected since nutrients, especially proteins, gradually break down during storage.

Feeding value of fermented milk is about equal to that of whole milk. As shown in Table 16, calves fed fermented milk gain about the same as those fed whole milk.

Table 16. **Gains of calves fed whole milk or fermented milk**[1]

Age of calves	Whole milk	Fermented milk[2]	Acid-treated fermented milk[2]
	Average daily gain (lb)		
0-4 weeks	0.59	0.46	0.53
0-5 weeks	0.66	0.66	0.59

[1] University of Minnesota

[2] Colostrum and transitional milk, fermented or treated with 1% propionic acid.

Whole Milk

Whole milk can be the primary feed for calves until they are weaned. Limited whole milk supplemented with proper amounts of starter is the best feed for growing young calves. Milk replacer is usually less expensive than saleable whole milk. Calves fed a good replacer make adequate growth but are not usually as sleek in appearance as those fed whole milk (Figures 4 and 5). Whole milk improves the sleek appearance of calves raised for show or sale.

However, there is no evidence that sleek appearance improves a calf's mature size or production ability.

Recommended daily feeding schedules are shown in Table 17. With careful feeding and good management, large-breed calves weaned at 5 weeks can be raised on 270 pounds of fresh or soured milk plus the 45 pounds of unsaleable milk (colostrum plus transitional milk) fed during the first 5 days. Weaning at 8

Table 17. **Limited whole milk plan for twice a day feeding**[1]

Age (days)	Type of milk	Calf birth weight 50 lb		75 lb		100 lb	
		Lb per		Lb per		Lb per	
		Feeding	Day	Feeding	Day	Feeding	Day
0-5	Colostrum and transitional milk	2-2.5	4-5	3-4	7-8	4-5	8-10
6-weaning[2]	Whole milk	2-2.5	4-5	3-4	7-8	4-5	8-10

[1] Offer starter at 3-5 days of age. Calves weaned at 5-8 weeks of age.

[2] Calves should consume starter at a rate of 1% of body weight before weaning.

weeks requires 45 pounds of colostrum and transitional milk plus 460 pounds of additional milk. Keep fresh starter available at all times.

Overfeeding whole milk can cause indigestion and scouring. Do not feed calves as much milk as they will drink. A sudden change in either the quantity or quality of milk can cause digestive problems.

To avoid digestive upsets, either weigh or measure the milk fed each calf or use a container holding the correct volume of milk.

Substantial changes in the fat and solids content of the milk fed can cause digestive upsets. Table 18 shows the composition of milk by various breeds. If milk containing more fat (5.5%) replaces a milk containing less fat (3.5%), add 1 part warm water to 3.5 parts of the high-fat milk to help prevent indigestion and scours. Milk containing less fat will not cause digestive upsets when it is substituted for richer milk.

The amount of whole milk fed depends on the birth weight and vitality of the calf and the fat content of the milk. The rule of thumb "feed 1 pound of milk per day for each 10 to 12 pounds of body weight at birth" is a fairly satisfactory feeding guide. Calves should be fed this amount until they are weaned.

Milk should be fresh, sweet and clean. Temperature of milk should be uniform. Milk may be warmed to about 100°F if desired. Milk for older calves need not be quite so warm or so uniform in temperature.

Bloody milk caused by a ruptured blood vessel may be safely fed to calves. Do not feed bloody milk from a cow that has an elevated temperature or that is off feed. Milk from such a cow may contain harmful bacteria.

Feeding Mastitic or Antibiotic-Treated Milk

Most of the milk that does not meet strict legal requirements for marketing can be used to feed calves. Milk that is obviously very abnormal in appearance, milk from sick cows (those with high temperatures) and the first milk following antibiotic treatment should not be fed.

Mastitic milk or milk from cows treated for mastitis can be fed to calves housed and fed in individual stalls or if each calf is locked up separately for at least 30 minutes after feeding. Calves fed mastitic milk that suck each other may inoculate the rudimentary teats and cause heifer mastitis. Calves consuming mastitic milk do not pass these organisms from the gut to the udder. Organisms enter the undeveloped mammary gland through the rudimentary teats when they are sucked by other calves.

Milk from antibiotic-treated cows cannot be sold for the specified withholding time. Calves fed milk or milk replacer containing antibiotics cannot be sold for slaughter until all antibiotics have been eliminated. Recommended feeding rates for mastitic or antibiotic-treated milk are similar to those for whole milk.

Substituting Extra Transitional Milk for Whole Milk

The nutrient composition of transitional milk is essentially the same as whole milk by the sixth milking. During this time, protein and immunoglobulin levels decrease and lactose levels increase (Table 11). Transitional milk stored with colostrum contains some immunoglobulins that may help control bacterial growth in the gut.

Table 18. **Average fat and solids composition of milk by breeds**

Milk component	Ayrshire	Brown Swiss	Guernsey	Holstein	Jersey
Fat, %	4.0	3.8	4.6	3.6	5.0
Total solids, %	12.7	12.6	13.8	12.2	14.0

When transitional milk is substituted for "normal" milk, dilute transitional milk by adding 1 part water to 3 parts of milk. Dilution reduces the percentage of solids in transitional milk so it equals that of whole milk. Whole milk contains 12.5% to 13% solids while transitional milk averages about 15% to 16% solids. A 3:1 dilution rate for transitional milk helps avoid stomach upsets in calves already adjusted to "normal" milk.

Other Substitutes for Whole Milk

Skim Milk Excellent calves can be raised by the "skim milk" method. Feed whole milk until the calf is about 3 weeks old, then gradually shift to skim milk during the next week. Gradually increase the amount fed. About 15 pounds of skim milk replace 10 pounds of whole milk.

Feeding value of 1 pound of skim milk powder equals that in 10 pounds of skim milk. Mix 1 pound of powder with 9 pounds (about 1 gallon) of warm water. Feed about 15 pounds of the reconstituted liquid skim milk to large-breed calves. Powder may be economical to use when dry skim milk is relatively low in price.

Be sure to keep a high-quality starter available at all times. Remember that skim milk powder does not contain vitamins A and D nor does it contain trace minerals normally added to milk replacer. Milk, milk replacer or whey powder that has been overheated should not be fed because heat-damaged proteins have very low digestibilities.

Liquid or Dry Whey Clean, fresh sweet whey may be fed to calves with fair success. Acid whey is not recommended for growing replacement heifers because it may cause sore gums and tooth decay. Sweet whey must be fed fresh daily. Feeding equipment must be kept clean. Overfeeding may lead to excessive urination and loose feces.

Gradually switch from whole milk to whey over 7 to 10 days when the calf is more than 4 weeks old. Since whey is low in protein, a high-protein starter is necessary. The starter must provide vitamins and trace minerals.

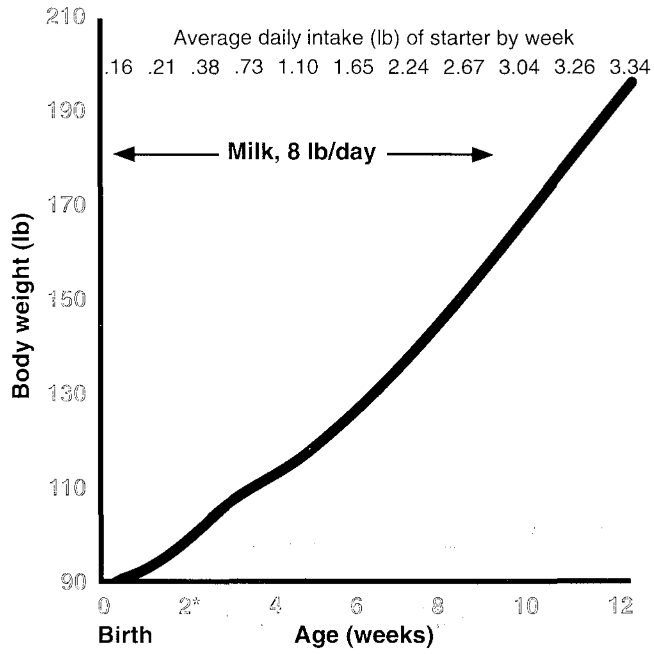


Figure 4. **Weight gains and starter intake of calves raised in hutches.**
*Forage offered free choice

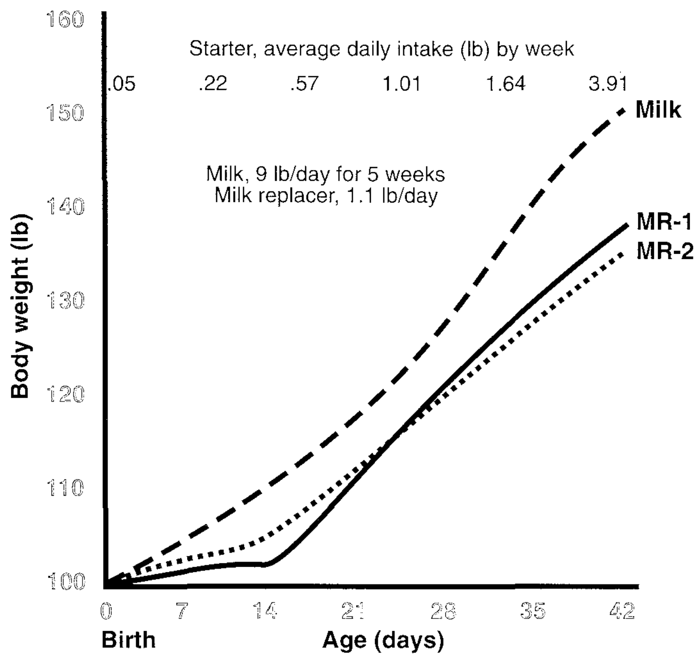


Figure 5. **Weight gains of holstein heifers fed milk or high-quality milk replacer.**

Good-quality dried whey is a satisfactory substitute for fresh whey. Mix 1 pound dry whey in 9 pounds of water (10% solids).

Combinations Whole milk/replacer, whole milk/skimmed milk or whole milk/whey combinations can be used. Combinations of fermented or sour colostrum and milk replacer are also satisfactory growing rations for calves. Make gradual changes to avoid digestive upsets. It is best not to change the feeding program during the first 2 weeks.

Feeding Milk Replacers

Calves may be started on a milk replacer at 4 to 6 days of age. However, many producers feed whole milk to calves until they are 10 to 14 days old, then gradually switch to a milk replacer.

Replacers usually contain less fat than whole milk on a dry basis. Most replacers contain 75% to 86% as much energy as whole milk on a dry basis. As shown in Figure 5, calves fed milk replacers weigh slightly less than calves fed whole milk. This reduction in weight is not "unhealthy" since the primary goal is to wean a healthy calf with adequate skeletal growth.

Suggested plans for feeding milk replacer are shown in Table 19. In all of these plans, colostrum and transitional milk are fed at least until calves are 4 days old. Milk is not legally saleable until the sixth day after freshening. There is some benefit in feeding fermented, frozen or refrigerated colostrum or other whole milk until calves are 14 days old.

Feed a Good-Quality Milk Replacer The feed tag or label provides basic information on a replacer's nutrient content and ingredients. Compare this information (Figure 6) to the following general guidelines or to labels on other brands. Also read the directions for using the replacer. A replacer designed specifically for calves more than 3 to 4 weeks of age should not be fed to younger calves. The reputation of the manufacturer is a good indication of the quality of ingredients used in a replacer.

Fat The energy content of a milk replacer varies with the amount of fat. The fat level in a good milk replacer should be at least 10% and may be over 20%. University of Wisconsin researchers found that there was no real difference in the performance of calves raised in hutches fed milk replacers containing 10,15 or 20% fat.

Milk replacers containing the higher levels of fat may be of added benefit when calves are raised in less than ideal conditions. The higher fat levels tend to

Table 19. Milk replacer (MR) plans for twice a day feeding

Age (days)	Feeding system	Per feeding based on birth weight of: 50 lb		75 lb		100 lb	
		Lb/feeding					
0-5	Colostrum and transitional milk	2-2.5		3-4		4-5	
		MR	**Water**	**MR**	**Water**	**MR**	**Water**
		Lb/feeding					
6-14	Milk replacer[1,2,3]	0.2	1.8	0.3	2.78	0.4	3.6
15-weaning	Milk replacer[4]	0.3	2.2	0.4	2.9	0.5	3.7

1 Follow the manufacturer's instructions.

2 May feed whole milk to 14 days of age, then gradually change to milk replacer.

3 Contains 9 parts water, 1 part milk replacer (10% solution).

4 Contains 7 parts water, 1 part milk replacer (12% solution).

reduce the severity of diarrhea and also provide additional energy for growth, particularly when energy needs are increased in very cold environments. High levels of fat are also recommended for finishing veal calves.

The quality of fat is as important as the quantity of fat. Animal fats (lard, tallow or grease) are the best fat sources. Hydrogenated vegetable oils (solid at room temperature) may be used while liquid (unsaturated) vegetable oils are less satisfactory. Soy lecithin, especially when homogenized, is an acceptable fat source and improves mixing properties of the replacer.

Protein A milk replacer containing only milk proteins should contain at least 20% to 22% protein. Milk replacers should contain 22% to 24% protein when soy isolates, soy concentrates or chemically modified soy protein are used because plant proteins are less digestible than milk protein. Acceptability of various protein sources in milk replacers is listed in Table 20. Comparisons can be made between this list and protein sources listed on milk replacer feed tags. Protein quality can affect calf growth. Calf performance is the true indicator of the value of milk replacers.

Carbohydrates Lactose (milk sugar) is the best source of carbohydrates for calves. Glucose and dextrose can be used as substitutes. Other carbohydrates (starch and common sugar) are poorly digested by young calves. Excessive starch intake is a primary cause of scours in calves less than 21 days of age. Milk replacers containing starch can be fed to calves that are more than 2 weeks old but preferably more than 3 weeks old.

Newborn calves do not utilize fiber; however, fiber does not harm the calf. More than 0.25% fiber in a replacer usually indicates that the milk replacer contains a plant source of carbohydrate or protein. However, check the ingredient listing on the milk replacer tag since milk replacers containing soy isolates will not necessarily contain high levels of fiber.

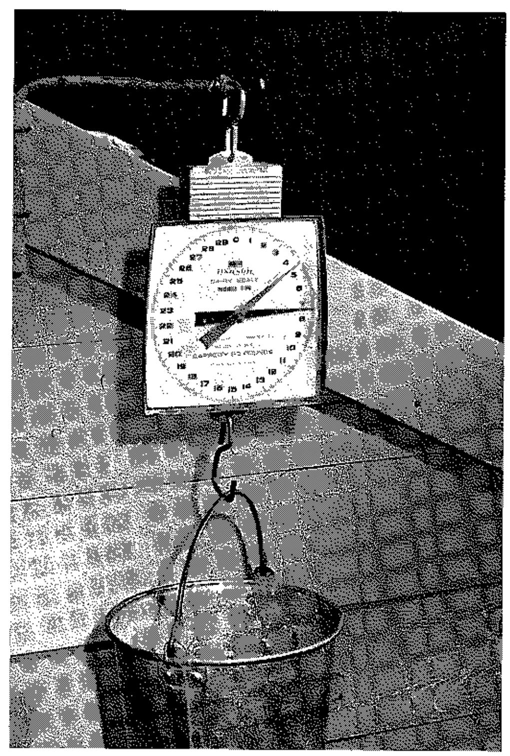
Minerals and Vitamins Since milk replacers are fortified with minerals and vitamins, additional supplements of minerals and vitamins are not usually needed. However, many dairymen provide calves with free access to trace mineral salt.

Table 20. Quality of proteins and fats in milk replacers

Protein sources		
Best	**Acceptable**[1]	**Inferior**
Skim milk	Chemically modified soy protein	Unprocessed soy flour
Buttermilk	Soy isolate	Meat solubles
Whole whey	Soy concentrate	Fish flour
Delactosed whey	Hydrolyzed fish protein	Distiller solubles
Casein[2]		Brewer's yeast
Milk albumin		Oat flour
Whey protein concentrate		Wheat flour
Fat sources		
Lard Tallow Stabilized greases	Hydrogenated vegetable oils	Liquid vegetable oils

[1] These specially processed products are acceptable when used with one or more sources from the "best" column.

[2] It is desirable that at least half of the protein be derived from casein.



Weigh or measure colostrum, transitional milk or normal milk before feeding.

Injecting vitamins A, D and E assures adequate levels for purchased calves that may have received limited amounts of colostrum before sale. Vitamin injections also provide reserves that a calf stores and uses if feed is withheld during scours treatment or when off-feed for any reason.

Antibiotics Many milk replacers contain antibiotics. When fed according to manufacturers' directions, legal levels are not exceeded. Antibiotics are no substitute for good management. Their value in reducing the incidence of scours and respiratory problems is debated. Be sure to follow recommended withdrawal times to avoid illegal residues if calves are marketed.

Dilution Rates Dry milk replacer must be mixed with water for feeding. The liquid replacer, as fed, should contain 85% to 90% water. Use the mixing rates suggested in Table 19.

It is important that calves consume enough water with the solids. Too little water with solids may increase the incidence of scours while too much water reduces solids intake and may reduce growth rates.

Water Temperature For ease in mixing, water should be about 110°F. Put water in the container and slowly stir in the powder with a wire whip. The temperature should decrease to about 100°F after mixing.

Keep Replacer Dry and Clean Close milk replacer bags and keep them in a container with a tight cover. Quality is reduced and replacer may become contaminated with disease organisms if the bag is left open and exposed to light, moisture, air, flies and rodents. Use only clean feeding equipment.

Feeding Methods — Milk or Milk Replacers

Most calves are weaned at 5 to 8 weeks of age. Regardless of the feeding system, a calf should not be weaned until it is growing well and is consuming the recommended amount of starter — at least 1% of body weight.

Do not wean a calf that is consuming less than the minimum amount of starter or that is not growing well at the desired weaning age. To encourage consumption of dry starter, feed either milk or milk replacer once per day for 5 to 7 days before the desired weaning age. Also limit the amount of forage to encourage starter intake and rumen development. Free choice access to clean fresh water is also a benefit to starter consumption.

Early Weaning Calves can be successfully weaned at 21 to 24 days of age if they are offered a high-quality starter by 3 days of age and if they are consuming enough starter by the desired weaning age. However, many calves weaned this young may not do well for 7 to 10 days following weaning or until they consume at least 2 pounds of starter per 100 pounds of body weight daily, plus forage.

Table 21. Age at weaning and heifer calf mortality[1]

Age weaned (weeks)	No. herds	Average mortality of calves 1-6 months of age
3 to 4	11	14.2
5 to 6	28	9.0
7 to 8	58	7.1
8	42	6.1

[1] Clemson University

Table 22. Adjusting amounts for other daily feeding schedules

Times fed per day	Amount fed (% of birth weight) Total per day	Total per feeding
1[1]	7	7
3[2]	9	3

[1] For example, a 100-pound calf would receive 9 pounds of whole milk or 8 pounds of reconstituted milk replacer daily when fed twice a day. For once-a-day feeding, the recommendation is:
6 pounds milk plus 1/4 pound milk replacer OR
1 pound milk replacer with 5-6 pounds (2 1/2-3 quarts) water.

[2] Divide total amount fed into three equal parts.

As shown in Table 21, mortality of calves weaned at 3 to 4 weeks of age was approximately 50% higher than in herds where calves were weaned at 7 or more weeks. Increased calf losses with early weaning probably resulted because the calves were not ready to be weaned. **Calves must be strong, healthy and consuming adequate amounts of dry feed before they are weaned.**

Frequency of Feeding

Most calves are fed two equal feedings per day. Weak calves may benefit from more frequent feeding. If calves are fed three times daily, divide the total milk or replacer fed per day into equal portions. Follow the same routine daily (see Table 22).

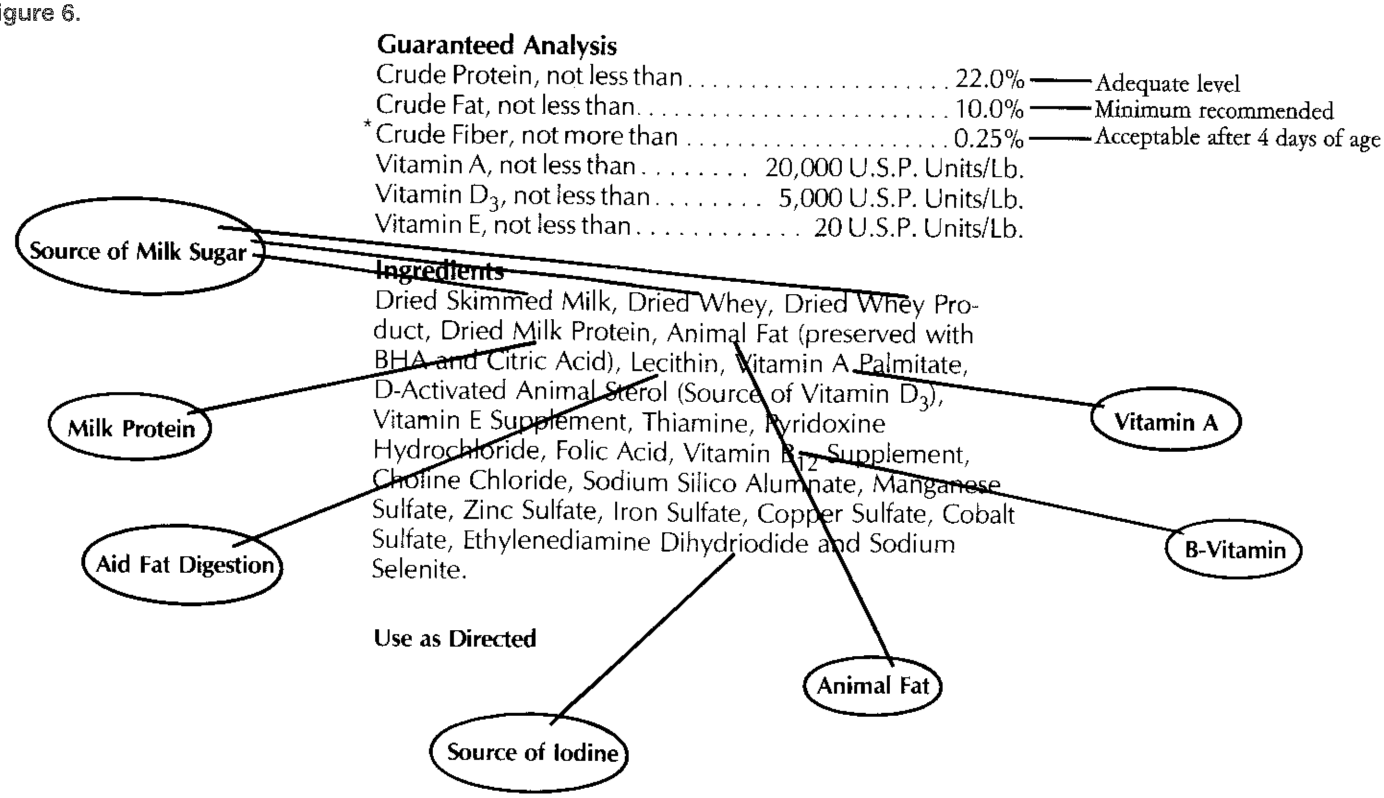
Once-A-Day Feeding Once-a-day feeding requires careful management. Total liquid intake should be limited. Reduce the volume fed to 70% of that fed daily with a twice-a-day feeding schedule. However, calves fed once daily should receive about the same amount of dry matter daily as calves fed twice daily.

Once the proper amount of dry replacer has been determined, mix 6 pounds of water (instead of 8 pounds) per pound of dry replacer. If whole milk is fed once a day, add 4 to 5 ounces of dry replacer or dry skim milk to each gallon of whole milk.

It requires careful management when calves are fed once daily. Calves should be observed 3 to 4 times daily the first 4 weeks to check on their health. Once-a-day feeding reduces time required for feeding but may not reduce total labor. It is certainly no substitute for good management and should only be tried when calves are raised under the best conditions. Once-a-day feeding may increase the incidence of scours due to high total solids intake at a single feeding or from excessive concentration of solids.

MILK REPLACER

Figure 6.



* Replacers containing chemically modified soy protein contain higher levels of fiber which may be acceptable

MILK REPLACER

GUARANTEED ANALYSIS

Crude Protein	(Min.) 22.0%	Adequate level
Crude Fat	(Min.) 10.0%	Minimum recommended
* Crude Fiber	(Max.) 0.5%	Acceptable after 14 days of age
Vitamin A—Not less than	15,000 IU/Lb.	
Vitamin D_3—Not less than	3,000 IU/Lb.	

Ingredients

Dried skimmed milk, dried whey, casein, animal fat preserved with BHA, soy protein concentrate, methionine, vitamin A supplement, D-activated animal sterol (source of vitamin D_3), vitamin E supplement, thiamine hydrochloride, niacin, ascorbic acid, calcium carbonate, dicalcium phosphate, magnesium oxide, zinc oxide, manganese sulfate, iron carbonate, copper sulfate, ethylene diamine dihydriodide, cobalt carbonate, sodium selenite and artifical flavor.

Milk Protein
Source of Milk Sugar
Plant Protein (source of increased fiber level)
Sulfur Containing Amino Acid
Vitamin C
B-Vitamin
Source of Iodine

Use as directed on back of label.

* Replacers containing chemically modified soy protein contain higher levels of fiber which may be acceptable

MILK REPLACER

GUARANTEED ANALYSIS

Crude Protein, not less than	24.0%	Adequate level
Crude Fat, not less than	10.0%	Minimum recommended
Crude Fiber, not more than	1.0%	Acceptable after 21 days of age
Vitamin A, not less than	20,000 U.S.P. Units/Lb.	
Vitamin D_3, not less than	5,000 U.S.P. Units/Lb.	
Vitamin E, not less than	20 U.S.P. Units/Lb.	

Ingredients

Dried Skimmed Milk, Dried Whey, Dried Whey Product, Dried Milk Protein, Soy Flour, Animal Fat (preserved with BHA and Citric Acid), Lecithin, Vitamin A Palmitate, D-Activated Animal Sterol (Source of Vitamin D_3), Vitamin E Supplement, Thiamine, Pyridoxine Hydrochloride, Folic Acid, Vitamin B_{12} Supplement, Choline Chloride, Manganese Sulfate, Zinc Sulfate, Iron Sulfate, Copper Sulfate, Cobalt Sulfate, Ethylenediamine Dihydriodide and Sodium Selenite.

Plant Protein
Milk Protein
Preservatives
Source of Selenium
Source of Trace Elements

Use As Directed

Provide calves with fresh starter and clean water. Clean water bucket regularly. Separating water from feed will keep water cleaner.

FEEDING CALF STARTERS

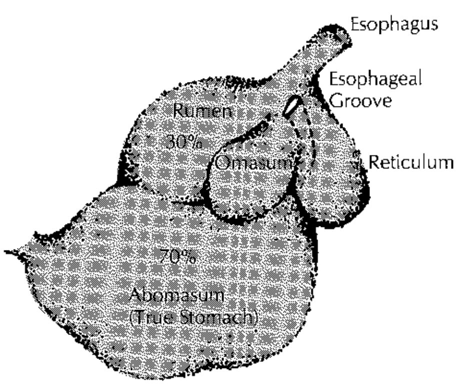
Rumen Development

The feeds young calves consume must be tailored to the stages of rumen development. The newborn calf is essentially a nonruminant, a single-stomached animal. It lacks a functional rumen and is unable to digest fiber. As shown in Figure 7, the true stomach (abomasum) is the largest compartment of a newborn calf's stomach. The esophageal groove diverts milk or liquid milk replacer to the abomasum. This prevents milk from entering the undeveloped rumen, which might lead to undesirable fermentation and cause scouring.

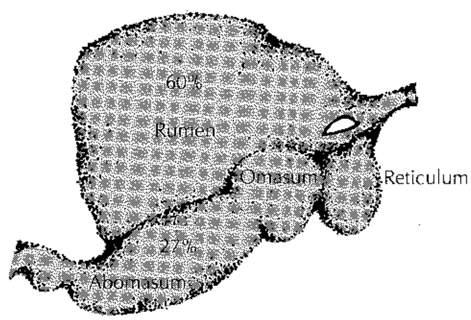
Intake of highly digestible starter stimulates development of the rumen microflora and rumen tissue (papillae). These microorganisms grow rapidly and produce volatile fatty acids (VFAs) — acetic, propionic and butyric acids — during fermentation. These acids help stimulate papillae development in the rumen. The population of rumen microbes must be established before calves are weaned.

Offer calves a high-quality starter (pp. 31-34) at 3 to 5 days of age. Limit milk or milk replacers to recommended levels (Tables 17 and 19) to encourage intake of starter. Calves fed more than recommended

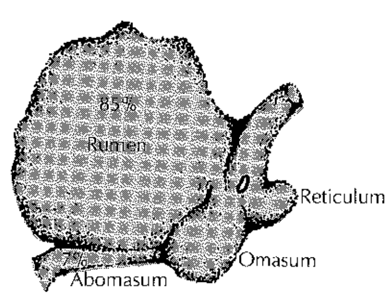
Figure 7. Rumen development



Phase 1
Non-ruminant (Birth to 21 days of age) Abomasum is 70% of total stomach. The rumen is undeveloped and nonfunctional. Rumen development is stimulated by dry feed intake.



Phase 2
(22 to 56-84 days of age) Dry feed intake, especially grain (starter) stimulates growth of the rumen microorganisms which produce volatile fatty acids. These acids stimulate growth of rumen tissue.



Phase 3
(More than 84 days of age) At this stage, the calf can be considered a ruminant.

amounts of milk or milk replacer will reduce their consumption of starter. This delays rumen development and increases rearing costs.

Feed for Good Growth

Feed for good growth, not just for weight gain. Excess fat gained from birth to puberty causes extra fat to be deposited in the mammary gland. This reduces the calf's future ability to produce milk. Fat heifers of recommended weight for their age are more prone to metabolic disorders and calving problems than well-grown heifers of the same weight.

Table 23 shows suggested weights for various breeds of heifers from birth to 4 months. Table 24 shows the average daily gain suggested for Holstein calves from birth to 4 months of age.

Feed for Health and Vigor

A feeding program should result in weaned calves that are healthy and strong. It is more important for calves to remain healthy that to achieve maximum growth. Calves are often overfed in an attempt to induce rapid growth. Overfeeding causes indigestion, as indicated by scouring (diarrhea), which severely retards growth.

Table 25 shows the nutrient requirements of dairy calves as suggested by the National Research Council.

Starting Calves on Dry Feed

The first dry feed offered to calves is starter. Starter is a very palatable, coarse-textured or pelleted concentrate. It should contain 75% to 80% TDN and 16% to 20% crude protein (see Table 26).

There are two types of starters. **Grain starters** are fed with forages. **Complete starters** contain forages.

A complete starter is preferred by many dairymen, especially those who raise large numbers of calves. Since calves can't select among feedstuffs, it is easier to control their intake of concentrate and forage and to make sure all calves consume both concentrate and forage.

Tables 27 and 28 show examples of ingredients used in starters.

Teaching Calves to Eat Starter Calves 3 to 5 days of age should be encouraged to eat some starter. Encourage a calf to eat by placing a handful of starter in a milk pail or on the calf's muzzle immediately after it has finished drinking milk. All calves should be eating some starter at 7 to 10 days of age.

Keep starter fresh by feeding small amounts. Regularly remove and replace any uneaten feed.

Feeding A Grain Starter Feed as much grain starter as a calf will eat until starter intake reaches 4 to 5 pounds daily. Provide good-quality forage free-choice with starter a week before a calf is weaned.

Table 23. Average birth weight and recommended weights for first four months

Age (months)	Brown Swiss, Holstein	Ayrshire, Guernsey	Jersey
	Lb		
Birth	90-100	65-75	55-60
1	135-145	90-100	70-80
2	175-185	135-145	110-120
4	270-280	225-235	190-200

Table 24. Average birth weight and recommended daily gain for Holstein calves

Age (months)	Weight (lb)	Average daily gain by month[1] (lb/day)
Birth	96	—
1	140	1.37
2	185	1.54
3	225	1.21[2]
4	280	1.87

[1] Average daily gain from birth to 4 months of age is about 1.5 pounds for Holstein calves.

[2] Slightly lower weight gains are somewhat normal post-weaning. Post-weaning lags should be minimized, however.

Feeding A Complete Starter A complete starter containing forage is fed free-choice. Additional forage need not be fed until the calf is about 3 months of age. Either type of starter should be fed to calves until they are 4 months of age. Calves should eat at least 1 pound of starter daily per 100 lbs. body weight before they are weaned.

Quality Is Important

The growth rate of young calves depends on starter intake. Unpalatable or poor-quality starters will decrease intake, retard rumen development and decrease calf growth.

A coarse mixture is preferred since texture is a major factor affecting palatability. Farm grains used in starters may be coarsely ground, rolled or crushed. Whole oats and/or corn are satisfactory.

High-moisture grains are also satisfactory but it is essential that they not be allowed to heat and mold in mangers. When feeding high-moisture grains, it is necessary to frequently feed small amounts and regularly remove any leftover material.

Coarse meals, pellets or a mixture of the two types are satisfactory for most calves. Added micronutrients are more uniformly mixed when starters are pelleted. Adding liquid molasses improves palatability, reduces separation of micronutrients and reduces waste.

Energy Young calves need dry feed containing large amounts of readily digestible energy. Their rumens lack the microbial population required to digest crude fiber. A readily fermentable feed improves microbial growth and fosters rumen development. Complete starters may contain as much as 35% good-quality forage. Beet pulp, soybean hulls

Table 25. Daily nutrient requirements of dairy calves[1]

	Body weight (lb)	Mcal NEm	Mcal NEg	TDN (lb)	Crude protein (lb)	Minerals Ca (grams)	Minerals P (grams)
Small-breed calves	60	1.02	0.23	1.03	.18	5.9	3.6
	75	1.21	0.36	1.55	.26	7.3	4.1
	100	1.50	0.70	2.24	.44	9.5	5.9
Large-breed calves	90	1.39	0.37	1.32	.24	6.8	4.1
	100	1.50	0.64	2.24	.44	8.2	5.4
	150	2.04	1.29	3.92	.77	15.4	7.7
	200	2.53	1.54	4.33	.99	17.7	9.1

[1] Adapted from 1989 NRC Nutrient Requirements of Dairy Cattle.

Table 26. Range in nutrient specifications for "grain starters" and "complete starters"

	"Grain starter"[1]		"Complete starter"[2]	
Nutrient (D.M. basis)	**Low**	**High**	**Low**	**High**
Energy, TDN, %	76.0	78.0	70.0	74.0
Crude protein, %	16.0	20.0	16.0	18.0
Ether extract, %	2.5	5.0	2.5	5.0
Crude fiber, %	2.0	7.0	8.0	15.0
Calcium, %	0.4	0.6	0.4	0.6
Phosphorus, %	0.3	0.4	0.3	0.4
Vitamin A, IU/lb	750	1000	750	1000
Vitamin D, IU/lb	140	300	140	300

[1] Offer free choice with or without forage

[2] Offer free choice **without** additional forage.

and early cut alfalfa are good-quality forages. Complete starters should not contain more than 15% total crude fiber or 18% to 19% acid detergent fiber (ADF).

Protein Quality Both types of starters should contain 16% to 20% crude protein. High-quality plant protein is adequate since the calf receives animal protein from milk or milk replacer. Calves weaned at 3 to 4 weeks of age should be fed starters containing 20% of a high-quality protein. Starters containing 16% plant crude protein are adequate for calves more than 6 weeks of age that are still consuming milk or milk replacer.

At 4 months of age, calves can be fed a growing ration. This may be the same grain and forage fed to the milking herd. Calves do not utilize urea or other nonprotein nitrogen efficiently when it is fed with typical rations containing 13% or more crude protein in the total ration (dry matter basis). Thus, nonprotein nitrogen is not a good crude protein supplement until calves are more than 6 months of age.

Vitamins and Minerals Most commercial calf starters are fortified with vitamins A, D and E. Young calves need these vitamins in the starter, since their forage intake and exposure to sunlight are not sufficient to ensure adequate vitamin intake.

Commercial starters are also fortified with minerals, a calcium-phosphorus source, salt and trace minerals. Provide a source of selenium if signs of selenium deficiency, such as white muscle disease, have been observed. Free-choice feeding of trace mineral salt and calcium-phosphorus source is a practical way to make adequate amounts of mineral available.

Most dairy farms do not use enough starter to justify mixing their own. Use the ingredients shown in Tables 27 and 28 as a guide to formulate starters and evaluate commercial starters.

Antibiotics Many starters contain antibiotics. Antibiotics are not needed in starters, although they are frequently used when whole milk or sour colostrum is the liquid feed. If the milk replacer contains antibiotics, do not use a starter containing antibiotics.

Ten to 15 milligrams of chlortetracycline (aureomycin) or oxytetracycline (terramycin) per pound of starter is a typical level. Follow label instructions when feeding starters containing antibiotics. Pay careful attention to suggested antibiotic withdrawal times if calves are marketed for slaughter.

Forages

Calves fed a complete starter do not need to be fed additional forages. However, feed calves forages for 2 to 3 weeks before starter is discontinued. Calves fed a grain starter may be offered forages at any time, but they should consume some forage for at least 1 week before they are weaned. The growth and development of the rumen and nutrient intake of young calves depend more on grain intake than on forage intake.

Alfalfa-grass or good-quality grass hay is the forage most commonly fed to calves. Hay can be long, chopped or pelleted. Chopped or pelleted hay is easier to handle and less wasteful. Calves tend to waste long hay. Chopped hay is often dusty.

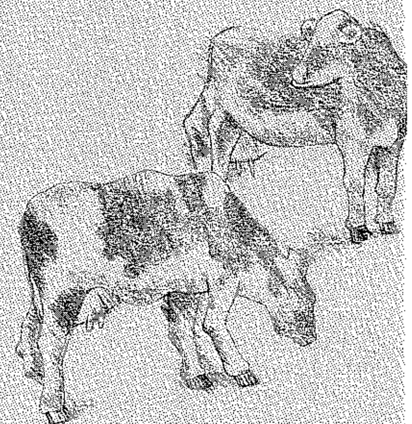
Very young calves can be fed high-quality corn silage and hay-crop silage (40% to 55% dry matter). It is difficult to keep silage fresh and palatable, however. Regularly remove silage that heats or molds from mangers. On most farms, dry hay is a more convenient source of forage for young calves than silage.

Table 27. Example "grain starters"

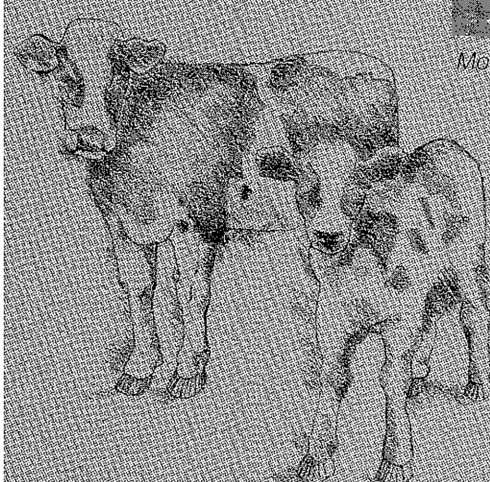
	Amounts Shown Air Dry Basis										
Ingredient	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Corn	40.0	36.0	32.0	40.0	35.0	30.0	45.0	44.0	32.0	50.0	50.0
Oats	30.0	35.0	30.0	21.0	35.0	13.0			15.0		
Wheat Bran						10.0	18.0	14.0	10.0	10.0	
Gluten Feed							10.0	20.0	10.0		20.0
Distillers Grains							15.0		10.0	10.0	
Linseed Meal						10.0			10.0	10.0	10.0
44% C.P. Supplement	22.6	21.6	20.8	21.8	22.7	10.0	14.8	14.7	5.9	12.8	12.9
Whey, Dried			10.0	10.0		10.0					
Molasses	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Mineral 23% Ca and 18% P	.6	.6	.5	.5	.6						
Feed Limestone or CaCO3	1.5	1.5	1.4	1.4	1.4	1.7	1.9	2.0	1.8	1.9	1.8
Trace Mineral Salt	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	Starter Composition, D.M. Basis										
Composition, D.M. Basis	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Crude Protein, %	19.7	19.5	19.4	19.4	19.9	19.6	19.7	19.5	19.6	20.2	20.7
TDN, %	80.7	80.2	80.3	81.2	80.3	79.5	81.3	80.9	80.0	81.8	82.7
NE-Maint. Mcal/lb D.M.	.90	.89	.89	.90	.89	.88	.90	.90	.89	.91	.92
NE-Growth Mcal/lb D.M.	.60	.60	.60	.61	.60	.59	.61	.61	.60	.62	.63
ADF, %	7.9	8.5	7.5	6.4	8.6	8.3	7.9	7.1	10.1	7.6	6.7
NDF, %	16.8	17.9	15.7	13.7	18.0	20.4	22.3	22.1	25.0	18.6	17.6
Calcium, %	.93	.92	.92	.92	.89	.95	.93	1.02	.92	.94	.95
Phosphorus, %	.51	.51	.52	.52	.51	.59	.57	.61	.54	.52	.51
Trace Mineral Salt, %	.28	.28	.28	.28	.28	.28	.28	.28	.28	.28	.28

Table 28. Example "complete starters"

	Complete Starter Ration, Amounts Shown Air-Dry Basis										
Forages	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Corn	24.0	22.0	45.0		24.0	28.0	15.0	33.0	15.0	20.0	30.0
Oats	35.0	22.0		22.0	24.0			10.0	10.0		
Ear Corn				35.0			23.0		10.0	10.0	
Gluten Feed					20.0	27.0	13.0		10.0		12.0
Distillers Grains							13.0	15.0	10.0	18.0	12.0
Beet Pulp		15.0				10.0			10.0	15.0	10.0
44% C.P. Supplement	15.0	17.0	18.0	17.0	10.0	10.4	10.0	10.0	12.0	12.0	11.0
Alfalfa	18.9	17.0	30.0	18.8	14.9	17.9	19.0	25.0	16.0	17.8	8.0
Molasses	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Mineral 23% Ca and 18% P	1.1	1.2	1.2	1.2	.8	.7	.9	1.2	1.0	1.3	1.0
Feed Limestone or CaCO3	.7	.5	.5	.7	1.0	.7	.8	.5	.7	.6	.7
Trace Mineral Salt	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	Complete Starter Ration, Analyses - Dry Matter Basis										
Composition, D.M. Basis	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Crude Protein, %	18.4	18.5	19.2	18.5	18.7	19.3	19.4	18.9	19.4	19.1	19.5
TDN, %	75.6	76.1	76.4	75.1	77.1	78.0	78.0	77.0	77.4	77.8	78.4
NE-Maint. Mcal/lb D.M.	.82	.83	.83	.82	.84	.85	.86	.84	.85	.85	.86
NE-Growth Mcal/lb D.M.	.54	.55	.55	.54	.56	.57	.57	.56	.56	.57	.57
ADF, %	14.2	16.6	13.4	15.4	13.1	14.6	14.3	14.8	16.1	17.1	15.0
NDF, %	24.3	27.6	20.4	26.2	26.7	29.2	28.0	25.6	30.1	30.1	28.4
Calcium, %	.82	.84	.88	.85	.86	.83	.83	.82	.85	.90	.87
Phosphorus, %	.51	.51	.53	.52	.53	.53	.52	.52	.52	.52	.53
Trace Mineral Salt, %	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34
Grain, % in Diet D.M.	91.9	93.9	80.2	92.4	96.3	93.1	92.2	85.4	95.1	93.2	93.0
Forage, % in Diet D.M.	21.4	19.2	34.4	21.4	16.9	20.3	21.6	28.5	18.1	20.2	20.4



Monitor heifer growth.



HOW FAST SHOULD HEIFERS GROW?

Large-breed heifers should weigh 825 to 875 pounds at 14 months of age. Heifers bred at that weight and age will calve at 24 months of age. As shown in Table 29, Holstein and Brown Swiss heifers should weigh 1,250 pounds at 22 months of age (2 months before calving). To reach that weight, large-breed heifers should gain an average of 1.7 pounds daily (50 pounds per month) during the period from 3 months of age to 2 months before calving. Comparable figures for Guernsey or Ayshire are 1.5 pounds daily or 45 pounds per month. Jersey heifers should gain an average of 1.3 pounds daily (40 pounds per month).

Feed heifers so they reach the recommended breeding size shown in Tables 29, 30 and Figure 8 when 14 to 15 months old. **A general guideline is to breed heifers when they reach 60% of their mature milking weight**.

Overfed heifers have adequate weight at a younger age but lack skeletal growth. Large-breed heifers that weigh 800 to 850 pounds at 11 to 12 months of age will be overly fat. Although these fat heifers have reached breeding weight, they lack sufficient bone growth, particularly in the pelvic area, and will have difficulty calving if bred at that time. Excessively fat heifers may also have lower conception rates. The amount of milk secretory tissue may be reduced when fat is deposited in the developing udder. Excess weight gain is more damaging to heifers before puberty than after they are bred.

Although heifers should not be overfed, they should not be underfed either. Large-breed heifers reach puberty, the onset of estrus, when they weigh about 600 pounds. If heifers are underweight, onset of estrus will be delayed, which eventually delays breeding and age at calving. With the right ration, it is possible to feed heifers so they have adequate weight and growth for breeding at 14 to 15 months of age.

Monitor Heifer Growth

Check weight gains of heifers to determine whether heifers are growing so they can be bred and will calve at the desired ages. Periodically checking weights and heights of heifers also helps you evaluate your feeding program. Use a scale or a tape to

Table 29. Desirable weights for dairy heifers

Age in months	Brown Swiss or Holstein	Ayshire or Guernsey	Jersey
	Lb		
Birth	90-100	65-75	55-60
1	135-145	90-100	70-80
2	180-190	135-145	110-120
4	280-290	225-235	190-200
6	390-400	315-325	270-280
12	750-780	585-600	510-520
*14	825-875	680-700	580-600
18	1000-1100	850-875	750-775
22	1200-1275	1025-1075	900-950
24	1300-1350	1100-1150	950-1000

* Breed heifers in this weight range. Heifers should weigh about 60% of their mature weight when bred. With proper feeding, heifers should reach these weights and have good skeletal growth when 14-15 months of age.

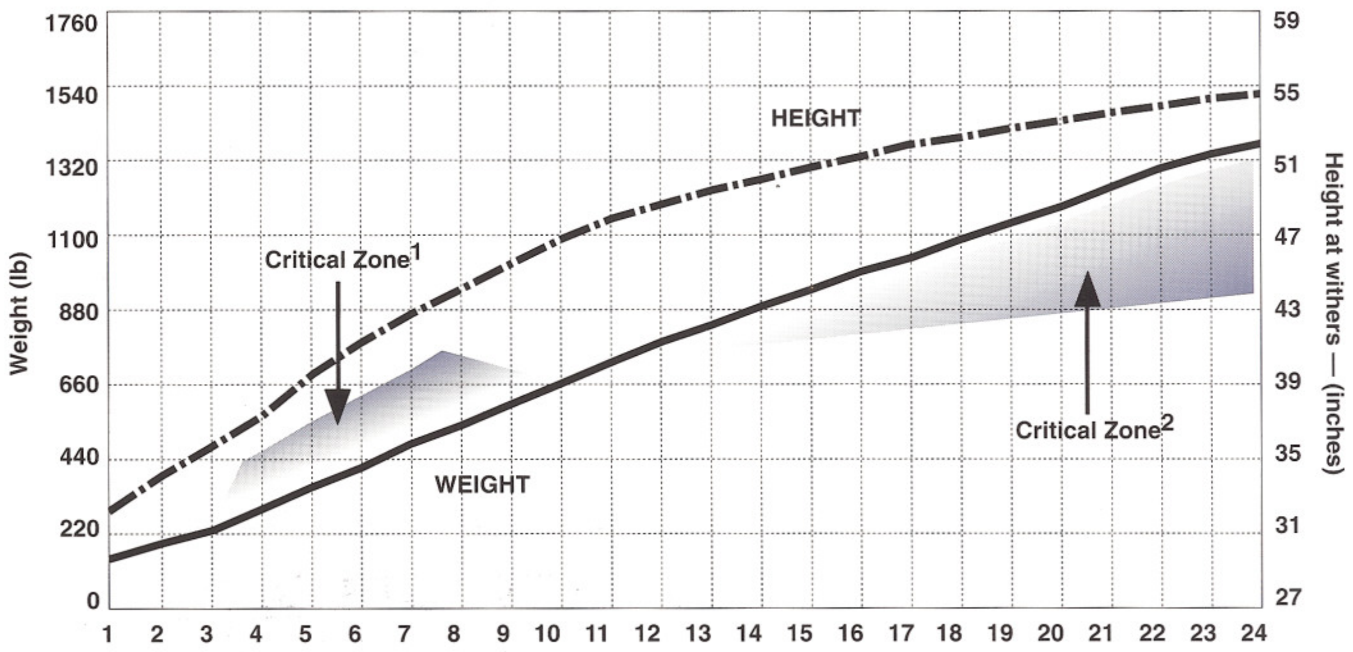
Table 30. **Heifer Growth Objectives**

	Holstein, Brown Swiss		Ayrshire, Guernsey		Jersey	
Age Months	**Weight[1] Lb**	**Height[2] Inches**	**Weight[1] Lb**	**Height[2] Inches**	**Weight[1] Lb**	**Height[2] Inches**
0	94	32	70	27	55	26
2	185	34	130	32	115	30
4	280	37	230	37	195	34
6	400	41	320	41	275	39
8	520	44	400	44	385	41
10	650	46	505	45	460	43
12	775	49	600	46	520	44
14[3]	**875**	**50**	**680**	**48**	**575**	**45**
16[3]	**975**	**51**	**770**	**50**	**650**	**46**
18	1050	52	860	51	730	47
20	1150	53	910	52	800	48
22	1275	54	1050	53	875	50
24	1340	54	1150	53	960	51

[1] Scale weight or estimated weight from a weight tape. Overfeeding energy and underfeeding protein, especially during birth to puberty, can result in overweight heifers that lack adequate growth (height).

[2] Height at withers.

[3] Breed heifers at 14 months of age if they have reached the approximate weight and height suggested.



[1]Heifers falling into this zone may have excessive prepuberty weight gains, resulting in reduced mammary development.

[2]Heifers in this zone are too light and not on target to calve at 24 months.

Figure 8. **Heifer growth chart for Holsteins**

Calving ages beyond 24 months are not recommended because they decrease potential profits.

monitor heifer weight gains. Also observe body condition and skeletal growth. Overconditioned heifers may be receiving too much energy or the ration may be low in protein. Lack of condition indicates underfeeding or poor-quality feed.

Balance Heifer Rations According to Stage of Growth

The nutritional requirements of heifers change as they mature. Younger heifers lack the rumen capacity to maintain satisfactory weight gains if they are fed only forage. Older heifers, however, have sufficient rumen capacity for adequate growth when fed only good-quality forage rations. Older heifers will gain an excessive amount of weight if high-energy forages, such as corn silage, are fed free-choice. A combination of corn silage and alfalfa limits energy intake and provides adequate protein. High-moisture corn (either ground ear corn or shelled corn) can be used in place of dry grains in rations for growing heifers. It is an excellent feed for growing heifers when included in a balanced ration.

Table 31 shows suggested nutrient specifications and dry matter intake for heifers in four age groups. Total dry matter intake of older heifers, as a percentage of body weight, decreases as forage intake increases. Dry matter intake of 300-pound heifers on forage and grain is about 3% of body weight while that of 1,100-pound heifers fed mostly forages is about 2% of body weight.

Forage quality determines the amount and protein content of supplemental grain needed. Table 32 shows how a decrease in forage quality increases the amount of grain that must be fed. Heifers that are gaining weight when bred have higher conception rates. Feed extra grain to heifers on poor-quality pastures or those fed poor-quality hay or other poor-quality forages so they are gaining weight at breeding time.

Table 31. Suggested ration specifications for growing heifers

	Age (months)			
	3-6	7-12	13-18	19-22
	Average weight (lb, large-breed heifers)			
	300	600	900	1100
Estimated dry matter intake, Lb/day	7-9	12-16	17-21	22-26
Percent of body weight	2.7-3.0	2.7	2.5	2.0
	Nutrient specifications (% of dry matter)[1]			
Crude protein	16	15	14[2]	12[2]
Total digestible nutrients (TDN)	68-74	64-70	60-63	60-63
Calcium	.50-.60	.40-.50	.40-.50	.40-.50
Phosphorus	.35-.40	.32-.35	.28-.32	.28-.30
Trace mineral salt	.30	.30	.30	.30
Acid detergent fiber (minimum)	16	19	19	19
Forage[3]	20-60	30-90	40-100	40-100
Vitamin A (IU/lb DM)	1,000	1,000	1,000	1,000
Vitamin D (IU/lb DM)	140	140	140	140
Vitamin E (IU/lb DM)	11	11	11	11

[1] Trace mineral salt, a high-calcium (15% to 25%) and phosphorus (10% to 20%) mineral mixture, and water should be available free choice at all times.

[2] Twenty to 30% of the total crude protein can be provided by nonprotein nitrogen sources for heifers weighing more than 800 pounds.

[3] The percent fiber and lowest of forage are minimum required for proper rumen function. Higher levels of ADF and forage are recommended for more economical rations and to limit T.D.N. levels shown above.

Table 32. Forage quality and grain needed in ration for large-breed heifers

		Forage quality[1]								
		Excellent			Good			Fair to Poor		
Age of heifers (months)	Average weight (lb)	Grain[2] ------ (lb/day) ------	Forage[2]	Forage: Grain ratio[4]	Grain[2] ------ (lb/day) ------	Forage[2]	Forage: Grain ratio[4]	Grain[2] ------ (lb/day) ------	Forage[2]	Forage: Grain ratio[4]
4-6	300	3-4	4-5	60:40	4-5	3-4	50:50	5-6	2-3	40:60
7-12	600	0-2	11-13	90:10	3-4	10-11	75:25	5-6	7-9	60:40
13-18	900[3]	0-2	18-20	100:0	3-4	14-16	80:20	6-8	12-14	65:35
19-22	1100[3]	0-2	22-24	100:0	2-3	20-22	90:10	6-8	16-18	75:25

[1] Forage quality is based on the following energy levels:
[excellent quality - at least 60% TDN]
[Good quality - 54% to 56% TDN]
[Poor to fair quality - 48% to 50% TDN]

[2] Pounds of grain and forage on air-dry basis (hay and air-dried grains). Equivalent amounts of dry matter can be fed as high-moisture grains and silages.

[3] Crude protein content required in grain is determined by crude protein content of forages. The total ration should contain at least 12% crude protein. When feeding a forage that is an excellent source of energy but low in protein (e.g. corn silage), feed 1 to 2 pounds of protein supplement or equivalent amounts of nonprotein nitrogen.

[4] Percent of total dry matter.

Table 33. Example rations for large breed heifers 3 through 6 months of age (300 lb average weight)

	Daily Ration Amounts Shown as lb Dry Matter										
Feed	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Alfalfa-Bud	5.8				4.0						
Alfalfa-Mid Bloom		4.8				3.7			2.7		
Alfalfa-Grass			4.3				3.4			2.5	
Grass Hay				3.5				2.5			2.1
Corn Silage					2.0	1.9	1.5	1.5	2.7	2.5	2.1
Corn, Shelled[1]	2.5	3.0	3.0	3.3	1.8	2.1	2.5	2.6	1.7	1.9	2.2
44% C.P. Supplement	.1	.6	1.0	1.4	.5	.8	1.2	1.6	1.1	1.4	1.6
Mineral 23% Ca and 18% P	.03	.03	.02		.04	.03	.02	.01	.03	.02	.01
Feed Limestone or CaCO3			.02	.09			.03	.09		.04	.08
Trace Mineral Salt	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02

	Diet										
Composition, D.M. Basis	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
D.M. Intake, lb/Day	8.5	8.5	8.4	8.3	8.4	8.5	8.7	8.3	8.3	8.4	8.1
Crude Protein %	17.3	16.7	16.6	16.4	16.6	16.2	16.5	17.0	16.8	17.0	17.0
TDN %	71.6	71.8	72.0	72.3	71.8	71.4	72.2	72.8	72.2	72.4	72.8
NE-Maint. Mcal/lb D.M.	.76	.76	.76	.77	.77	.76	.77	.78	.77	.77	.78
NE-Growth Mcal/lb D.M.	.48	.48	.48	.49	.49	.48	.49	.50	.49	.49	.50
ADF %	22	22	22	21	22	23	22	20	22	22	21
NDF %	30	31	33	35	34	35	35	35	36	36	36
Calcium %	.95	.80	.63	.63	.81	.71	.62	.66	.63	.64	.65
Phosphorus %	.35	.37	.38	.38	.38	.36	.38	.39	.38	.38	.39
Trace Mineral Salt %	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Grain, % in Diet D.M.	31	43	49	58	28	35	43	52	67	70	74
Forage, % in Diet D.M.	69	57	51	42	72	65	57	48	33	30	26

[1] Oats, barley or high-energy grain by-products can be used to replace all or part of the corn. Corn or other high-energy feeds, protein supplement, minerals and vitamins may be included in a total grain mix, or dry corn or equivalent amount of dry matter in high-moisture corn may be fed separately and the other required ingredients combined in a complete supplement. Feed high-moisture corn daily to prevent spoilage in bunks.

Table 34. Example rations for large breed heifers 7 through 12 months of age (600 lb average weight)

Feed	Daily Ration Amounts Shown as lb Dry Matter 1	2	3	4	5	6	7	8	9	10	11
Alfalfa-Bud	14.3	8.0	8.7		5.3					4.2	
Alfalfa-Mid Bloom				7.0		12.5		7.0			
Alfalfa-Grass							6.1		6.1		
Corn Stalks			4.2		3.7					4.2	9.4
Corn Silage		6.9		6.0	3.7		6.1	6.3	6.1	4.2	
Corn, Shelled[1]	.5		2.0	1.1	1.2	2.5	1.2	.9	1.2	1.0	2.6
44% C.P. Supplement				.6	.8		1.2	.6	1.2	1.1	2.5
Mineral 23% Ca and 18% P	.02	.06	.06	.04	.05	.04	.02	.04	.02	.05	.05
Feed Limestone or CaCO3											.04
Trace Mineral Salt	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Composition, D.M. Basis	**Diet 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
D.M. Intake, lb/Day	14.9	14.9	15.0	14.8	14.8	15.1	14.7	14.9	14.7	14.8	14.6
Crude Protein, %	19.6	14.4	14.6	14.0	14.1	15.8	14.0	14.0	14.0	14.0	14.0
TDN, %	66.0	65.8	65.9	66.4	66.4	65.7	66.7	66.1	66.7	66.3	67.1
NE-Maint. Mcal/lb D.M.	.68	.68	.68	.69	.69	.68	.69	.68	.69	.69	.70
NE-Growth Mcal/lb D.M.	.42	.41	.41	.42	.42	.41	.42	.42	.42	.42	.42
ADF, %	29	29	29	28	28	30	28	29	28	29	28
NDF, %	39	45	43	44	46	40	46	45	46	47	48
Calcium, %	1.23	.90	.93	.77	.72	1.06	.54	.77	.54	.66	.50
Phosphorus, %	.30	.31	.30	.31	.30	.31	.31	.30	.31	.30	.31
Trace Mineral Salt, %	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Grain, % in Diet D.M.	4	1	14	12	14	17	17	11	17	15	36
Forage, % in Diet D.M.	96	99	86	88	86	83	83	89	83	85	64

[1]See table 33 footnotes

Table 35. Example rations for large breed heifers 13 through 19 months of age (900 lb average weight)

Feed	Daily Ration Amounts Shown as lb Dry Matter 1	2	3	4	5	6	7	8	9	10	11
Alfalfa-Bud	19.9	11.4	10.0		9.0				13.2	6.0	
Alfalfa-Mid Bloom				11.2		22.3		11.2			
Alfalfa-Grass							11.9			4.8	
Corn Stalks			9.0		5.0					4.9	14.4
Corn Silage		7.6		8.8	6.5		8.0	8.8	6.0	4.8	
Corn, Shelled[1]			2.2							.6	3.3
44% C.P. Supplement							.6				2.9
Mineral 23% Ca and 18% P	.02	.06	.11	.08	.1	.05	.04	.08	.06	.09	.09
Feed Limestone or CaCO3											.05
Trace Mineral Salt	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Composition, D.M. Basis	**Diet 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
D.M. Intake, lb/Day	20.0	19.1	21.3	20.1	20.7	22.4	20.6	20.1	19.3	21.2	20.8
Crude Protein, %	19.9	15.1	12.9	13.0	12.7	16.9	12.6	13.0	16.2	12.3	12.6
TDN, %	65	67	63	65	64	61	64	65	66	63	64
NE-Maint. Mcal/lb D.M.	.67	.69	.63	.66	.65	.61	.65	.66	.69	.63	.65
NE-Growth Mcal/lb D.M.	.40	.42	.37	.40	.39	.35	.38	.40	.42	.37	.38
ADF, %	30	29	33	32	32	35	33	32	29	33	31
NDF, %	40	44	48	48	50	47	52	48	43	51	51
Calcium, %	1.27	.94	.88	.89	.85	1.25	.66	.89	1.02	.80	.52
Phosphorus, %	.30	.30	.30	.30	.30	.30	.30	.30	.31	.30	.30
Trace Mineral Salt, %	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Grain, % in Diet D.M.	0	1	11	1	1	0	3	1	1	3	31
Forage, % in Diet D.M.	100	99	89	99	99	100	97	99	99	97	69

[1]See table 33 footnotes

Tables 33 and 34 show example rations for heifers from 3 months through breeding age. Numerous combinations of ingredients can be used; however, be sure rations provide required nutrients.

A deficiency of energy is not usually a problem unless the total ration is corn stalks, poor-quality hay or pasture. These feedstuffs are usually deficient in both energy and protein. Excellent-quality forage will provide the protein and energy needed by bred heifers. A ration consisting of one-third to one-half legume hay or silage and one-half to two-thirds corn silage contains adequate levels of protein and energy. Feed 2 to 3 pounds of grain mixture daily if bred heifers are fed average-quality legume or legume-grass forages.

Corn silage is low in protein and high in energy. Heifers fed a ration consisting largely of corn silage are likely to grow poorly and become excessively fat. Limit intake of corn silage and feed supplemental protein if corn silage makes up more than two-thirds of the ration. Offering calcium-phosphorus mineral and trace mineral salt free-choice is a common method of providing heifers with adequate minerals.

Tables 35 and 36 shows several rations for bred heifers. There is little difference in the composition of these rations. Any one of them will maintain desired growth rates for heifers.

Overall feed quality and a feeding system that assures adequate intake are essential. Note that extra protein and energy (protein supplement and grain) are needed when low-quality forages are fed (Tables 35 and 36).

Table 36. Example rations for large breed heifers 19 to 22 months of age (1100 lb average weight)

	Daily Ration Amounts Shown as lb Dry Matter										
Feed	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Grass	20.0									7.0	
Alfalfa-Mid Bloom		25.2		16.0	9.5	15.3		14.5	14.8		
Alfalfa-Grass			24.4				17.5			5.0	
Corn Stalks					4.8	8.0		9.0		5.0	18.9
Corn Silage				8.0	8.7		7.7		9.0	5.0	
Grain-Concentrate											
Corn, Shelled1	2.0		1.5			2.0		1.6		.7	2.6
44% C.P. Supplement	1.6				1.0					1.7	3.3
Mineral 23% Ca and 18% P		.04	.12	.08	.09	.01	.04	.11	.08	.5	.11
Feed Limestone or CaCO3											.05
Trace Mineral Salt	.059	.063	.065	.060	.060	.064	.063	.063	.060	.061	.062
						Diet					
Composition, D.M. Basis	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
D.M. Intake, lb/Day	23.7	25.3	25.9	24.1	24.1	25.5	25.3	25.3	23.9	24.5	25.0
Crude Protein, %	13.5	18.1	15.0	14.1	13.0	13.8	12.9	13.3	13.6	13.0	12.7
TDN, %	64	61	60	63	63	61	61	60	63	62	62
NE-Maint. Mcal/lb D.M.	.65	.61	.60	.64	.63	.61	.61	.60	.64	.63	.62
NE-Growth Mcal/lb D.M.	.38	.35	.34	.37	.37	.35	.35	.34	.38	.37	.35
ADF, %	32	35	36	32	33	35	35	36	32	33	34
NDF, %	57	47	52	48	51	50	54	52	48	55	54
Calcium, %	.45	1.23	.82	.97	.76	.94	.71	.93	.93	.53	.45
Phosphorus, %	.30	.29	.29	.30	.29	.28	.28	.28	.30	.29	.29
Trace Mineral Salt, %	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Grain, % in Diet D.M.	16		6	1	5	8		7	1	10	24
Forage, % in Diet D.M.	84	100	94	99	95	92	100	93	99	90	76

[1]See table 33 footnotes

Ionophores

Ionophores improve average daily gain and feed efficiency in dairy heifers. Expect gain increases of .1 to .2 pounds per heifer per day when ionophores are added to the diet.

To reduce grain supplementation, add ionophores to heifer diets whenever forage energy values fall below heifer energy requirements. Avoid ionophores if high-energy forages, such as corn silage, comprise more than 50 percent of the diet.

Limit NPN to no more than 15 percent of the crude protein equivalent if you feed ionophores. Ionophores can inhibit rumen bacterial protein synthesis, and reduce the effectiveness of NPN.

You can feed ionophores to heifers up to calving, but not to milking animals. Table 37 lists the two available ionophores and their feeding rates.

Cost of Raising Replacement Heifers

The cost of raising dairy heifers depends on the price of feeds, age at calving, quality of forages, death losses, culling percentages and other fixed and variable costs. On most farms, rations based on high-quality forages will reduce feed costs and maintain good growth. Balancing rations for different age groups can significantly lower feed costs.

See publication A2731, "Wisconsin Farm Enterprise Budgets: Dairy Cows and Replacements." Your actual costs will vary by area, current prices and facilities.

Feed costs are about half the cost of raising replacements. Also consider the initial cost of a calf, whether purchased or from your herd, and a reasonable charge for death losses to obtain a realistic value for a freshening heifer.

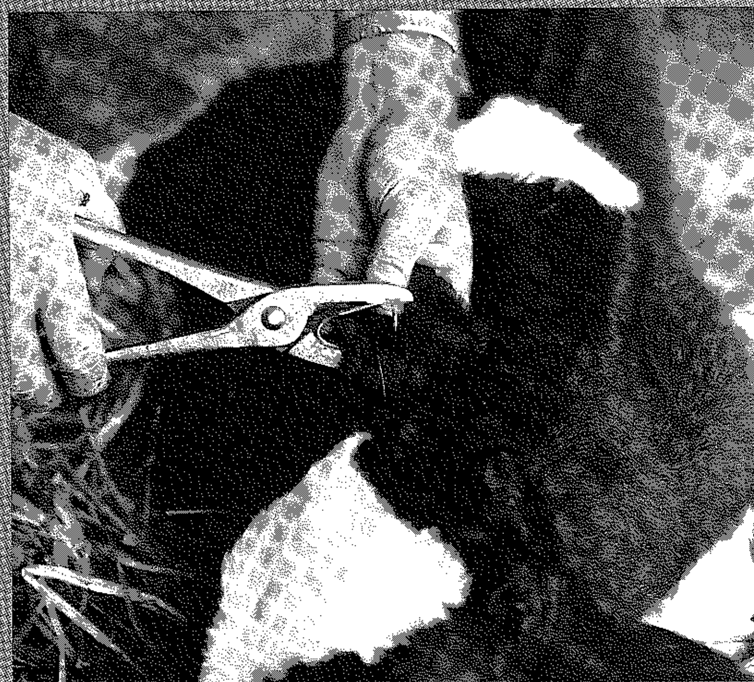
Group Heifers by Age and Size

Differences in nutrient requirements and feed intake at different stages of growth are some of the reasons heifers of approximately the same weight and size should be grouped together. The number of heifers in a group varies with the size of herd and number of heifers raised. Small groups of heifers are easier to observe and control. A timid or poor-growing heifer is easier to spot in a small group and can be separated for special attention. Older heifers fed total mixed rations free-choice are often raised in large groups. It is important to observe these heifers regularly and separate those that are not doing well.

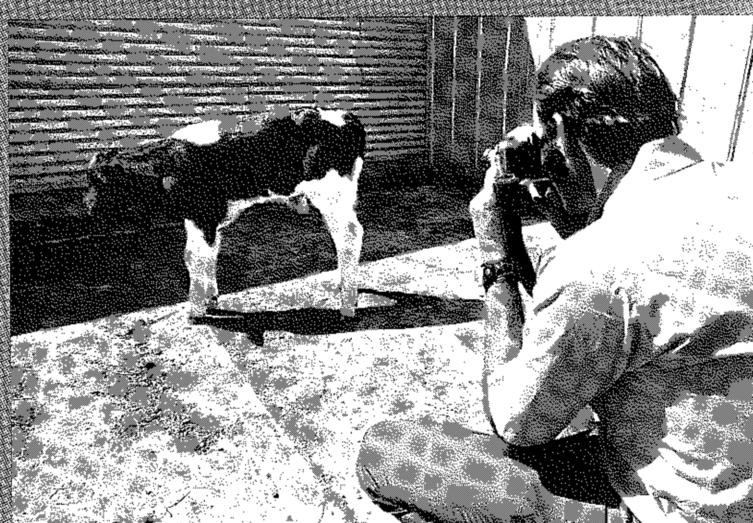
Table 37. Ionophores for dairy heifers

	Milligrams head/day	
Heifer Weight[1]	Lasalocid	Monensin
200	60-90	0
300	90-140	0
400	140-180	100-200
500-Calving	200	150-200

[1] Monensin is labeled for only those animals over 400 lbs



Temporary identification — use neck straps or chains with a number and metal or plastic ear tags. Use a tattoo to identify solid-colored breeds.



A photograph is one method of permanent identification.

Identification

Positively identify each calf before removing it from the dam. Permanent identification is required to register purebred calves and is essential for a good breeding program. Positive identification is required before records can be used for sire proving, cow indexing or sire indexing. Breed associations will furnish registration forms and permanent identification requirements. Use a neck strap or chain with a number or metal or plastic ear tag for temporary identification. Enter ear tag or registration numbers of calves, sires and dams and birth dates in a permanent record book.

Permanent identification methods are: photograph, sketch, tattoo and freeze branding. A photograph or sketch is required to register broken-color breeds (Holsteins, Guernseys and Ayrshires). Solid-color breeds (Jerseys, Brown Swiss and Milking Shorthorns) require tattoo markings inside the ear. For farm use, a tattoo or freeze branding provides permanent identification of grades or purebreds of any breed. Photographs or sketches can be used to identify broken-color grades.

How to Tattoo Use good-quality tattoo ink and place the tattoo mark between the ribs in the upper half of the ear. Remove the wax and avoid hairy areas. Use black ink on light-colored ears and red ink on dark-colored ears.

Apply a generous amount of ink with a toothbrush to the numbers or letters and the ear surface. Hold the ear between the thumb and fingers. Puncture and push the ear away from the points of the instrument as you release the pressure. Immediately rub additional ink into the puncture. A well-applied tattoo should last throughout the life of the animal.

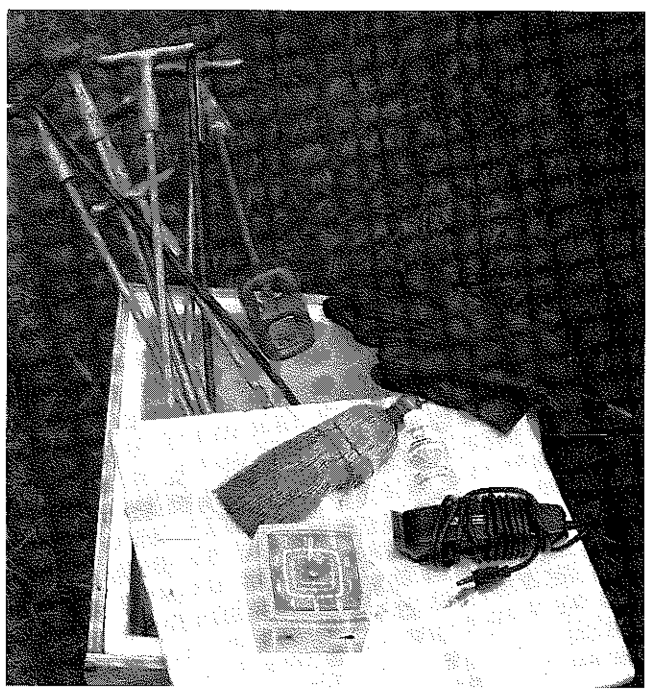
Examine the ear when the heifer is about 1 year old. Another tattoo could be applied if necessary. Be sure to follow breed association requirements if another tattoo is applied to registered calves.

How to Freeze Brand Applying a super-cold branding iron to the skin destroys the pigment cells that produce dark hair. White hair grows where the iron was applied. For details on freeze branding and other forms of cattle identification, see publication A2834, "Identify Your Cattle."

Extra Teats

A good udder with four well-placed teats is important. Extra teats on a cow's udder are unsightly, may become a site for infections and may interfere with machine milking. Extra teats should be removed as soon as they can be positively identified. It is best to remove extra teats when a heifer calf is 2 to 6 weeks old and is still small and easy to handle.

Use Disinfectant Before and After Tie the calf securely. Clean and disinfect the teat and surrounding area with iodine or other reliable disinfectants.

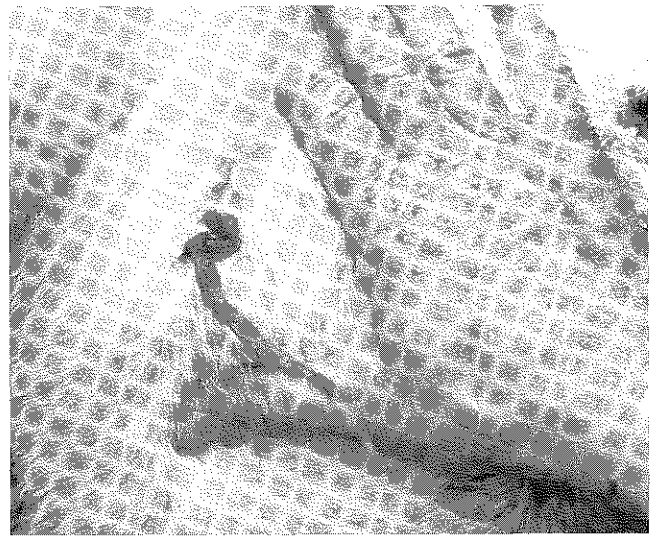


Materials needed for freeze branding.

Then draw the teat down and snip the teat off cleanly at the line where the teat joins the udder. Use a serrated curved shears for an accurate cut. Swab the area with a disinfectant after the operation. There is seldom any bleeding. Apply a fly repellent to the wound during fly season.

The wound may be so large that stitches will be needed to close the skin for proper healing when extra teats are removed from older heifers. **Only an experienced dairy farmer or veterinarian should attempt to remove teats from older heifers or cows.**

Make Sure the Teat Is "Extra" A heifer will freshen with only three normal teats if the wrong teat is removed. If in doubt, leave the extra teats until they can be positively identified.

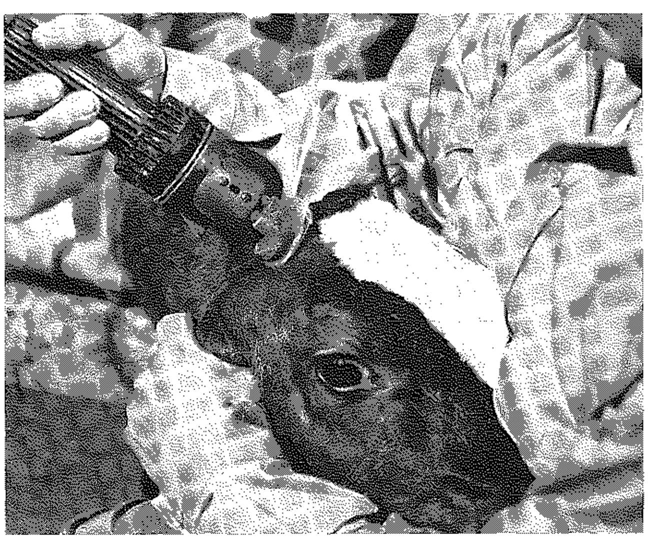


A well healed navel cord prevents disease organisms from entering the body.

Dehorning

Horns serve no useful purpose on dairy cattle; they can be a nuisance and cause body and udder injuries. All breeds of dairy cattle should be dehorned. Horns do not improve general appearance and are seldom seen on the best show cattle.

Proper dehorning when horn buttons are very small can be a neat, clean job that causes little discomfort to the animal. After a little experience, you will find that dehorning is a simple task.



Experienced users can dehorn calves in about 1 minute with electric dehorners.

Caustic Potash Caustic potash is very satisfactory for dehorning calves. Special caustic sticks for dehorning are readily available and are economical.

Dehorn when a calf is 4 to 10 days old, or as soon as the horn buttons can be easily detected. The earlier calves are dehorned, the better.

Remove hair from the horn button. Moisten the caustic stick and rub it vigorously over the horn button in a circular motion. When the skin softens, repeat the procedure on the other horn and return to the first horn. When enough caustic has been applied, the skin will have softened so it can be easily broken with the end of the caustic stick.

Be careful with caustic. It is not necessary to take off the entire horn at the time of the operation since the caustic will continue to work and destroy the horn. Keep calves in individual pens so caustic does not rub off on other calves. Place a ring of vaseline or grease around the horn button following caustic application so caustic doesn't get on a calf's face and eyes. Protect your fingers by wrapping paper around the caustic stick. Rubber gloves provide additional protection.

Store caustic in a sealed glass or plastic container. Label clearly and keep it in a dry place that is not accessible to children and animals.

Electric Dehorners Many use electric dehorners. These are similar to large soldering irons with hollowed tips that fit over the horn. The irons are available in different sizes or with exchangeable tips of different sizes. Follow directions supplied with the horn button to burn away skin around the horn. By carefully following directions for use of the irons and after some experience, a calf can be dehorned in about 1 minute. Although dehorners come in different sizes for calves of different ages, calves should be dehorned when about 1 month of age for best results.

Gouge or Scoop Gouging out the horn button causes excessive bleeding and invites serious, unnecessary infections.

Saw or Horn Clippers Horns may be removed with a saw or clippers if horn growth was not prevented at a young age. Do not use a saw or horn clippers until an animal has reached an age when horns will not regrow (usually more than 12 months). Dehorn in winter to avoid contamination by flies.

Necessary supplies for dehorning can be purchased from farm supply stores or veterinarians. If you have any questions or doubts, consult with your veterinarian about how to safely dehorn calves.

Keep Feeding Utensils Clean

Dirty feeding pails are disease carriers. Use easy-to-clean utensils and disinfect with a milk utensil disinfectant or rinse utensils in very hot water after washing. Keep feed boxes clean and sanitary.

Keep Calf Pens Clean

Disease germs lurk in dirty bedding. Clean, dry and well-bedded pens help keep calves healthy, thrifty and comfortable.

Sanitation

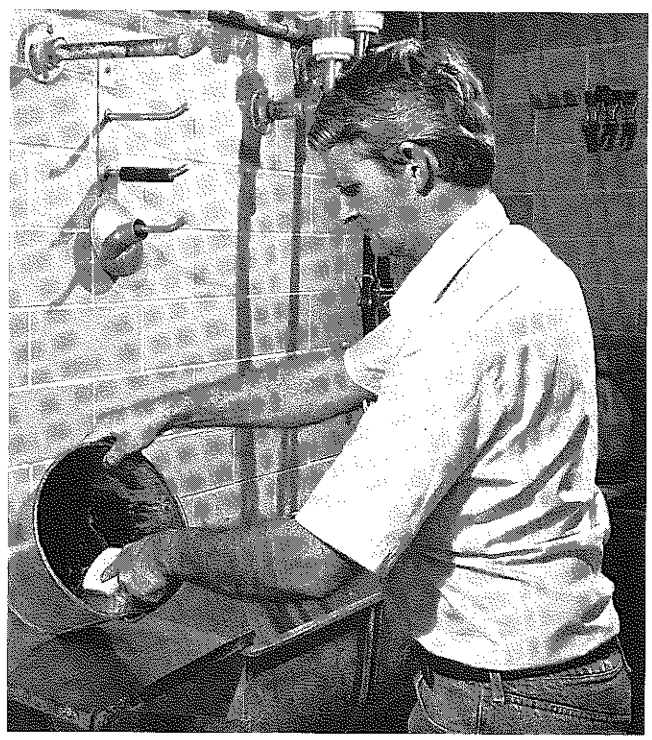
It is easier to prevent infectious diseases than to cure them. When large numbers of calves pass through a rearing facility, there is a gradual increase in infections caused by bacteria and viruses. Prevent diseases and infections with a "sterilization break" of about 6 weeks and by thoroughly cleaning and disinfecting facilities between groups of calves. In the summer, move vacant hutches to fresh ground. Return hutches to a protected area for the winter.

Digestive disorders, one of the common calf ailments, can be controlled or prevented by a strict sanitation program. Scrub utensils after each use. Clean feed boxes daily.

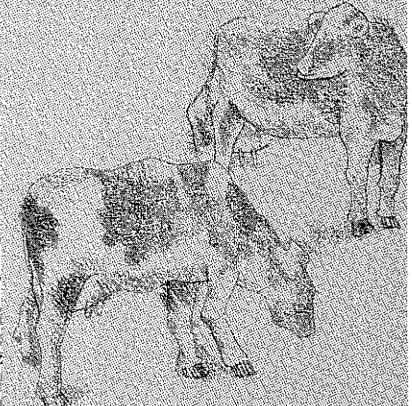
Isolate Sick Calves

Abnormal or sick calves should be isolated and their condition diagnosed. Preventing spread of infectious diseases reduces calf losses.

Thoroughly clean and disinfect feeding pails after each use. Remove, clean and sterilize nipple when feeding is complete.



Thoroughly clean and disinfect feeding pails after each use. Remove, clean and sterilize nipple when feeding is complete.



Management determines whether calves are healthy

or sick and unthrifty.

KEEP CALVES HEALTHY

The period immediately after birth and the first days of life are critical times for calves. Full attention to details during this time can reduce death losses and lower the incidence of disease.

It is far better to prevent diseases and ailments than to try to correct them after they occur.

Always be on guard to keep diseases from getting started. Feed calves correctly. Provide clean surroundings.

Regular use of a rectal thermometer is one of the best methods to detect health problems early. Early detection is essential for effective treatment and to prevent disease from spreading to other calves.

The two major types of calf health problems are scours (diarrhea) and pneumonia. Scours are most likely to be a problem in calves less than 1 month old while pneumonia is usually the major health problem in calves after 1 month of age.

Causes of Calf Scours

Calf scours are a complex disease problem since they can be caused by several types of bacteria, viruses, and protozoan parasites. Poor nutrition and management make calves more susceptible to infectious agents that cause scours.

Bacterial causes of calf scours include:

Escherichia coli This is the most common bacterial organism associated with calf scours. Since the K99 strain can adhere to the intestinal mucosal surface, it is a common cause of calf scours.

Salmonella There are several types of salmonella and many types can cause scours. Salmonella typhimurium is the most common salmonella bacteria associated with scours.

Clostridium perfringens type C This bacteria is a soil organism and causes scours on many farms.

Viral causes of calf scours include:

Rota-virus

Corona-virus

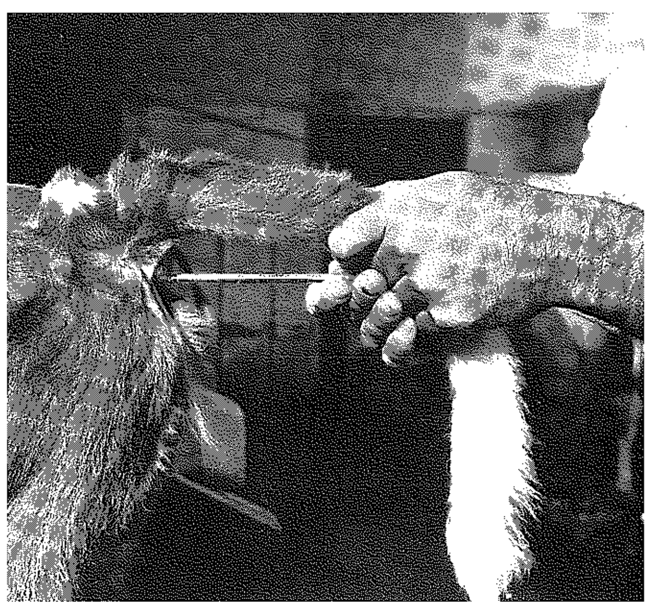
Protozoan parasite causes of scours include:

Cryptosporidia

Coccidia

Overfeeding and poor-quality milk replacers may also cause scours.

Treatment The principal damage caused by diarrhea is loss of water and bicarbonate, sodium and potassium ions from blood and body fluids. When the scour-causing agent irritates the intestine, the calf's body tries to neutralize, destroy and flush out the irritant. The feces of calves with scours may contain 5 to 10 times as much water as normal. A calf becomes dehydrated when this extra water is removed from its body and may die within a few hours due to dehydration and/or increased acidity of the blood.



A rectal thermometer helps detect health problems early.

Treat calf scours as soon as detected.

Do not feed the calf milk when scours occur. Milk encourages growth of bacteria in the intestine and further complicates the situation.

Feed an electrolyte solution instead of milk. Easy-to-use packets of electrolytes that are mixed with water can be purchased from veterinarians or farm supply stores. Carefully formulated homemade electrolyte solutions that are mixed and fed in clean containers are nearly as effective.

A rectal thermometer helps detect health problems early.

Homemade electrolyte formula:

1 package MCP pectin
1 teaspoon low-sodium table salt
2 teaspoons baking soda
1 can beef consomme soup

Mix the ingredients and add water to make 2 quarts

The calf should receive 2 quarts of the solution 3 or 4 times a day. A calf will usually drink or nurse the electrolyte solution when given instead of milk. If not consumed, force-feed with stomach tube or esophageal feeder. These can be purchased from veterinarians. Gradually replace the electrolyte solution with milk as the calf recovers. Each day give the calf an oral scour medication that contains antibiotics. Always provide sick animals with a warm, dry place. Isolate sick calves. Never give up on a dehydrated calf, even near death. Electrolyte treatment often gives dramatic results.

Major Causes of Pneumonia

Poor ventilation and constant exposure to pneumonia-producing organisms make calves more prone to pneumonia. Gases from manure and decomposing bedding in poorly ventilated buildings reduce the ability of a calf's natural defenses to resist pneumonia organisms. Constant exposure to large numbers of these organisms, as when healthy calves are penned with infected calves, can "overwhelm" a healthy calf's resistance.

Organisms causing pneumonia include:

Pasteurella multocida and **Pasteurella hemolytica** These bacterial organisms are frequently found in the nasal passages of cattle. They often follow other infectious agents and cause permanent lung damage.

Chlamydia

Mycoplasma dispar

Para-influenza 3 (PI-3) virus

Infectious Bovine Rhinotracheitis (IBR)

Bovine Respiratory Syncytial Virus

Bovine Virus Diarrhea (BVD)

Haemophilus somnus

Pneumonia Treatment Successful treatment of calf pneumonia requires early diagnosis. Calves are usually at least 1 month of age when they show signs of pneumonia, but calves 1 to 3 weeks of age may be afflicted. A calf's temperature is the best indication of whether it is sick. Normal rectal temperature is 101°F to 102°F. 105°F or higher often indicates a pneumonia problem.

Antibiotic treatment is usually suggested for calves with elevated temperatures. Continue treatment at least 1 day after the temperature returns to normal. Antibiotics may be added to the feed as a long-term treatment when calves have recovered from the acute phase of pneumonia. Fresh air and sunshine often aid recovery.

Be sure to observe withdrawal times before selling treated calves. Calves with chronic pneumonia seldom recover completely and should not be used for replacements.

Prevention of Scours and Pneumonia

There are two basic methods which will help prevent a disease — limit or avoid exposure of an animal to a disease and proper immunization. Preventive procedures include:

Sanitation Clean calving locations, calf pens and feeding utensils.

Colostrum Feed calves colostrum as soon after birth as possible (see pp. 13-17).

Antibody Commercially available monoclonal antibodies are available to help prevent Escherichia coli infections. Products should be given within an hour or two of birth.

Adequate ventilation helps keep bedding dry and minimizes manure gases.

Individual pens help prevent disease organisms from spreading by contact. Calf hutches are excellent for raising calves.

Vaccination Program Vaccines are available to prevent many diseases. All of the vaccinations in the immunization schedule shown in Table 38 may not be necessary in some herds.

Vaccines should not be used without a veterinarian's recommendation and approval. The list of approved vaccines frequently changes as old ones are dropped and new ones are added. Additional vaccines to be considered are shown in Table 39.

Other Problems

Ringworm This skin disease caused by a fungus infection does not cause any economic losses, although circular areas of hair loss (most often on the head and neck) are unsightly. Ringworm lesions generally heal without treatment in 2 to 3 months. Topical treatment with fungicides will hasten recovery. The dewormer Thiabendazole is also a fungicide. Deworming with this product may also be effective against ringworm.

Warts These raised skin lesions caused by a virus normally fall off after 2 to 3 months without causing any problems. Small warts can be surgically removed with a scissors. Cut them off as close to the base as possible. A wart vaccine may help clear up warts more quickly.

Bloat Bloat is an abnormal accumulation of gas in a calf's stomach. It is usually caused by abnormal fermentation. The accumulated gas must be released immediately. In severe cases, release gas with a stomach tube, trocar or large needle. Evaluate the diet to determine if more roughage is needed and if the ration or milk replacer should be changed to alter fermentation.

Navel Hernias A condition in which the abdominal wall at the navel does not close properly. Most navel hernias are caused by an infection of the navel. Abscesses of the navel are similar in appearance to navel hernias. A veterinarian should examine any abnormalities of the navel to determine possible treatment or surgery.

Contracted Tendons This condition is noticeable at birth. The toes on an affected calf are pulled back so the calf walks with its hoof knuckled under. The condition is often corrected without treatment. More severe cases may require splinting or cutting the tendon to get the foot in the proper position. Causes of contracted tendons are unknown.

Medications should be properly stored and labeled.

Pinkeye Pinkeye is characterized by a reddening and swelling of the eye membranes and a watery discharge from the eye. More severe cases may result in corneal opacity (white color) and may even rupture the eye. Pinkeye is caused by bacteria. Treat cases promptly with antibiotics and shield the affected eye from sunlight with eye patches. Control faceflies since they often spread the disease. Vaccination may prevent pinkeye. IBR, eyeworms and other organisms may also cause eye lesions.

Colic Calves sometimes develop abdominal pain due to overeating, drinking cold water and many other causes. Colic usually abates within a couple of hours. Prevention may require changing calf nutrition or management practices.

Internal Parasites Calves raised in clean confinement facilities usually need not be dewormed. However, calves raised in unsanitary conditions may become heavily infected with Trichostrongylus and may require deworming. Follow a deworming program for pastured animals since they are likely to become infected with stomach worms.

Coccidiosis Coccidiosis produces loose stools, with mucus and sometimes fresh blood in the feces of infected calves. Clinical symptoms appear following a 16-day incubation period. Most calves recover, but growth rate often suffers. Rough hair coat and gut swelling are common, especially on post-weaning calves.

Calves become infected by eating, licking or drinking material that has been contaminated with infected manure. Good sanitation can prevent or greatly reduce problems. Commercial products such as decoquinate, lasalocid and amprolium will prevent or control coccidiosis. These products are generally mixed into calf starters or water. Your veterinarian can examine a fecal sample to diagnose coccidiosis.

Table 38. Vaccines to consider for routine use

Disease	Type of vaccine	Initial immunization	Booster
Brucellosis[A]	Live culture	Heifers, 2-6 months old	No
Clostridium chauvoei (Blackleg)	Bacterin-Toxoid	Single injection of combined vaccine	Repeat in 2 months if calves first injected when less than 6 months of age
Clostridium septicum (Malignant edema)	Bacterin-Toxoid		
Leptospirosis[A]			
L. pomona*	Bacterin	Single injection of vaccine containing five strains is recommended	Annually (all strains) Booster 6 months after initial injection in problem herds
L. hardjo*	Bacterin		
L. grippotyphosa	Bacterin		
L. canicola	Bacterin		
L. icterohemorrhagiae	Bacterin		
Bovine Rhinotracheitis[ADP]	M.L.V	Nasal spray or single injection (6-14 months preferred). Nasal spray can be used in young calves if repeated in 6 months.	Annually for maximum protection
	or		
	Killed virus	Two injections	
Bovine Parainfluenza-3[P]	M.L.V.	Nasal spray or single injection	Annually for maximum protection
	or		
	Killed virus	Two injections	
Bovine Virus Diarrhea[AD]	M.L.V.	Single injection (6-14 months preferred)	Annually for maximum protection
	or		
	Killed virus	Two injections	
Bovine Respiratory Syncytial Virus[P]	M.L.V.	Two injections	Annually for maximum protection
	or		
	Killed virus		
Haemophilus somnus[P]	Bacteria	Two injections	Usually not required

A=abortion D=diarrhea M=mastitis P=pneumonia

Table 39. Vaccines to use under special conditions

Disease	Type of vaccine	Initial immunization	Booster
Vibriosis[A]	Bacterin	Single injection 30 days before breeding	Annually
Trichomoniasis[A]	Killed Protozoa	Two injections 30 days before breeding	Annually
Pink Eye	Bacterin	One or two injections	Annually for maximum protection
Calf scours			
Rota-virus[D]	M.L.V.	Calves-orally immediately after birth	Cows-annually 1 month before calving
Corona-virus[D]	M.L.V.	Cows-injection 1 month before calving	
Escherichia coli[D]	Bacterin	Cows-injections 1 month and 2 weeks before calving	Cows-annually 1 month before calving
Clostridium perfringens[D] Types C & D	Bacterin-Toxoid	Single injection	2-4 weeks before calving
Clostridium novyi	Bacterin-Toxoid	Single injection	Every 6 months
Clostridium sordelli	Bacterin-Toxoid	Single injection	Usually not required
Clostridium haemolyticum	Bacterin	Not needed in Wisconsin	—
Pasteurella hemolytica[P]	M.L.V.	Single injections	Usually not required
Pasteuralla multocida[P]	Bacterin	Two injections	—
Salmonella typhimurium	Bacterin	Two injections	Usually not required
Staphylococcus aureus[M]	Bacterin-Toxoid	Two injections	Usually not required
Warts	Killed virus	Two injections	Usually not required
Anaplasmosis	Bacterin or modified live bacteria	Not for use in Wisconsin	—
Rabies	M.L.V.	One or two injections depending on the type of vaccine	1-4 years depending on type of vaccine
Tetanus	Toxoid	Two injections	Usually not required

A=abortion D=diarrhea M=mastitis P=pneumonia

Terms

Antibody Modified globulin produced in an animal's body in response to a disease or injection of a vaccine. It usually requires 5 to 10 days after infection or vaccination to produce antibody, after which the animal is protected against or immune to the disease for several months or, in some cases, for life.

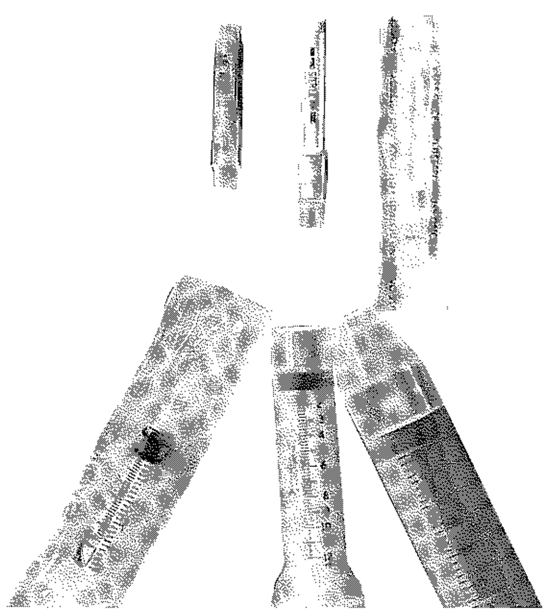
Antiserum A concentration of blood serum containing preformed antibody to those diseases which the donor animal contracted or had been vaccinated. Antiserum is given to calves by injection. It may provide some protection against bacterial and viral diseases and provides immediate benefit lasting as long as 3 weeks.

Bacterin A suspension of bacteria killed by chemical means. Repeated injections are required to maintain good immunity.

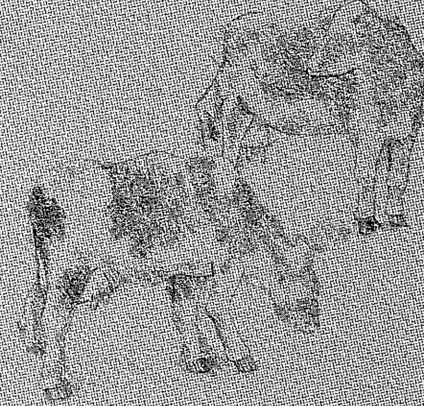
Killed virus A suspension of virus killed by chemical means.

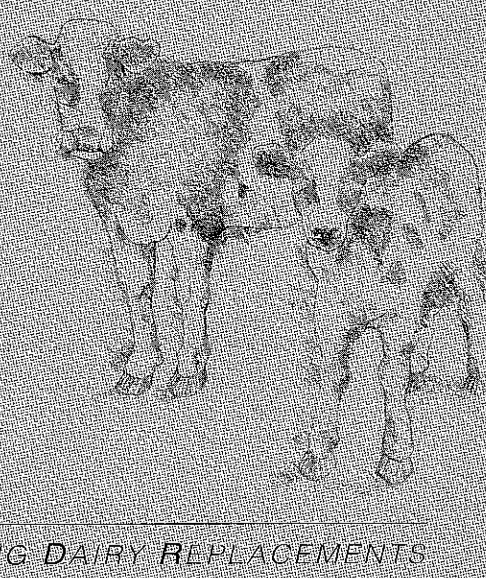
Modified live vaccine (MLV) Suspensions of modified live bacterial or viral organisms which, when given by injection, orally or intra-nasally, cause an animal to produce its own antibody against a specific disease. Cattle require 7 to 10 days to form protective levels of antibodies. Immunity lasts for months or, in some instances, for life.

Toxoid Toxins produced by bacteria which have been inactivated by heat or chemicals. When injected, it may cause production of antibody to a disease.



Disposable syringes and needles are recommended for injections.





RAISING DAIRY REPLACEMENTS

FEED ADDITIVES FOR REPLACEMENT DAIRY HEIFERS

L. E. Chase and C. J. Sniffen

The importance and economics of dairy replacement programs have received considerable emphasis in the last few years. At the 1987 Winter Dairy Management Schools, Dr. T. R. Smith estimated the cost of raising a heifer to 29 months of age to be $1265. He also estimated the net cost per heifer per month was about $34. Thus, it would cost about $170 less to raise a heifer to 24 months of age rather than 29 months.

A second factor relates to the total number of replacements which need to be raised to maintain herd size. The number of heifers required is a combination of the age at first calving and the culling rate of the herd (Table 1). Note that within any specific culling rate that more heifers are needed as age at first calving increases.

An average daily gain of 1.2-1.6 pounds is required if a dairy heifer is to attain a desirable calving weight at 24 months of age. Target weights at 24 months are about 1250 pounds for Holsteins and 950 pounds for Jerseys. With an average age at calving of 29 months for Holstein heifers in DHI herds in the Northeast, it is apparent that many herds are not achieving the goals listed above. Average weight at calving for these heifers is reported to be 1120 pounds.

A key factor in developing a dairy replacement program is the nutrition component. The first step in this process is a ration balanced to meet the nutrient needs of the animal at the various growth changes. Once this program is in place, then the use of an additive to enhance performance or feed efficiency could be considered.

What Products Are Available?

At present, two feed additives which enhance growth are approved for dairy heifers. Rumensin is marketed by Eli Lilly while Bovatec is available from Hoffman-LaRoche.

What Are the Active Ingredients?

The active ingredient in Rumensin is monensin sodium. The active ingredient in Bovatec is lasalocid sodium. Both of these products are ionophores.

How Do These Products Work?

The exact mechanism of action has not been clearly defined. Both Rumensin and Bovatec appear to alter microbial activity in the rumen. A number of papers have examined the effects of these two ionophores using in vitro fermentation systems. General results can be summarized as follows:

1. Neither ionophore consistently alters the total amount of volatile fatty acids (VFA's) produced.

2. There is normally an increase in propionic acid as a proportion of the total VFA's and a decrease in acetic and butyric acids.

3. Both ionophores tend to decrease methane production.

4. The effects on ammonia levels have not been consistent. In some cases, the ionophores depress ammonia levels while in other studies there has been no change.

5. Total bacterial growth in continuous fermenters was not altered by either ionophore.

The overall results appear to indicate that Rumensin and Bovatec induce similar alterations in ruminal fermentation patterns.

What Research Data Is Available?

Both companies had to submit animal performance data to FDA to obtain approval to market their product. The average improvement in daily gain for 10 trials conducted with dairy heifers fed Rumensin was 9.8% (1.42 vs. 1.57 lbs/day). Similar trials using Bovatec indicated an improvement of 13.1% (1.30 vs. 1.47 lbs) in average daily gain. Tables 2 and 3 contain more detailed data from studies with Rumensin.

What Levels of Supplementation Are Recommended?

The daily dosage levels for Rumensin are between 50-200 mg per animal per day. Bovatec is fed at the rate of 60-200 mg per day. The dosage level varies somewhat with the weight of the animal. As an example, calves weighing 200 pounds should receive 60-90 mg/day of Bovatec while those over 500 pounds should receive 200 mg/day.

What About Reproductive Problems?

The data collected from trials using Rumensin has indicated no differences in reproductive performance (Table 4). There have also been no differences detected to date in calf birth weight. At this point, we have not seen comparable data for Bovatec.

What About Lactating Dairy Cows?

Neither product is approved for use in lactating dairy cows.

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March, 1991

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REPLACEMENT HOUSING

Animal housing facilities must be well designed and properly managed if replacements are to grow well and remain healthy. **Housing facilities for calves and heifers must provide:**

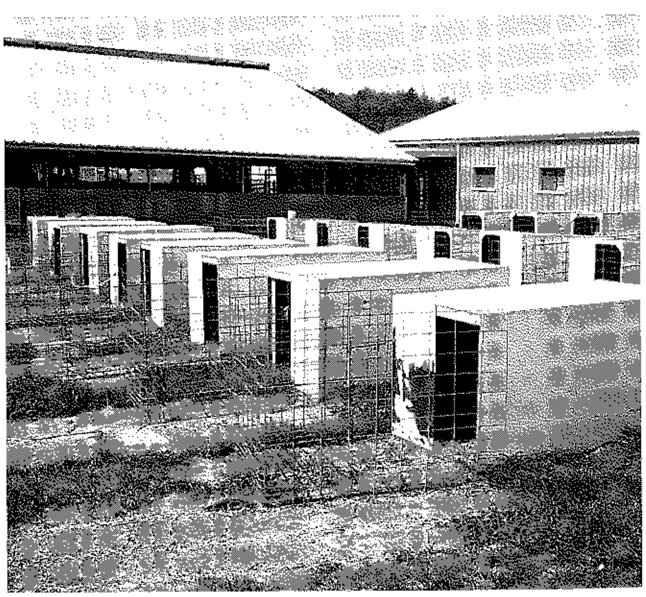
1. Adequate space;
2. Dry, draft-free resting areas;
3. Fresh air;
4. Adequate space for feed and water;
5. Space and facilities to group animals by size or age;
6. Sanitary conditions; and
7. Ease of handling and treatment.

Poorly planned or improperly managed animal housing increases the risk of disease or injury. Pneumonia, scours and other diseases can permanently damage vital body organs. Calves and heifers raised in a poor environment may never reach their full genetic potential for milk production.

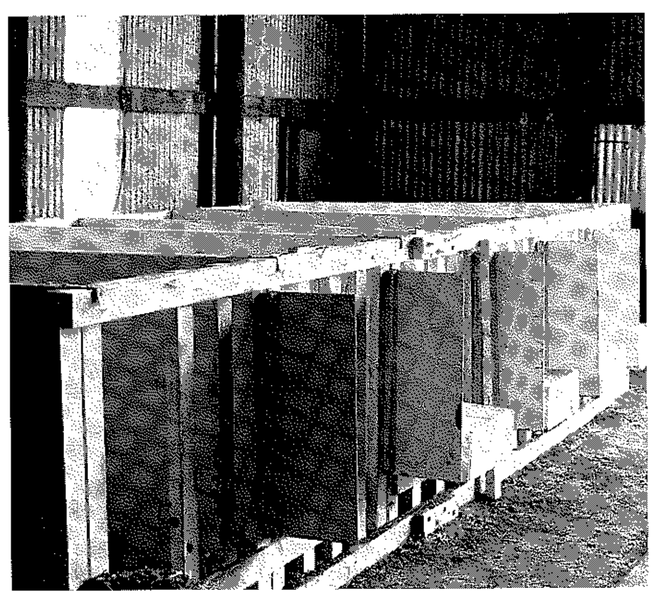
Types of Housing Facilities

Birth to Weaning Young calves have been satisfactorily housed with milking herds in stanchion barns. This is more common in smaller herds (40 cows or fewer). As herd size increases, illness and death losses among calves housed with the milking herd tend to increase. Many factors may contribute to increased losses when calves are housed with milking herds. Increased contact with disease organisms from other calves and cows is probably the major factor. Crowding, inadequate ventilation, drafts and reduced observation and care may also contribute to the problem. In larger herds, it is better to plan housing facilities specifically for calves and heifers. Housing facilities vary with animal size and maturity.

Calves can be tied in individual pens or stalls. Calves also do well in individual floor-level bedded pens. Install solid partitions between pens to minimize drafts and prevent contact among calves.



Hutches are a popular housing system for young calves.



Partitions between individual stalls prevent contact among calves.

Unweaned calves should be housed individually to prevent disease transfer and prevent udder damage caused by calves sucking each other.

Unweaned calves do very well in outdoor calf hutches. Hutches — covered pens with outside runs — should be separated to prevent contact through fences. Move hutches to a clean, well-drained location between calf crops when weather permits.

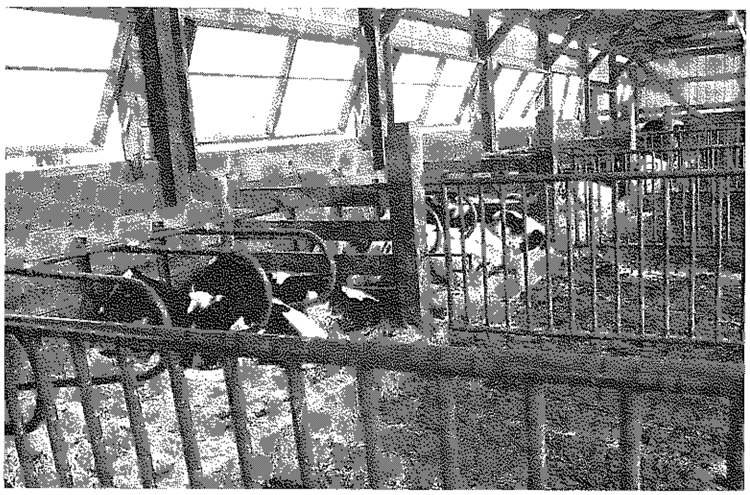
After Weaning to 4 months Young weaned heifers can be housed in group pens. Groups should contain animals of about the same age and size to reduce stress and the risk of injury. For heifers up to 8 months, limit group size to 5 to 7 animals and provide 20 to 25 square feet per animal.

Loose housing consists of a covered, bedded resting area and an optional outside run.

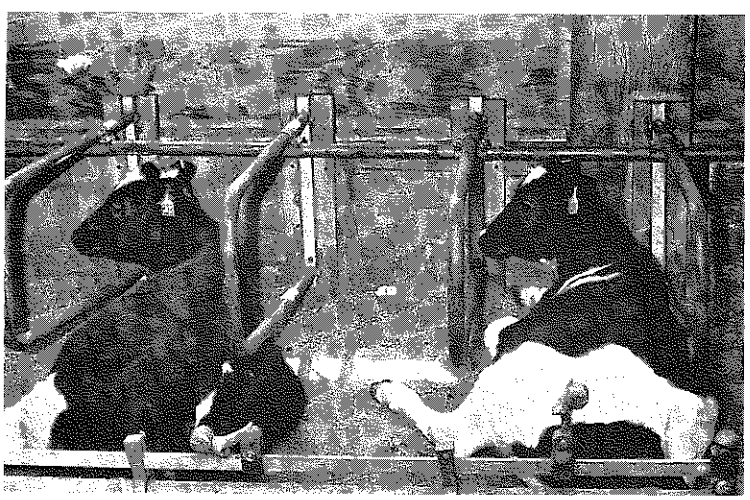
Free stalls are an alternative to loose housing for heifers. The manure alley between rows of free stalls should be at least 6 feet wide, depending on the manure handling system. Adequate width for scraping equipment or properly designed slatted floors are essential. Provide draft protection for young heifers in free stalls.

Table 40 shows the minimum space required in various types of housing facilities for calves 3 months and older.

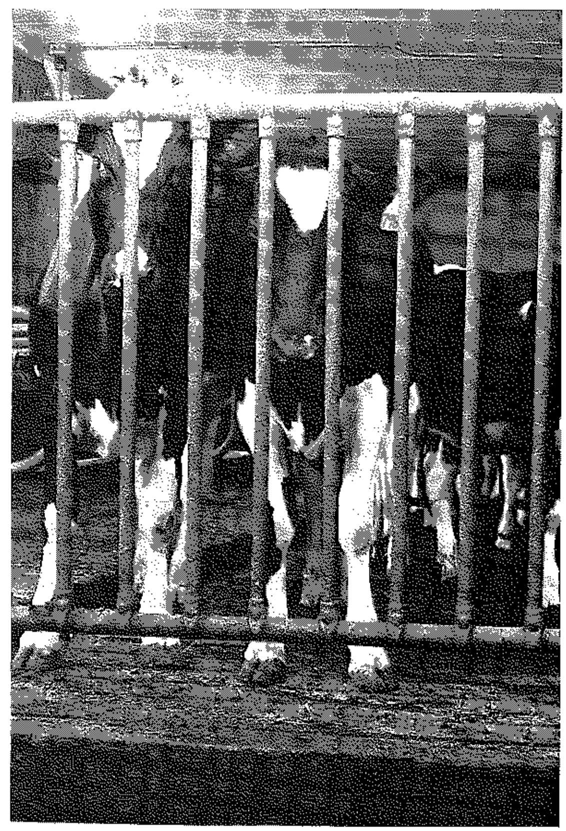
Older heifers can tolerate the stresses associated with larger groups. Heifers 8 months old to freshening can be housed in groups containing 10 to 25



A free-stall barn with solid concrete aisles for regular scraping.



Properly sized and constructed freestalls are important.



A free-stall barn with slatted floors and a pit for manure storage.

animals. Older calves and heifers are usually raised in cold or modified environments (bedded packs, free stalls, total slatted floors or self-cleaning platforms). Some characteristics of these types of housing facilities:

Bedded Pack

Requires sufficient bedding

Manure pack usually removed in the spring and fall

Manure packs provide warm resting surfaces

Free Stalls (Solid Floor)

Requires relatively small amounts of bedding

Manure in unbedded areas must be removed frequently (once or twice per week) unless floors are slatted

Manure may freeze in cold barns

Total Slatted Floor

No bedding required

Required stocking rates are higher than other housing facilities

Manure stored under buildings (removed every 6 to 8 months)

Ventilation system must remove harmful manure gases

May be too cold and/or drafty for young (2 to 6 month old) heifers

Manure may freeze on slats in cold barns

Counter-Slope Floor

No bedding required

Manure must be removed frequently unless litter alley floor is slatted

Manure will freeze

Animals may become dirty if stocking rate is too low

Manure-contaminated runoff from unroofed litter alleys must be properly handled

Not recommended for bred heifers during last 3 months of pregnancy

Not recommended for heifers under 5 months of age

Table 40. Minimum housing space

	Age (months)				
Type of facility	3-4	5-8	9-12	13-15	16-25
	Square feet/animal				
Resting area	20	25	28	32	40
and					
paved outside lot	30	35	40	45	50-75
Solid floor (total confinement)	20	25	30	40	60
Slatted or self cleaning floor (total confinement)	11	12	13	17	25
	Dimensions				
Free stalls	2'x 4'6"	2'6"x 5'	3'x 5'6"	3'6"x 6'6"	3'6"x 6'6"
Minimum manure alley width	6'	8-10'	8-10'	8-10'	8-10'

Care and Management of the Housing Facility

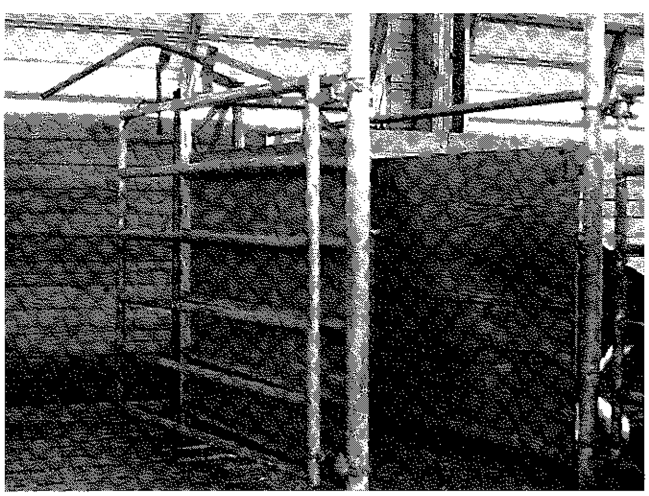
Proper management is necessary in any system. Poor management can make the best housing facility a failure. Some management practices also change with animal size and maturity.

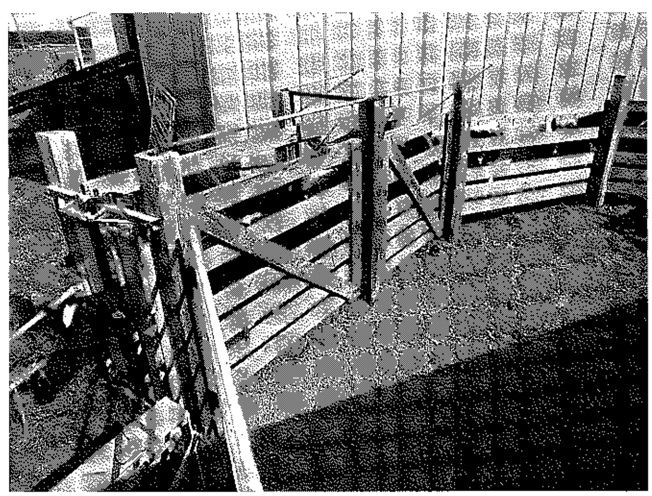
- Observe animals to monitor their growth and health. Limit group size to reduce crowding and to make observation easier.
- Keep calves less than 2 months old in dry, draft-free facilities and minimize their exposure to disease organisms. Hutches, pens and floor-level stalls must be kept dry. This requires proper bedding.
- Well-planned facilities can reduce time and labor required for cleaning, feeding, observation and treatment.
- Eliminate daily hauling and reduce feeding time by storing at least a 1- or 2-week supply of feed near the feeding area. Total feed needed may be stored in the same structure where animals are housed but provide separate areas for resting and feeding. Feeding in resting areas increases manure accumulation there and more bedding will be required to keep animals clean and dry.
- Consider systems to mechanically remove manure.
- Animal treatment areas (hospital stalls) should be separated from the small-calf housing facility. Maternity pens should be nearly square and provide about 150 square feet. One pen for every 20 to 25 cows is recommended. (See UW Extension publication A3446, "Guidelines for Convalescent and Maternity Pens in a Milking Barn").
- Clean and provide fresh bedding in the maternity area before each use. Locate maternity pens where observation and milking are convenient.
- Restraining facilities make artificial insemination, pregnancy testing, treatment and examination convenient and safe.

Cleanliness and Sanitation Cleanliness can reduce the incidence of calf diseases and help control flies. Proper sanitation requires:

1. Periodic manure removal.
2. Sanitizing facilities between each calf crop.
3. Letting pens dry out or "rest" between each use. Treat pen surfaces to make cleaning easier.

Hutches, pens and floor-level stalls must be properly bedded. Add fresh bedding as needed to keep calves dry. Remove manure daily from elevated stalls. Sanitize individual pens, stalls or hutches and





Plan treatment and handling facilities for your replacement housing.

let them remain unoccupied for a week or more between calves. Moving hutches to an unused location when the manure pack is not frozen helps break the disease cycle.

The bedded pack in resting areas for calves 3 to 5 months old should be removed twice per month in warm barns and twice per year in cold barns. Remove manure at least twice a week from alleys and feeding areas in free stall or loose housing facilities. Manure may have to be removed more often in cold environments to prevent freezing.

Provide Adequate Space The number of replacement animals to be housed depends on the number of milking cows and bred heifers. As herd size increases, so does the number of replacements. Increasing herd size without expanding facilities for replacements results in crowding and can increase injury and disease. Table 41 shows the average number of animals for different herd sizes. The figures assume only heifer calves are kept and that 5% of the calves are lost at birth.

Even though the figures reflect no culling, in actual practice, 25% of the heifer calves may be lost or sold. However, the number of calves produced by freshening 2-year-olds is approximately equal to the number of heifer calves that are lost or sold.

Provide adequate feeding space so youngstock do not have to compete for feed. Optimum feeding space varies with the type of feed, feeding schedules, and animal size.

Water is essential at all times. Provide at least one watering space per 40 animals. Dairy heifers need 1 to 1.5 gallons of water daily per 100 pounds of body weight. Pipe and waterers in cold or modified housing facilities should be designed to prevent freezing.

Types of Environment

Replacements can be raised in several types of environments. Each has advantages and disadvantages. Warm, cold and an intermediate type or modified environments are used.

A warm, insulated barn requires regulated fan ventilation. Auxiliary heat is also required for young animals. Some dairymen house replacements for the first year in warm barns and then move them to a cold or modified facility.

Cold housing facilities are usually uninsulated and utilize unregulated natural ventilation. Small calves are often kept in an enclosed building or hutch until after they are weaned. They are then moved to a building that can be open to the south.

Table 41. Approximate number of animals by age group*

Group No.	Type of animal						Average weight (large breeds)
							lbs.
9	Cows milking	30	40	75	83	100	1400
8	Dry cows	6	8	15	17	20	1550
7	2-year-olds	8	10	20	22	25	1200
	Total Mature cows	**36**	**48**	**90**	**100**	**120**	**1450**
	Replacements						
6	16-24 mo.	14	18	34	38	45	1050
5	13-15 mo.	4	6	11	12	15	800
4	9-12 mo.	6	8	15	17	20	600
3	5-8 mo.	6	8	15	17	20	400
2	3-4 mo.	3	4	7	8	10	250
1	0-2 mo.	3	4	8	9	10	150
	Total replacements	**36**	**43**	**90**	**100**	**120**	

* Based on uniform calving throughout the year, a 13-month calving interval, 5% of calves lost at birth, 50% female calves, male calves not housed, and 25 heifers freshen per year per 100 cows.

A modified environment facility is insulated and requires natural ventilation. The building temperature fluctuates with changes in outside temperature. The following section lists some characteristics of each of these housing facilities.

Warm Barns

- More comfortable for farmers
- More expensive to build than cold or modified environment buildings
- Freezing is not a problem
- Ventilation systems must be properly designed, maintained and operated
- Fuel is required to maintain desired temperature during cold weather
- Insulation helps keep the barn cool during warm weather
- Excellent sanitation is critical

Cold Barns

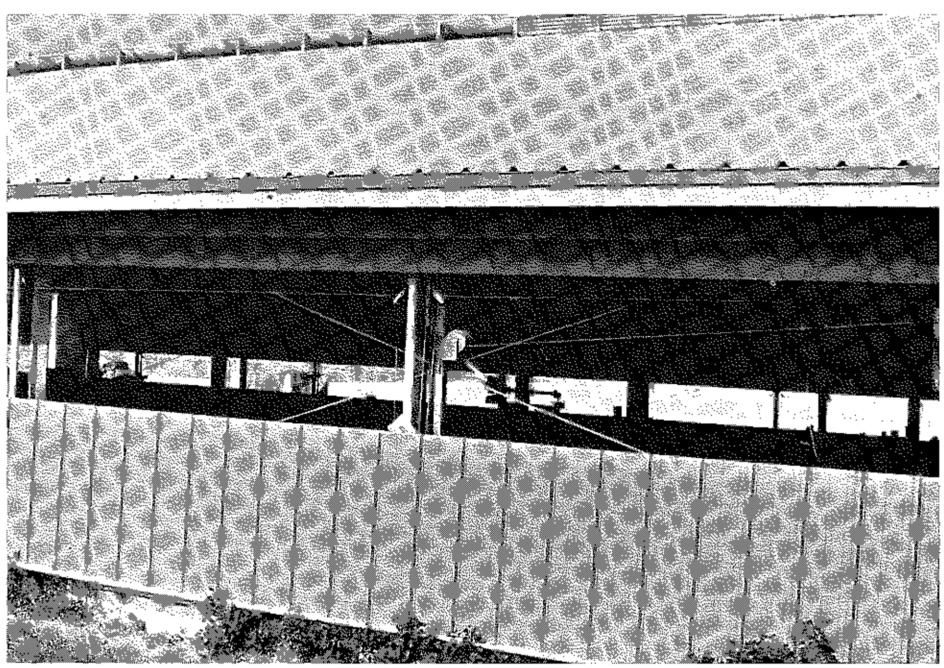
- Least expensive to build
- Freezing can make manure handling more difficult
- Pipe and waterers must be freeze protected
- Frostbite of calves may be a problem
- More feed required to maintain body heat
- Farmers must dress for cold weather
- Properly designed natural ventilation maintains good air quality and minimizes condensation

Modified Barns

- Medium cost (insulation required)
- Manure may freeze
- Insulation helps cool barn during hot weather
- Natural ventilation systems must be properly designed and maintained
- Less moisture condenses on ceilings than in uninsulated barns
- Requires freeze protected pipe and waterers

Natural Ventilation Natural ventilation is generally used in cold or modified environment buildings. During the summer, wind currents provide the force for air exchange. Wind and the "chimney effect" provide air movement during cold weather.

Natural ventilation designs incorporate sloping ceilings and openings under the eaves and at peaks. Size of ridge openings increases as building width increases. Adjustable doors under eaves and/or at



Adjustable panels and openings under the eaves are incorporated in this naturally ventilated building.

peaks adjust air flow and can prevent snow from blowing in. Large sidewall panels permit cross ventilation during warm weather.

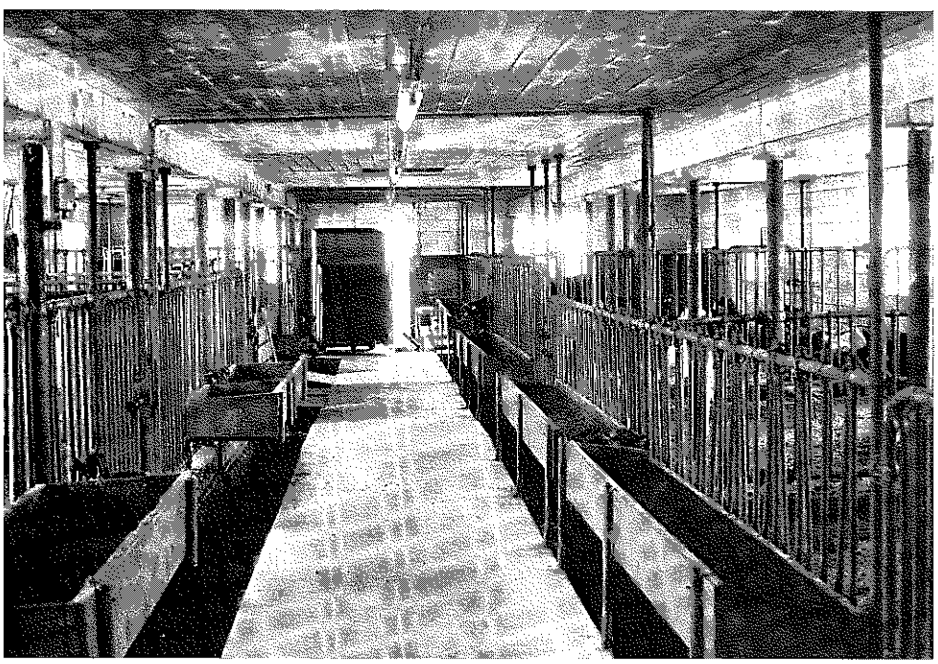
Mechanical Ventilation Fan ventilation systems must be carefully planned. Buildings must be well insulated and fully stocked to design capacity. A ventilation system must deliver fresh outside air at the proper rates. Properly designed inlets allow fresh outside air to be evenly distributed throughout the structure.

Mechanical ventilation systems in calf barns should be designed to provide a minimum, continuous exchange of air. Since the number of calves and young heifers in a facility will vary, mechanical ventilation systems must be designed for several stocking rates. Because this is difficult to accomplish, an alternative method based on the number of air changes per hour in the structure has proven effective if animal stocking rates do not vary widely.

1. Fans must provide a continuous air flow of 4 air changes per hour during cold weather.
2. At some pre-set temperature, the air flow is increased to approximately 8 air changes per hour.
3. At a still higher temperature, the air flow increases to approximately 12 air changes per hour.
4. During hot weather, fans must provide 20 air changes per hour.

Conclusions

To raise healthy replacements with the potential for high production, carefully plan facilities for replacements. Provide adequate space for water, feed, resting and exercise. Remember that even the best facility is no better than the manner in which it is managed. Well-planned facilities let dairymen use their time and labor efficiently to raise healthy replacements.



Calves can be successfully raised in a warm environment if sanitation and ventilation are adequate.

Do calves need water?

Yes. Provide calves with plenty of fresh water. Pail feeding is best. Water can be provided when calves are less than 1 week old. Do not feed water just before feeding milk or milk replacer to calves less than 3 weeks of age.

Pail-feed fresh water until calves adjust to free-choice water. Drinking cups may then be used.

Do growing calves and heifers need supplemental vitamins?

Calves are born with little or no reserves of the fat-soluble vitamins A, D and E. Colostrum is high in vitamin A activity and other fat-soluble vitamins. Weak newborn calves, purchased calves, or those born in a disease-infected environment will benefit from intramuscular injections of vitamins A, D and E. Consult with your veterinarian.

The vitamin concentration of colostrum depends on how pregnant cows are fed. Rations of dry pregnant cows should be supplemented with at least 50,000 I.U. of vitamin A and 25,000 I.U. of vitamin D daily. Supplemental vitamins are not necessary for cows on good pasture but are recommended if cows are fed stored or fermented feeds year round.

A deficiency of vitamin A decreases a calf's resistance to disease, particularly scours and pneumonia. Vitamins A and D should be added to starters (Tables 26, 27 and 28). Commercial sources of vitamins A and D also contain vitamin E. Most dry commercial starters and milk replacers contain vitamins A, D and E.

High-quality dry forages are a good source of carotene (the precursor of vitamin A) and vitamins D and E as well as the water-soluble vitamins. The carotene content of forages decreases during harvesting and storage. The carotene content of ensiled forages remains constant after preservation is complete but the carotene content of dry forages continues to decline during storage. To make sure heifers receive enough vitamin A, provide 1,000 I.U. of vitamin A daily per pound of dry matter consumed (see Table 31).

Whole milk and milk replacers usually contain adequate amounts of the water-soluble vitamins (B-complex vitamins). Once a calf starts to eat dry feed and fermentation occurs in the rumen, rumen bacteria start to synthesize B vitamins. Rumen synthesis and feeds usually supply adequate amounts of B vitamins for growing calves and heifers.

Do growing heifers need salt and supplemental minerals?

Yes. Salt and other minerals are extremely important in good growth. Salt must be provided for all livestock. Feeds are low in iodine and cobalt in some areas. Trace mineral salt contains adequate amounts of these and other trace minerals — iron, copper, manganese and zinc. A trace mineral salt should also contain selenium if white muscle disease is a problem or you are in an area known to be deficient in selenium.

Calcium and Phosphorus Calves and heifers require large amounts of calcium and phosphorus. The feeding methods recommended in this publication will provide adequate amounts of these minerals.

Milk is a good source of both calcium and phosphorus. The suggested starters and commercial calf feeds are fortified with these minerals. Legume hays are rich in calcium. Heifers consuming legume hay or legume silage will receive plenty of calcium. Concentrates, especially the high-protein feeds, are rich in phosphorus. When one-fourth of the grain ration is made up of protein supplements such as soybean oil meal or commercial protein supplements, 3 to 4 pounds of the grain mix will provide adequate phosphorus.

A phosphorus supplement will be needed as heifers grow older and are fed largely roughages and limited grain. Include 1% steamed bonemeal, dicalcium phosphate or commercial mineral of similar composition in home-mixed feeds in addition to providing mineral free choice. This will ensure ample calcium and phosphorus.

What kinds of bedding are best?

Clean dry straw or sawdust are preferred for young calves. Older animals can be bedded with chopped corn stalks, ground corn cobs, wood shavings, ground bark or combinations of these and similar materials.

ADDITIONAL INFORMATION

The following publications and software are available from county University of Wisconsin-Extension offices.

Breeding and Reproduction

A3022	The Annual Cost of a Dairy Sire
A3084	Using Prostaglandins in A Reproductive Management Program for Dairy Cattle

Feeding

A1178	Corn Silage for the Dairy Ration
A2183	Selecting the Grain Mix Protein Level in Dairy Rations
A2309	Taking an Accurate Forage Sample
A2945	Managing the Dairy Feed Inventory and the related Worksheet (A2945-1)
A2914	Determining Intake of Forages and Ensiled Grains

Health

A2661	Prevent Calf Pneumonia
A2841	Calf Management — Birth to Weaning
A3141	Calf Management and Facilities on Selected Wisconsin Dairy Farms
A3255	Ventilation Worksheet for Dairy and Swine Buildings
A3446	Guidelines for Convalescent and Watering Pens in a Milking Barn

Facilities and Housing

A2823	The Calf Hutch — Building and Using
A81NE100	Troubleshooting Livestock Environmental Control Systems
A3077	Livestock Yard Runoff Control Systems
A2796	Above Ground Liquid Manure Storages
A2795	Earth Storage Basins for Liquid Manure
A2803	Breeding Chutes to Simplify Artificial Insemination
NCR125	Stray Voltage Problems with Dairy Cows
A7811204	Dairyman's Stray Voltage Checklist
A2704	Ventilating Calf Barns
MWPS-7	Dairy Housing and Equipment Handbook
MWPS-32	Mechanical Ventilating Systems for Livestock Housing
MWPS-33	Natural Ventilating Systems for Livestock Housing
MWPS-34	Heating, Cooling and Tempering Air for Livestock Housing
A3307	Housing Dairy Replacements
A3430	Dairy Cow Manure Storage — Can it Pay?
MWPS-18	Livestock Waste Facilities Handbook

Financial Analysis and Budgeting

NCR34	Managing Your Farm Financial Future
A2731	Wisconsin Farm Enterprise Budgets: Dairy Cows and Replacements

Dairy Herd Improvement Testing Programs

A2735	What to Expect When You Join DHIA
A2765	Use DHI Records for Culling
A2989	How DHI Cow Records Are Calculated

Computerized Decision Aids

WIS*PLAN, the UW-Extension's library of computer programs, is available to Wisconsin residents through county Extension offices. Dairy production programs in the WIS*PLAN library include:

Badger Balancer

Least-Cost Dairy Ration Balancer

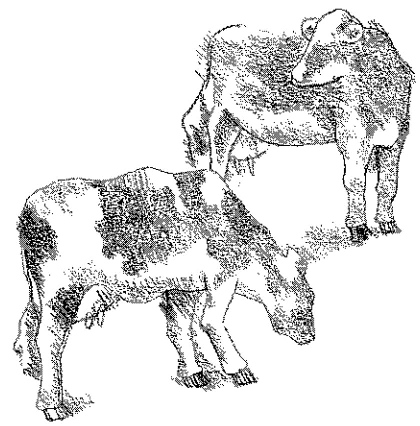
Inventory (calculates silage storage capacity and determines how many pounds of roughage per day a dairyman can feed without prematurely emptying his silo)

Silosizer (estimates additional required storage capacity)

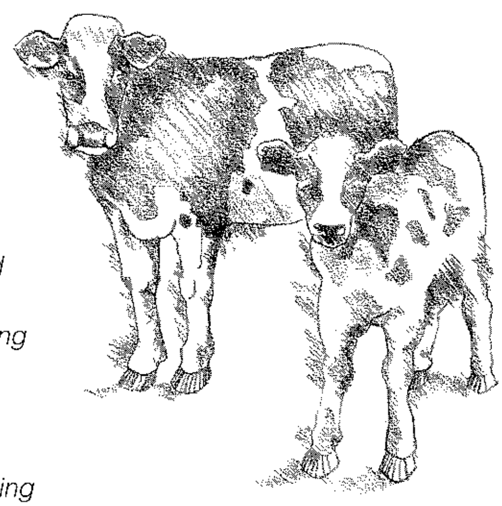
Sire Select (selects active AI bulls according to your specifications)

Vent (determines the ventilation requirements of dairy housing units)

To Raise Healthy, Productive Herd Replacements



- *Keep accurate records*
- *Rely on a good breeding program*
- *Properly manage and feed dry cows*
- *Provide adequate calving facilities*
- *Be present at calving time*
- *Dry and massage the newborn calf*
- *Force-feed an adequate amount of good-quality colostrum within 30 minutes after birth*
- *Disinfect the calf's navel*
- *Identify the calf*
- *Feed milk or milk replacer*
- *Provide a good-quality starter*
- *Make sure a calf is healthy and consumes the recommended amount of starter before weaning*
- *Monitor calf health and growth*
- *Detect and treat ailments early*
- *Feed balanced rations to growing heifers*
- *Monitor heifer growth*
- *Breed heifers at 14 to 15 months of age*
- *Include facilities for replacements in your housing plans*



What About Withdrawal Periods?

There is no withdrawal period for either product. They can be fed up to calving.

What About Young Calves?

Rumensin is not approved for calves that weigh less than 400 pounds. There is no lower weight limit restriction for Bovatec. Bovatec has been mixed into both the milk replacer and calf starter for young calves.

A recent report from Kansas State examined the use of Bovatec in young Holstein bull calves. All calves were fed colostrum until 3 days of age and then milk until 3 weeks of age. A prestarter was fed until consumption reached 0.5 lbs per day. At this point, 0.5 lbs per day of the prestarter was fed along with calf starter ad libitum. Bovatec was incorporated into both the milk and prestarter for the first 2 weeks. After this time, it was only in the dry feed. The feeding rate of Bovatec was 0.5 mg/lb of body weight which is equivalent to about 60-90 mg/animal/day. Daily feed intake was 3.3 lbs for the control group and 3.7 for the treated group. Average body weights at 12 weeks of age were 213 lbs for the control group and 238 lbs for the treated calves. The calves fed Bovatec gained about 25 lbs (11.7%) more weight over the 12 week period than the control calves.

What About Coccidiosis?

Rumensin is approved for use as a cocciodiostat in goats. This product is not approved for cattle. Bovatec has been used for coccidiosis control in sheep for a number of years. On November 2, Bovatec was approved by FDA for control of coccidiosis in cattle weighing less than 800 pounds. Dosage rate is 1 mg/per 2.2 pounds of body weight.

What ABout Toxicity to Horses?

Both products can be toxic to horses. It appears that it takes a higher level of ingestion of Bovatec to cause a toxicity. However, both companies indicate their product should not be fed to horses.

Which Product Should be Used?

At present, there appear to be very minor differences between Rumensin and Bovatec. The biggest difference in the two products is the approval of Bovatec for coccidiosis control and the fact that Bovatec can be fed to calves of any weight. Both appear to have potential to assist in improving the overall dairy replacement program. Daily costs appear to be similar for both products. An individual dairyman will probably use the product that his feed company decides to market.

Table 1. Total number of heifers required to maintain herd size (100 cow herd)[a]

Cull rate (%)	Age at 1st Calving (months) 22	24	26	28	30	32	34	36
20	40	44	48	51	55	59	62	66
22	44	48	52	56	61	65	69	73
24	48	53	57	62	66	70	75	79
26	52	57	62	67	72	76	81	86
28	56	62	67	72	77	82	87	92
30	61	66	72	77	83	88	94	99
32	65	70	76	82	88	94	100	106
34	69	75	81	87	94	100	106	112

[a]Smith, 1987

Table 2. Replacement heifer weight gain and day of trial at first estrus[a]

Trial	Beef or Dairy	ADG, lbs Control	Rumensin[b]	Trial Day of 1st Estrus Control	Rumensin[b]
1	Beef	1.40	1.48	90	79
2	Beef	1.08	1.45	178	163
3	Beef	1.43	1.32	198	174
4	Beef	1.17	1.41	-	-
5	Beef	1.86	2.10	-	-
6	Beef	1.00	1.04	-	-
7	Beef	1.36	1.49	-	-
8	Dairy	1.50	1.59	136	113
9	Dairy	1.33	1.52	150	153
10	Dairy	1.58	1.71	-	-

[a]Data provided by Eli Lilly and Company
[b]Rumensin fed at the rate of 200 mg/animal/day

Table 3. Dairy Replacement Heifer Data - Cornell

Item	Treatment	
	Control	Rumensin[a]
Initial weight, lbs	513	518
Number of heifers	28	27[b]
ADG, lbs	1.50	1.59
DMI, lbs	11.35	11.17[c]
Average trial day of 1st estrus	136	113
Percent conception	96	89
Number of live calves	25	23

[a]200 mg/animal/day of Rumensin
[b]One heifer removed due to a broken leg
[c]Intake includes only supplement during the pasture phase

Table 4. Dairy Replacement Heifer Reproductive Data

Item	Control	Rumensin
Number of heifers	205	208
Average trial day at first estrus	152	139
Average day of age at first estrus	421	408
Weight at first estrus, lbs	667	664
Conception rate, %	91	89
1st service conception rate, %	69	65

[a]Data provided by Eli Lilly

Feeding the Dairy Calf

L E. Chase and C. J. Sniffen
Department of Animal Science
Cornell University

The raising of dairy replacements represents the foundation for the future productivity and success of the dairy enterprise. Genetic improvement in a herd relies upon replacing cows leaving the herd with genetically superior heifers. The first step in a total replacement program must be an emphasis on the principles of genetic selection. The next step is to provide a feeding, management and housing program to optimize growth and development of the heifer at a reasonable cost.

The dairy calf is born with essentially no immunity or antibodies against disease and infection. Passive immunity is acquired by absorbing the immunoglobulins in colostrum through the intestinal wall and into the bloodstream. The types of immunoglobulins present are:

Type	% of Total Ig	Provides Immunity Against
IgG	80-86	Systemic infections
IgA	7-10	Intestinal infections
IgM	7-10	Systemic infections

What is Colostrum?

Colostrum is usually defined as the milk produced in the first 3-5 days after parturition. Table 1 compares the composition of colostrum and whole milk. Note that first milking colostrum is a more highly concentrated product. The decline in composition between the first and third milking postcalving is quite dramatic. True colostrum is the product of only the first milking. Colostrum provides energy, protein, vitamins and immunoglobulins for the young calf.

Does All Colostrum Contain High Immunoglobulin Levels?

No. There is considerable variation in the immunoglobulin content of colostrum. The following factors influence the immunoglobulin content of colostrum:

1. Breed - The immunoglobulin content of Jersey colostrum is generally higher than Holsteins.

2. Age - Older cows generally have higher immunoglobulin levels than first-calf heifers.

3. Milking number after calving - see Table 1.

4. Dry period length - Cows with short dry periods, less than 40-45 days, will usually produce colostrum with a lower immunoglobulin content.

5. Premilking - Milking cows prior to calving will lower the immunoglobulin content of the colostrum produced after calving. Cows which leak milk prior to calving may exhibit a similar change in colostrum composition postcalving.

How Can the Quality of Colostrum be Monitored?

There is a relationship between the specific gravity and the quality of colostrum. High quality colostrum will be thick and creamy in appearance. Colostrum which is thin and watery will be of lower quality. A better method to evaluate quality is to use a colostrometer. This device measures the actual specific gravity of the colostrum which is directly related to immunoglobulin content. You should purchase and use this device in the feeding and management program for the newborn calf.

What Are the Key Factors in Colostrum Management?

Adequate intake of high quality colostrum is the key to providing passive immunity to the calf and also lowering mortality. The following points should be kept in mind:

1. The degree of passive immunity attained is directly related to the amount of colostrum fed, the immunoglobulin content of the colostrum and the amount absorbed.

2. The efficiency of colostrum absorption across the intestinal wall into the blood decreases rapidly after birth. Maximum absorption occurs in the first few hours. After 12 to 24 hours, the ability to absorb colostrum declines to essentially zero.

3. Calves should receive 5% of their body weight as first milking colostrum within 15-30 minutes after birth. This is about 2 quarts (4-5 lbs) for large breed calves and 1-1 1/2 quarts (2-3 lbs) for small breed calves.

4. Offer another feeding of first milk colostrum in the next 3-5 hours. The goal is to get 12-15 pounds of first milk colostrum into a Holstein calf during the first 12-24 hours of life. The amount of colostrum fed has a dramatic effect upon blood immunoglobulin levels and calf mortality (Tables 2 and 3).

5. Calves that nurse the cow seem to absorb immunoglobulins better than those fed with bottles or nipple pails. The problem is that all calves do not get up to nurse within the first few hours. One study indicated that 25% of the calves did not nurse within the first 8 hours. Force feeding colostrum to the calf in the presence of the mother seems to help enhance absorption.

6. Measure the immunoglobulin levels in any excess first milking colostrum, put it in a container, label it with the immunoglobulin content and freeze it for future use. This provides a bank of high quality colostrum for future calves in situations where either inadequate amounts or low quality first milking colostrum are available.

7. Continue feeding colostrum for the first 3-4 days.

Liquid Feeding Programs

After the colostrum feeding period ends, there are a number of options for liquid feeding programs. Choices available include whole milk, milk replacer, waste milk or fermented colostrum. All of these systems can work well and provide for adequate weight gains. Fermented colostrum and waste milk are essentially "free". Whole milk is usually the most expensive.

Levels of 180 to 350 pounds of milk equivalent during this time period have been used (Table 4). A simple method is to feed a constant level of liquid to the calf until weaning. A level of 7-8 pounds per day has worked well for Holsteins (5-6 pounds for Jerseys). Calves can be fed once a day if they are observed at least twice a day.

Milk replacers have worked well for many dairymen. Quality milk replacers should contain 20-22% protein and 10-20% fat. A key factor in evaluating milk replacers is the protein sources used in the product. The protein sources listed on the feed tag can be grouped as follows for acceptability:

Best	Acceptable	Inferior
Skim milk	Processed soy flour	Unprocessed soy flour
Buttermilk	Soy concentrate	Meat solubles
Whole whey	Hydrolyzed fish protein	Fish flour
Delactosed whey		Distillers solubles
Casein		Brewers yeast
Milk albumin		Oat Flour
Whey protein concentrate		Wheat flour

When feeding a milk replacer, mix and feed according to the directions on the bag. Don't try to stretch it by adding more water and less solids. This practice will short change the calf on needed nutrients for growth during this critical period.

Fermented colostrum is another option which may be used. If this system is used, generally 3 separate containers will be used. One is being filled, one is fermenting and the other is being fed. It is desirable not to store this material for longer than 30 days. Optimum temperature for good fermentation to occur is 60-80F. Milk from cows treated with antibiotics should not be added as this may inhibit fermentation. At time of feeding, 2 parts of fermented colostrum should be mixed with 1 part of warm water.

What About Access to Water?

This is a topic of much debate and controversy. However, free access to water is generally recommended once dry feed is made available.

How About Hay Feeding?

Calves will consume small amounts of hay prior to weaning. However, hay is not necessary during the first 8 weeks. If you desire to feed hay during this time, it should be a high quality hay. You may have to limit hay consumption to encourage intake of calf starter.

Using Calf Starters

Calf starter should be introduced to the calf at 3-4 days of age. A coarse textured starter seems to be more acceptable than a pellet. Calf starters should contain a minimum of 16% crude protein with an ADF level of 12% or more. Calves should be consuming 3-4 pounds per day by 7-8 weeks of age. All-in-one calf starters have worked well for many people. The end products of digestion of calf starters provide the stimulus for rumen development.

When Should the Calf be Weaned?

This is a point of continuing discussion. Calves have been weaned as early as 2 weeks of age when fed a special prestarter containing high levels of milk products. However, this system may not fit well in many situations. A common guideline is to wean calves abruptly when they are consuming 1-1 1/2 pounds of calf starter per day. This should occur by 4-6 weeks of age in most calves.

Summary:

The feeding and management of the neonatal calf is the first step in a successful dairy herd replacement enterprise. The period of time from birth to weaning has 3 critical components. These are colostrum feeding, liquid feeding and calf starter. The point outlined above should provide a basis for establishing a feeding program during this phase of the calf's development.

Selected Calf and Heifer References

1. Economical Rearing of Dairy Herd Replacements. S. T. Slack, R. G. Warner, N. B. Haynes and W. W. Irish-Animal Science Mimeo No. 12, cost $2.00.

2. Neonatal Calf Nutrition and Feeding - D. J. Walsh, R. G. Warner, H. R. Ainslie, M. A. Brunner and J. M. Elliot -Animal Science Mimeo No. 69, cost $2.00

Available from:

Mrs. Joyce Dickens
Department of Animal Science
Cornell University
272 Morrison Hall
Ithaca, NY 14853-4801

3. Raising Dairy Herd Replacements - J. W. Crowley, N. A. Jorgensen and W. T. Howard. North Central Regional Publication 205, cost $2.50

Available from:

Publications Office
Cooperative Extension Service
1535 Observatory Drive
University of Wisconsin
Madison, WI 53706

Table 1. Composition of Colostrum and Whole Milk[a,b]

Item	Colostrum (milking number) 1	3	5	Whole Milk
Specific gravity	1.056	1.035	1.033	1.032
Total solids, %	23.9	14.1	13.6	12.9
Fat, %	6.7	3.9	4.3	4.0
Protein, %	14.0	8.4	4.2	4.0
Lactose, %	2.7	3.9	4.6	4.9
Immunoglobulins, %	6.0	2.4	.1	.09

[a]Foley and Otterby, 1978.

[b]Analyses are primarily Holstein data.

Table 2. Blood changes after colostrum feeding during the first 12 hours[a]

Days After Birth	Colostrum fed[b] (lbs)	Blood Protein (g/100 ml)	IgG ---(Mg/100 ml)---	IgM	IgA
0	0	4.4	0	0	0
3	3	5.7	1320	140	48
3	12	6.5	2640	320	288

[a]Robb and Warner, 1984.

[b]Amount of colostrum fed during first 12 hours.

Table 3. Colostrum fed during the first 12 hours and calf mortality[a]

Amount Fed (lbs)	Number of Herds	Average Mortality[b]
2-4	18	15.3
5-8	16	9.9
8-10	26	6.5

[a]Clemson University.

[b]Between 1 week and 6 months of age.

Table 4. Relative Value of Various Milk Feeding Systems to 7 Weeks of Age (Holsteins)[a]

	Milk Feeding System			
	350 lb.	250 lb.	180 lb.	25 lb Milk Replacer
Average daily gain, lb	1.2	1.1	1.05	1.05
Milk consumed, lbs.	350 $__	250 $__	180 $__	25 $__
Grain consumed, lbs.	49 $__	59 $__	77 $__	87 $__
Hay consumed, lbs.	11 $__	11 $__	11 $__	11 $__
Total cost	$_____	$_____	$_____	$_____

[a]Warner, 1984.

PLANNING HEIFER HOUSING FACILITIES

William Menzi, Jr.

Many dairy heifers get the short end of the stick when it comes to housing. Often, an old barn down the road or the dairy barn which no longer is adequate for cows becomes the "place to put the heifers for the winter". Inadequate housing facilities, coupled with less than optimum feeding and management contribute to the fact that most heifers in the Northeast are not well grown and ready to freshen at 24 - 26 months.

A summary of data from 6619 Holstein herds on DHI in 1981 in the Northeast (Ainslie 1982) indicates that the average age of first calving is 28 months, with an average body weight of 1120 lbs. Summary data further indicated the effect of management on growth and development. The top quarter of those herds (ranked on rolling herd average) had heifers which freshened at 27 months weighing an average of 1150 lbs, compared to the bottom quarter of the herds which freshened heifers at 29 months at a weight of 1090 lbs. This data points out that weight at first calving is influenced more by management then by age.

One of the most important factors in proper management of heifers is adequate and efficient housing. Good housing does not have to be expensive or elaborate to be efficient, but it must be designed to complement the existing dairy herd housing and management system. The planning process should include a careful evaluation of existing facilities, with special emphasis on the integration of the new facility into the total farm operation.

FACTORS TO BE CONSIDERED

Number of Heifers

Knowing the number of heifers which must be housed is essential to determine building size. The dairymen must consider present as well as future needs so as to allow for growth of the herd.

Three major factors influence the number of heifers which must be housed on any particular farm. These are (1) number of cows, (2) culling rate, and (3) average age at first calving. The relationship of these factors for a 100 cow herd is presented in Table I. Note that as the culling rate increases, the heifer herd must also increase to provide an adequate number of replacements for the milking herd.

The effect of average age at first calving, on the total number of heifers which need to be housed, fed, and managed is dramatic. For example, a 100 cow herd with a 30 percent culling rate and heifers freshening at 24 months needs approximately 66 heifers. In contrast, the same herd with an identical culling rate, but an average age at first calving of 36 months, would require 99 heifers -- a 50 percent increase.

The author is: William Menzi, Jr., Regional Extension Specialist, Cornell University, Ithaca, New York.

finished. It is also necessary to balance the ration properly for the requirements of the animals in each group to insure proper growth without over-conditioning.

Feed Storage and Handling

The feed storage and handling facilities for the heifer feeding program should be integration with that of the main dairy herd. The sharing of facilities and equipment between animal groups can reduce the cost of raising replacements and improve labor efficiency. This multiple use of systems, such as upright or horizontal storage, mixer wagons, or automated feeding systems with both herds can reduce the cost of the accessory equipment which is often a major cost item in building a new heifer facility.

Manure Handling

The same principles hold true for manure handling as for feed storage and handling. If at all possible, the same manure handling methods should be used for both animal systems, this allows the dairyman to take advantage of existing equipment and facilities.

Animal Handling Facilities

Any facility for young stock should contain equipment for the convenient movement and restraint of both groups and individual animals. Design facilities and equipment to allow one person to catch any animal in a minimum of time and with a minimum risk to himself and the animal.

Many types of self-locking head gates, working shutes, and catch pens are available. Consideration should be given to that which best meets the need, and fits the housing system which is being built.

Convenient animal handling systems will encourage dairymen to carry out routine management practices such as de-horning, vaccinating, and worming, as well as promoting the use of artificial insemination in the heifer breeding program. A job is more likely to be done if it can be done easily.

Climate and Weather Conditions

Any housing system must be built to deal with the normal weather conditions of a given area. Dairy replacements on a good nutritional program can do very well with a minimum of protection. A dry place to lay down, protection from wind and cold rain, and easy access to feed and water are the basic necessities.

Facilities should provide an environment which will keep animal stress at a minimum. Proper ventilation in both summer and winer is particularly important to reduce stress from climatic extremes.

TYPES OF HOUSING

Most heifer facilities being built today in the Northeast fall into three major categories; free stalls, bedded pack, and counter-sloped systems. Of the three, free stall systems are predominant. Any of these systems can provide a satisfactory environment for raising replacements if properly managed. The dairyman must evaluate the unique characteristics of each system, assess his resources, and pick a system which will best suit his needs based on the criteria outlined above. Counter-sloped housing systems are addressed fully in another paper in these proceedings, therefore the remainder of this discussion will focus on the adaptability of bedded pack and free stall systems to meet various farm needs.

Bedded Pack

Bedded pack systems have been used for many years to house dairy heifers. The present trend however is away from this method of housing. Although this type of housing can provide excellent conditions for raising replacements, the high cost of bedding, and the large amounts of bedding required to maintain the pack has encouraged many dairymen to seek alternate housing system.

The new bedded pack systems which are being built generally provide for a separate feeding and resting area. The manure in the feeding area is scrapped routinely. This reduces the load on the pack and reduces the bedding requirement by approximately one-third.

One potential problem with this system is the two types of manure which must be handled. The manure from the feed alley will be slurry whereas the pack manure will be solid. This may cause duplication in manure handling equipment and increased cost.

Table 2 lists the minimum square feet of pack per animal at various weights. Bedding required to maintain the pack is in direct proportion to the density of animals on the pack.

The new pack systems which are being built generally are for calves in the age group from weaning to four - six months. This allows the calves a period of social adjustment in a low stress environment before moving into free stall systems. Another area of interest in bedded packs is for the housing of dry cows. Many dairymen feel that there is benefit in getting cows off concrete during the dry period. The main benefits are in reduced injuries, and improved condition of feet and legs.

Free Stall Systems

Free stall heifer housing systems have been adopted rapidly by dairymen in the Northeast. Many of the advantages of free stall housing for the milking herd also hold true for housing heifers. These advantages include labor efficiency, reduced bedding requirements and relatively low cost construction.

Systems to be described are variations of the gated free stall system designed by Professor Roger Grout, Pennsylvania State University. The variations presented allow for differences in feeding methods, climatic conditions and management. All layout variations take advantage of a straight-line free stall arrangement which has several advantages over other designs.

With separate feeding and resting areas, straight line systems make it easy to group different size animals with a minimum of gates and cross alleys. Heifers can be moved easily from the resting to the feeding area and vice versa for straight-thru cleaning. The amount of feed bunk space available is in direct proportion to the number of stalls in any group pen, so there is always enough bunk space for all heifers to eat at one time.

Figure 1 shows the basic floor plan of a heifer barn for 96 heifers from two months of age to freshening. There are four groups with different size stalls. It may be advisable to further sub-divide the two - seven month group to reduce size variation within that group.

Notice that two stalls are left out on the feed alley side to provide a cross alley so the heifers may move from the resting area to the feeding area. In several systems, this cross alley is used as a catch pen for animal handling. In smaller units, one stall is adequate for a cross alley. This cross alley should be raised to the same height as the free stall curb to provide for more efficient manure scrapping.

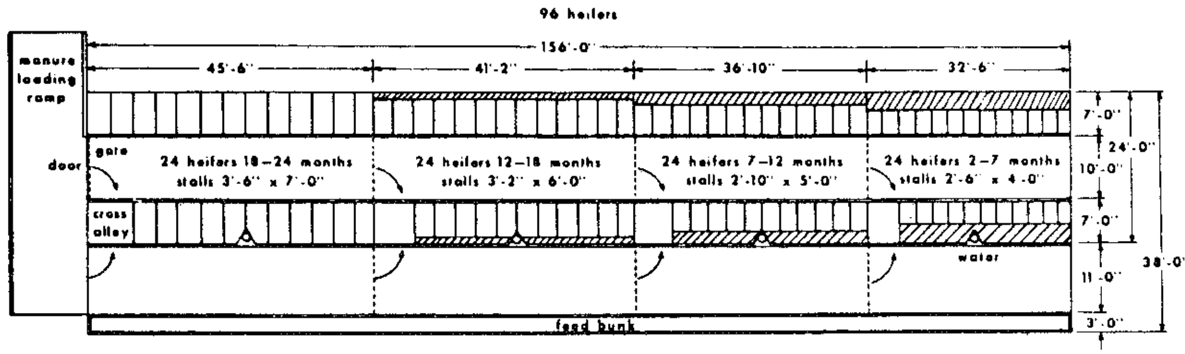


Figure 1. Floor plan shows basic layout for 96-stall heifer barn. Heifers are easily confined in either the stall or feed alley while the other side is being scraped. Note the straight curbs for easy manure handling.

The floor plan shown in Fig. 1 is easily adapted to various feeding methods. The feeding area can be left uncovered as in Fig. 2, or completely covered as in Fig. 3. In either case, mechanical or wagon feeding can be used. The basic single slope roof shown in Fig. 2 has a four foot overhang to provide some protection to the front of the building. The single slope roof with a 2/12 pitch directs most of the rain and snow to the back of the building rather than into the feed alley. Buildings with open fronts would be oriented to the south or away from prevailing winds.

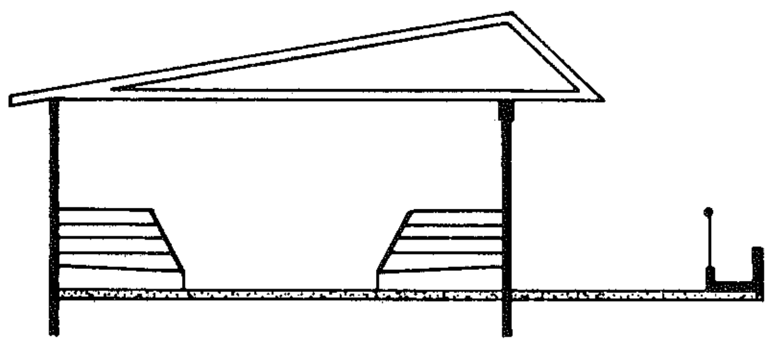


Figure 2. Roof design allows for an open feed area with stalls under cover.

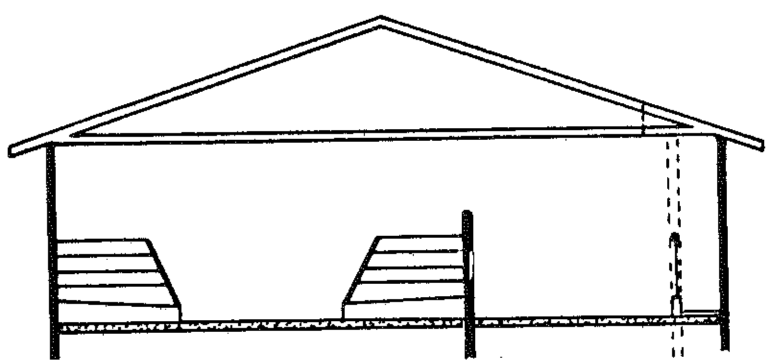


Figure 3. A bunk feeder or wagon can be used in this totally covered system. (Dotted line shows the location of post for wagon feeding).

Another interesting variation of the same basic floor plan is shown in Fig. 4. In this barn, the feed bunk has been placed on the front of the free stalls, but heifers eat from the open feed alley. Use of a suspended feeder allows heifers to walk under the feeder to reach the feed alley. A diverter board is placed under the feeder at the cross alleys so feed does not drop into the cross alley.

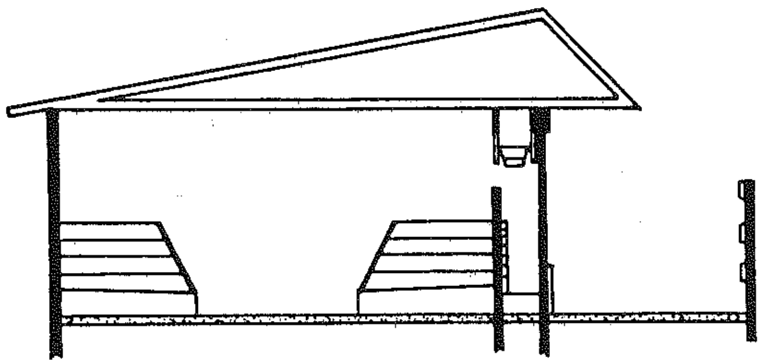


Figure 4. Stalls and bunk are covered while roofed area is kept to a minimum. Heifers eat from open alley.

This barn is designed primarily for mechanical feeding systems. The free stalls and feed bunk are covered by the same roof, so there's a minimum of building area. Heifers still can get outside for fresh air and sunshine which are beneficial in most areas.

With larger herds, double arrangements can be used to reduce the length of the barn. These can take the form of a 4-row, or 6-row barn with drive-thru or mechanical feeding.

High density layouts also can be used for heifers in the same basic straight-line system. Most high density systems contain three rows of free stalls, a single row against the wall and a double row in the middle. Use of high density systems would require that heifers be on a total mixed ration since there would not be enough bunk space for all to eat at one time.

All of the free stall systems discussed above, have worked well under North-east conditions. Dairymen with new housing facilities have been able to reduce the age of first calving. A recent survey of dairymen in central New York with new heifer facilities showed an average age of first calving of 25.2 months compared to 28 months for Northeast DHI herds.

SUMMARY

On many dairy farms, heifer housing is inadequate and inefficient. Well designed housing is one of the most important factors for proper management of replacement animals. Dairymen should strive to produce heifers which calve at an average age of 24 months at an average body weight of 1150 lbs. Reducing the average age of first calving will have the result of decreasing the total number of heifers needed on the farm, reduce the cost of raising replacements and improve the rate of genetic improvement.

The goal for those designing heifer systems should be to provide a facility which is compatible with the existing dairy operation and is labor efficient. The system should also provide an environment which minimizes competion between animals, and reduces stress.

Table 1. Total Number of Heifers Needed (All Ages) for a 100 Cow Herd [a,b]

Culling percentage	Age at First Calving (Months) 24	30	36
25	55	69	83
30	66	83	99
35	77	97	116

[a]Numbers may be used as a percentage for various size herds
[b]Number includes a 10% allowance for mortality and culling

These factors all have a significant effect on the size of facilities which must be built and are directly related to the management ability of the dairyman.

Number of Groups

Heifers should be grouped according to size. A minimum of four groups are needed for heifers from weaning to freshening. In large herds, further subdivision may be necessary to reduce competition. Calves will do best in groups with no more than two - three months age difference between animals.

Table 2 list the recommended design criteria for various components of heifer facilities based on the body weight of the heifers.

Table 2. Recommended Space Needs for Dairy Heifers

Group	Max. weight (lb)	Approx. age (mo)	Free Stalls width (in)	Free Stalls length (in)	Feed Bunk height (in)	Feed Bunk width (in)	Feed Bunk lin/head (in)	Bedded Pen (ft^2) Minimum
1.	250	2-4	24	48	16	22	12	15
2.	480	4-8	30	54	18	24	15	20
3.	650	8-12	33	60	20	27	16.5	25
4.	800	12-16	36	66	22	30	18	30
5.	990	16-20	39	72	23	33	20	35
6.	1100	20-23	42	78	24	36	22	40

Adapted from: Raising Dairy Replacements, University of Vermont and Plan #848 - Free Stall Heifer Barn, Ag. Engineering, Cornell University

Feeding Program

The type of feeding program which is followed will have an effect on the design of the heifer facility. If hay, silage and grain are fed separately, the barn must be designed to allow for adequate bunk space for all heifers to eat at one time without crowding. (See table 2 for minimum feed bunk allowance). Total mixed rations, where the grain and roughage are mixed together, make high density housing feasible for heifers. It then becomes a management responsibility to see that there is always enough feed in the bunk to allow for the more timid animals to eat after the others have

The planning process should include consideration of the number of heifers to be raised, number of groups, feeding program, feed storage and handling, manure handling, animal treatment facilities, and climate.

The three major types of heifer housing in the Northeast include the bedded pack, free stall and counter-sloped. The dairyman should evaluate the characteristics of each, and pick the system which best suits his needs and resources.

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RAISE, CONTRACT OR BUY REPLACEMENTS

In Raising Dairy Heifers For More Profit

by

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INTRODUCTION

The purpose of this paper is to provide the information used in one of the speeches given as part of the winter series of extension schools called, "Raising Dairy Heifers For More Profit." The first section discusses the economic cost of raising heifers on dairy farms. The second shows the variations in labor needed. The third section describes how to do a partial budget analysis of whether to continue growing replacements or to quit growing and start buying the heifers needed. Other economic studies are also discussed. The fourth section mentions the alternative of contracting for the growing of heifers.

COST OF GROWING A HEIFER FROM BIRTH TO FRESHENING

Researchers have long felt the full economic costs of growing heifers on dairy farms were probably greater than farmers realized. Table 1 shows the variation in reported costs over time and in various regions of the country. Inflation has certainly had an impact over the past 20 years. In any given year, a dairy farmer could have probably bought a reasonable quality replacement for less than the listed cost of growing a heifer.

Table 1. COST OF RAISING HEIFERS AROUND THE U.S.

Birth To Freshening

Michigan, 1973	$ 617
Ohio, 1978	910
Michigan, 1980	1,085
Wisconsin, 1982	1,549
Washington, 1984	1,244
Pennsylvania, 1985	
Low cost	925
Medium cost	1,271
High cost	1,597
Michigan, current	1,177

The 1984 State of Washington cost started from a survey. The current Michigan cost of $1,117 was derived using the Washington format, but with input prices adapted to Michigan conditions. The Michigan cost, then is an economic engineering estimate.

Table 2 gives the details on how the Michigan estimate was developed. There are three major groupings of costs; 1) feed, 2) operating, and 3) ownership. Feed costs, from milk replacer to pasture, make up almost half (49%) of the total cost. Dairy farmers in western Washington probably have longer access to pasture than do those in Michigan. For our purposes, we would probably have more silage and alfalfa with less pasture in the total ration.

Speicher and Brown in the 1980 and 1973 Michigan budgets showed a much larger amount of ownership costs in the buildings and equipment categories than shown in Table 2. These will vary with the amount of buildings and the age of the buildings. Similar factors affect the equipment costs. Table 3 gives the details on how the ownership costs are calculated.

Table 4 takes the total 24 months of cost and allocates them among the age groups used in the other papers of the winter meeting series. These allocations were estimates I made without the benefit of any research. No attempt was made to capitalize the interest by monthly periods. The gross estimation procedure of Table 3 remained in Table 4. The far right column looks large, but it covers a 9-month period, while the other columns each deal with about only three months.

Table 4 shows that in the early weeks of life, a disproportionate amount of the total costs are incurred. Once a calf is weaned, the incurred cost becomes a fixed cost. Therefore, it is important to have a calf raising policy set for any calf at the time of its birth. If it is not going to be raised to freshening, it should be moved off the farm immediately.

It would be ideal from a cost accounting viewpoint if dairy farmers regularly kept enterprise accounts and could summarize them to compare with the items in Table 2. For those farmers that don't, Tables 2 and 3 still provide a useful framework for thinking about replacement raising costs. They can estimate the amounts of feed, labor, bedding and other costs going into heifers. When prices are then assigned, the major cost factors in Table 2 can be estimated for an individual farm.

The message in Table 2 is that if one could buy an adequate quality replacement for less than $1,176.59 (and if this relationship would be expected to hold for several years) it would be profitable to do so. In 1986, heifers were available for less than that. However, few, if any, farmers bought their entire supply of heifers. They raised them. The section below on partial budgeting attempts to explain this seemingly nonprofit maximizing behavior.

Table 2. COST OF RAISING HEIFERS TO 24 MONTHS

	Amount		Price	COSTS
Operating Costs				
Feed				
Milk replacer	60 lbs.	@	$0.60	$36.00
Calf starter	60 lbs.	@	0.22	13.20
Calf grain	400 lbs.	@	0.10	40.00
Grain	0.7 tons	@	160.00	112.00
Alfalfa	2 tons	@	80.00	160.00
Silage	5 tons	@	22.00	110.00
Pasture	6 mo.	@	15.00	90.00
Salt and min.	100 lbs.	@	0.12	12.00
Total feed costs				$573.20
Other Operating Costs				
Initial value of heifer				$100.00
Labor	19.50 hrs.	@	5.00	97.50
Vet. & med.				46.00
Breeding	1.50 ser.	@	14.00	21.00
Bedding	0.75 tons	@	50.00	37.50
Supplies, power, etc.				18.50
Interest on average of above expenses for 2 yrs @	9 percent			80.43
Death loss %, average value			10	50.00
Total operating costs				$450.93
Total feed and operating costs				$1,024.13
Ownership Costs				
Buildings				$42.96
Equipment				19.50
Interest on heifer value				90.00
Total ownership costs				$152.46
Total Cost of Raising Heifers:				$1,176.59

Table 3. OWNERSHIP COSTS EXPLAINED

Buildings, new	$150 per heifer	
Depreciation=	$150 new cost	
minus	12 salvage	
divided by	20 years life	
times	2 yr. old heifer	
---------	equals	$13.80
Interest, taxes, insurance, repairs		
	$150 new cost	
plus	12 salvage	
divided by	2 average amount	
times	18 percent	
times	2 yr. old heifer	
---------	equals	29.16
Equipment, new	$30 per heifer	
Depreciation=	$30 new cost	
divided by	5 yr. life	
time	2 yr. old heifer	
---------	equals	12.00
Interest, taxes, insurance, repairs		
	$30 new cost	
divided by	2 average amount	
times	25 percent	
times	2 yr. old heifer	
---------	equals	7.50
Interest on average value of heifer		
plus	$100 initial value	
plus	900 end market value	
divided by	2 yrs to grow	
times	9 percent	
times	2 yr. old heifer	
---------	equals	90.00

	Total ownership costs	$152.46
		=========

Table 4. TOTAL COST BY AGE GROUP TO RAISE HEIFERS

Operating Costs	Total To 24 months	Birth to Wean	Wean to 6 mo	6 to 8 mo	9 to 12 mo	13 to 15 mo	16 to 24 mo
Feed							
Milk replacer	$36.00	36.0					
Calf starter	13.20		13.2				
Calf grain	40.00		40.0				
Grain	112.00			11.2	16.8	16.8	67.2
Alfalfa	160.00	1.6	11.2	25.6	35.2	21.6	64.8
Silage	110.00					22.0	88.0
Pasture	90.00				18.0	27.0	45.0
Salt and min.	12.00	1.2	1.2	1.2	1.2	1.2	6.0
Total feed costs	$573.20	$39	$66	$38	$71	$89	$271
Other Operating Costs							
Initial heifer value	$100.00	100.0					
Labor	97.50	19.5	19.5	9.8	9.8	9.8	29.3
Vet. & med.	46.00	18.4	4.6	4.6	4.6	4.6	9.2
Breeding	21.00						21.0
Bedding	37.50	7.5	7.5	7.5	3.8	3.8	7.5
Supplies, power, etc	18.50	3.7	3.7	3.7	1.9	1.9	3.7
Interest on average of above	80.43	16.1	16.1	16.1	8.0	8.0	16.1
Death loss % ave val	50.00	15.0	5.0	5.0	5.0	5.0	15.0
Total operating cost	$450.93	$180	$56	$47	$33	$33	$102
Total feed and oper.	$1,024.13	$219	$122	$85	$104	$122	$373
Ownership Costs							
Buildings	$42.96	8.6	8.6	8.6	4.3	4.3	8.6
Equipment	19.50	3.9	3.9	3.9	2.0	2.0	3.9
Interest on ave. val	90.00	5.4	5.4	7.2	9.0	9.0	54.0
Total ownership costs	$152.46	$18	$18	$20	$15	$15	$66
Total Cost of Raising	$1,176.59	$237	$140	$104	$119	$137	$439

VARIATIONS IN LABOR NEEDED FOR A HEIFER

The labor component of a heifer cost budget has varied considerably over time. Following the Washington model, the current Michigan budget shows 19.5 hours of labor to raise a heifer from birth to freshening. Table 5 shows the previous Michigan estimates used 29 hours per heifer. Jack's New York study is probably the best research cited in Table 4. He did a farm survey of stanchion barn operators to arrive at his 28 hours per heifer. Research may exist on the different labor requirements for various types of heifer handling systems, but I did not find it. The 1984 Washington data may reflect economies of size and more efficient building systems.

Table 5. LABOR HOURS TO RAISE ONE HEIFER

Birth To Freshening

New York, 1963	28
Ohio, 1978	25
Michigan, 1980	29
Washington, 1984	19.5
Pennsylvania, 1985	27
Michigan, current	19.5

Labor is the largest single item of cost in Table 2, other than the individual roughage and grain items. As profit margins are squeezed, it is usually best to look to those cost items which are largest in order to make significant savings. If Table 2 had used the earlier labor requirements of 28 to 30 hours per heifer, only one of the feed items would have been greater than labor. Michigan dairy farmers need to have more labor efficiency built into their heifer raising systems while maintaining optimum growth rates and healthy animals.

GROW OR BUY? A PARTIAL BUDGET ANALYSIS

A dairy farmer that has the luxury of creating a brand new dairy farm operation should carefully calculate the total cost of raising replacements in any heifer system being considered. If the cost per heifer was going to be higher than the projected purchase price of heifers, then the decision would be to skip the heifer facilities and plan to buy the animals as needed. The cost to study for decision purposes would be the bottom line of Table 2.

Most managers in Michigan are already in the dairy business. If they were to quit growing their heifers and start buying them all, they would face a more complicated decision. If they are already growing heifers, they must have barns and equipment devoted to replacements. They likely have feed and labor sources suited to the task. If they quit raising heifers, could they sell off these heifer oriented resources and be better off with buying? To answer this type of question, a good tool is a partial budget, such as Table 6.

Table 6. PARTIAL BUDGETING FORMAT

Decision Being Evaluated: ______________________________

A.	1.	Additional receipts	$__________	
	2.	Reduced costs	$__________	
	3.	Subtotal (1 + 2)		$__________
B.	4.	Additional costs	$__________	
	5.	Reduced receipts	$__________	
	6.	Subtotal (4 + 5)		$__________
C.		Net income change (A3 - B6)		$__________
				===========

In order to use a partial budget, one must look back at Table 2 and ask which costs can actually be avoided if heifer raising is stopped. Table 7 attempts to do this. It is like Table 2, but with two more columns. One is the remaining costs, and the other is the total cost minus the remaining costs. In the feed and bedding areas, 40 percent of the costs are assumed to be not avoidable. This is based on the belief that those items are farm raised and that at least 40 percent of the resources used to grow feed and bedding are fixed. If heifer raising were stopped, the feed harvesting and handling equipment plus land and buildings would remain. Of the $1,176.98 total, it appears $901.96 could be avoided if heifer growing ceased.

These assumed values from Table 7 are fed into Table 8 along with the assumption that adequate replacments could be bought when needed for $900 per head. The two dollar savings on Line C of Table 8 means it would be profitable to buy instead of grow all the needed heifers. The margin of error in these budget estimates is likely to be more than $2.00. But, what if adequate replacements could be purchased for $800, or even $700, per head? Would large numbers of Michigan dairy farmers then quit growing heifers? I doubt it, despite the cost arguments in this paper.

A 1978 New England study edited by Woelfel and Gibson included a partial budgeting analysis showing a 60 cow farm could quit growing heifers, move up in size to 80 cows, buy all the needed replacements, and improve net management income by $7,200 per year. Yet, there is little evidence that New England farmers have gone to buying all their heifers.

The answer to why the lack of interest in buying replacements probably lies in our inability to measure nonmonetary costs. Snyder in 1978 suggested some of these factors which tend to offset profit margins that look good on paper. They are:

1. Known background of the animal - more confidence in her potential if raise instead of buy her.
2. Farmers have the space and feed which would not be used otherwise.
3. Feeding calves is something the family can do, and learn responsibility while doing it.
4. The out-of-pocket costs of growing are not large in any one time compared to the purchase of a springing heifer.

I would add a fifth idea; there is no risk of bringing in disease and insect problems.

If the assumptions in Tables 2 and 8 of this paper are correct, the nonmonetary costs in the previous paragraph must add up to $277 or more. The total cost of growing was $1,177 and the purchase alternative was $900, yet Michigan farmers continue to grow their own. Consequently, there must be $277 or more of hidden costs I failed to list in the budget.

Table 7. COST OF RAISING HEIFERS TO 24 MONTHS

Operating Costs	Amount	Price	COSTS	Remaining Costs If NOT Raised		Reduced Costs
Feed						
Milk replacer	60 lbs. @	$0.60	$36.00		$0.00	$36.00
Calf starter	60 lbs. @	0.22	13.20		0.00	13.20
Calf grain	400 lbs. @	0.10	40.00		0.00	40.00
Grain	0.7 tons @	160.00	112.00		0.00	112.00
Alfalfa	2 tons @	80.00	160.00	40%	44.00	116.00
Silage	5 tons @	22.00	110.00	40%	36.00	74.00
Pasture	6 mo. @	15.00	90.00	40%	4.80	85.20
Salt and min.	100 lbs. @	0.12	12.00		0.00	12.00
Total feed costs			$573.20		$84.80	$488.40
Other Operating Costs						
Initial value of heifer			$100.00		$0.00	$100.00
Labor	19.50 hrs. @	5.00	97.50		97.50	0.00
Vet. & med.			46.00		0.00	46.00
Breeding	1.50 ser. @	14.00	21.00		0.00	21.00
Bedding	0.75 tons @	50.00	37.50	40%	22.50	15.00
Supplies, power, etc.			18.50		0.00	18.50
Interest on average of above expenses for 2 yrs @	9 percent		80.43		7.37	73.06
Death loss %, average value		10	50.00		0.00	50.00
Total operating costs			$450.93		$127.37	$323.56
Total feed and operating costs			$1,024.13		$212.17	$811.96
Ownership Costs						
Buildings			$42.96		$42.96	0.00
Equipment			19.50		19.50	0.00
Interest on heifer value			90.00		0.00	90.00
Total ownership costs			$152.46		$62.46	90.00
Total Cost of Raising Heifers:			$1,176.59		$274.63	$901.96

Table 8. PARTIAL BUDGETING HEIFERS

Decision Being Evaluated: WHETHER TO STOP RAISING HEIFERS

A.	1.	Additional receipts	None	
	2.	Reduced costs		
		Feed costs	$488	
		Operating costs	324	
		Ownership costs	90	
	3.	Subtotal (1 + 2)	---------	$902
B.	4.	Additional costs		
		Buy a heifer	$900	
	5.	Reduced receipts	None	
	6.	Subtotal (4 + 5)	---------	900

C.		Net income change (A3 - B6)		$2
				===========

The idea that raising heifers is a profitable part of a dairy farm has been born out in linear programming studies. Linear programming, like partial budgeting, depends on variable cost enterprise budgets being available. In the traditional southern Michigan dairy farm organization, corn and other grain is raised, hay or alfalfa is raised, heifers are raised, and corn silage is raised. In unpublished research in the 1970s, I found linear programming to suggest that if resources such as land and labor became severely restrictive, the most profitable answer suggested giving up corn or other grain, give up hay or alfalfa, but keep growing heifers and keep growing corn silage while maintaining cow numbers.

Linear programming research in the Northeastern U.S. has indicated that as things get tight, don't give up growing your own heifers. An example is Cuykendall and Casler who, on page 15 said, "At all solutions....replacements were raised rather than purchased because forage and labor were available." Their study was dated 1973.

A whole-farm budgeting study done in Tennessee in 1968 dealt specifically with whether heifers should be grown or bought to maximize profit. The key factors are summarized in Table 9. Notice that if heifers were not grown, it was assumed the idled resources were used up by keeping more cows. Cow numbers could increase from 23 to 29 percent if heifer growing were stopped. Net annual income would increase from 9 to 11 percent depending on farm size. To my knowledge, this study did not move southern dairy farmers towards buying most of their heifers. Again, it is suspected that nonmonetary costs exceeded the 9 to 11 percent theoretical profit gains.

It is assumed that in the foreseeable future Michigan dairy farmers will continue to grow their own heifers. The other presentations in the winter extension series were aimed at teaching dairy farmers how to most profitably do it.

CONTRACTING FOR REPLACEMENTS

There is a possible position between growing all the heifers needed versus buying all of them. This is to contract for the growing of replacements. If a farmer is short of key resources such as labor, feed, or building space to devote to heifers, and someone not too far away does have these resources, contracting is a possibility.

There are two ways to approach contracting. The difference lies in who holds title, or ownership, of the heifers while they are growing. First is the option to purchase. The grower takes title to the heifers and when they are ready to freshen, the dairy farmer is given the option to purchase at a preset price. If refused, the grower sells her elsewhere. The second approach is the direct contract agreement. The dairy farmer keeps title to the heifers, and the grower merely does the work and provides the feed in the grower's facilities.

Details on heifer contracting are given in Staff Paper No. 86-107 titled, "Contract Raising of Dairy Replacements."

Table 9. RAISE OR BUY REPLACEMENTS?

Farm Size:	Small	Medium (no. cows)	Large
Buy heifers, keep more cows	32	58	91
Raise heifers, fewer cows	26	45	72
Added cows possible if heifers were bought	6	13	19
Percent increase in cows	23%	29%	26%
Added net income if heifers were bought	$797	$1,611	$1,950
Percent increase,net income	11%	10%	9%

Source: Tennessee, 1968

SUMMARY

It costs nearly $1,200 to grow a heifer from birth to freshening in Michigan in 1986. This will vary noticeably with the feeds used and the amount of labor needed.

If a dairy farmer does not now have facilities, and is creating a brand new dairy operation, perhaps it would be more profitable to buy all the needed replacements instead of growing them on the farm.

If a dairy farmer is already in business and growing heifers, the idea of fixed or sunk costs likely precludes saving enough money to quit growing and start buying all the heifers needed. Dairy farmers probably feel the nonmonetary costs and risk factors exceed any theoretical monetary savings from such a move.

Contracting, either with an option to purchase or direct contracting with retention of title, might be an acceptable position for dairy farmers who are short of feed, labor and building space.

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Heifer Meter Measurments for

Holstein Heifers

Interpreted from Penn-State Data
by: Menzi - 1989

Months of Age	Height (in)
2	37
4	39 3/4
6	42
8	44 1/2
10	46 1/2
12	48 3/8
14	50
16	51
18	52
24	54

Nutritional Management of Dairy Herd Replacements

C. J. Sniffen, L. E. Chase and Wm. Menzi

Introduction

The nutritional management of heifers is of the same importance as balancing rations for the lactating herd. It is an investment in the future. The objective is to provide the replacements with the proper nutritional environment so that they can achieve their genetic potential for growth and frame size. The evidence would suggest that the average frame size for a first calf Holstein heifer at 24 months after calving should be 1250 lbs. at average condition. This means the heifers need to average nearly 1.6 lbs of gain/day. Our challenge then is to develop a total program for the growing heifers.

Grouping

Carefully examine growth curve patterns in Figure 1. Even though the overall rate of gain is 1.6 lb/day to achieve 1250 lb at 24 mo., growth rates for various periods are very different. For example note that the rate of gain is greatest during 2 to 8 months of age and can be less (although it must still be adequate for that period) during 15 to 24 months. This means that the heifers need to be grouped on their physiological requirements. Also note that heifers grow after calving and need to be fed accordingly. In Table 1, five groups are suggested. The heifers, post weaning (3-4 months) are under stress and should not be mixed with the large heifers. It is assumed that these heifers will be eating hay and grain before weaning but understand that the rumen is not yet fully developed. The 5-8 month age group will gain at a very rapid rate and needs a carefully controlled ration for highest efficiency. The older heifers in this group may start cycling. The 9-12 month age group will start cycling and needs to be watched carefully. The 13-17 month age group is the breeding group and should be checked at least twice daily. The 18-24 month age group have been confirmed pregnant. We feel this is an optimum grouping. If groups are to be merged the 5-8 and the 9-12 month age group could be combined but this is not recommended. In the last 3 to 4 weeks prior to freshening it would be essential that these heifers be separated to prepare for freshening. Note they are still gaining so you do not want to include them with the mature dry cows. Balance rations carefully, run them through the parlor routine and watch carefully.

Heifers should be weighed and condition scored (Virginia condition score system - 1 very thin, 5 fat, obtain fact sheets from extension office) as they move into each group. Taping would seem to be the preferable. It may be advantageous to construct or purchase some type of restraining system. Be sure to record the information in an individual animal record system. For larger herds scales can be purchased. They are less than $5000 for a complete installation. Height measurements may also be taken to help gage heifer performance. Height or weight alone is not adequate. Weight and height along with body condition scoring is highly preferable.

Pasture

The use of pasture is very high in the Northeast, especially for bred heifers. On the surface this approach would seem reasonable: less labor, better utilization of land, and more healthy animals. As you examine this practice, however, you will find that heifers will very rarely attain the target weights and rates of gain that are described in table 1. Can we use pasture? The answer is yes if we do the following:

1. Rotate pastures
2. Follow good agronomic practices with pastures and obtain analysis of pastures.
3. Weigh heifers and condition score every 2 weeks through the pasture season.
4. Supplement pastures with hay, grain, and minerals to nutritionally balance the pasture.
5. Provide good shade and plenty of fresh water.

Younger heifers (5-12 months) can be put on these pastures but <u>only</u> if the above are followed <u>extremely</u> carefully.

Nutrition

The replacement dairy animal is possibly the most poorly fed animal on the typical dairy farm. We find two major problems: First, the heifers will be fed adequately until bred then are moved to pasture and forgotten about. The result is a small heifer at 24-26 months of age. Second, the replacement is not fed adequately during the whole growth period and is bred according to weight, resulting in an animal that doesn't calve until it is 36-38 months of age or if bred according to age only, an undersized heifer at 24-26 months.

Figure 1 provides a guideline to optimum growth curves. You should strive to have a replacement calve at 24 months of age at a condition score 3+. Ending tape weight <u>after calving</u> for Holsteins of 1250-1300 and for Jerseys 850-900 are reasonable expectations. A major consideration would be to grow out a replacement that has frame size (not necessarily height) for a large rumen that is in balance with the production expected.

Nutritional guidelines are based on weight classes (Table 1). These weights and rates of gain will provide an animal in the desired weight range if the animals consume as is indicated at the top of the table.

Protein recommendations in the light weight range are close to NRC 1988. We would point out, however, that this is the point where the rate of growth is highest (see also Figure 1). It is critical that protein requirement be met during the early growth period. If the protein quantity and quality (degradability and amino acids) is inadequate then the gain will be fat, and mammary tissue will be compromised. The solubility requirement is an addition to the crude protein and degradability and undegradability requirements. If the solubility concentration is maintained reasonably close to the guideline then good ration performance can be expected. The low degradability/high undegradability requirements for the young heifers is almost impossible to achieve, however it points out the importance of including a low degradability protein source. Note, however, that the undegradability requirement is low for the older heifer, providing the opportunity for low cost protein sources. The major objective is to maintain a supply of soluble protein and true protein being degraded in the rumen so that the rumen microbes will maximize their growth.

The major objective in raising replacements is to maximize forage utilization in order to reduce replacement costs. To do this it is necessary to provide the right amount of fiber. The suggested guidelines on fiber include NDF which according to Mertens, USDA, Madison, Wisconsin and Van Soest, Cornell, is highly correlated with intake. The NDF concentrations should provide maximum intake of forage and maximum growth. It is recommended that the early growth period up to 400-500 lbs include some alfalfa. Also, during this period the greatest response can be expected from lower protein degradability diets. Including 20-30% of the concentrate protein from ingredients such as distillers, brewers protein, fish meal or animal by-products, or an extruded protein would be most beneficial. If you are using a computer, balancing for protein degradability can be easier and more exacting.

The use of ionophores during the grow out period are recommended. Rumensin and Bovatec are ionophore currently cleared for use in replacement heifers. These types of products increase efficiency and result in a savings of 20-30 days in time to achieve final target weight. Improvement is particularly noticeable on the lower energy diets fed after breeding.

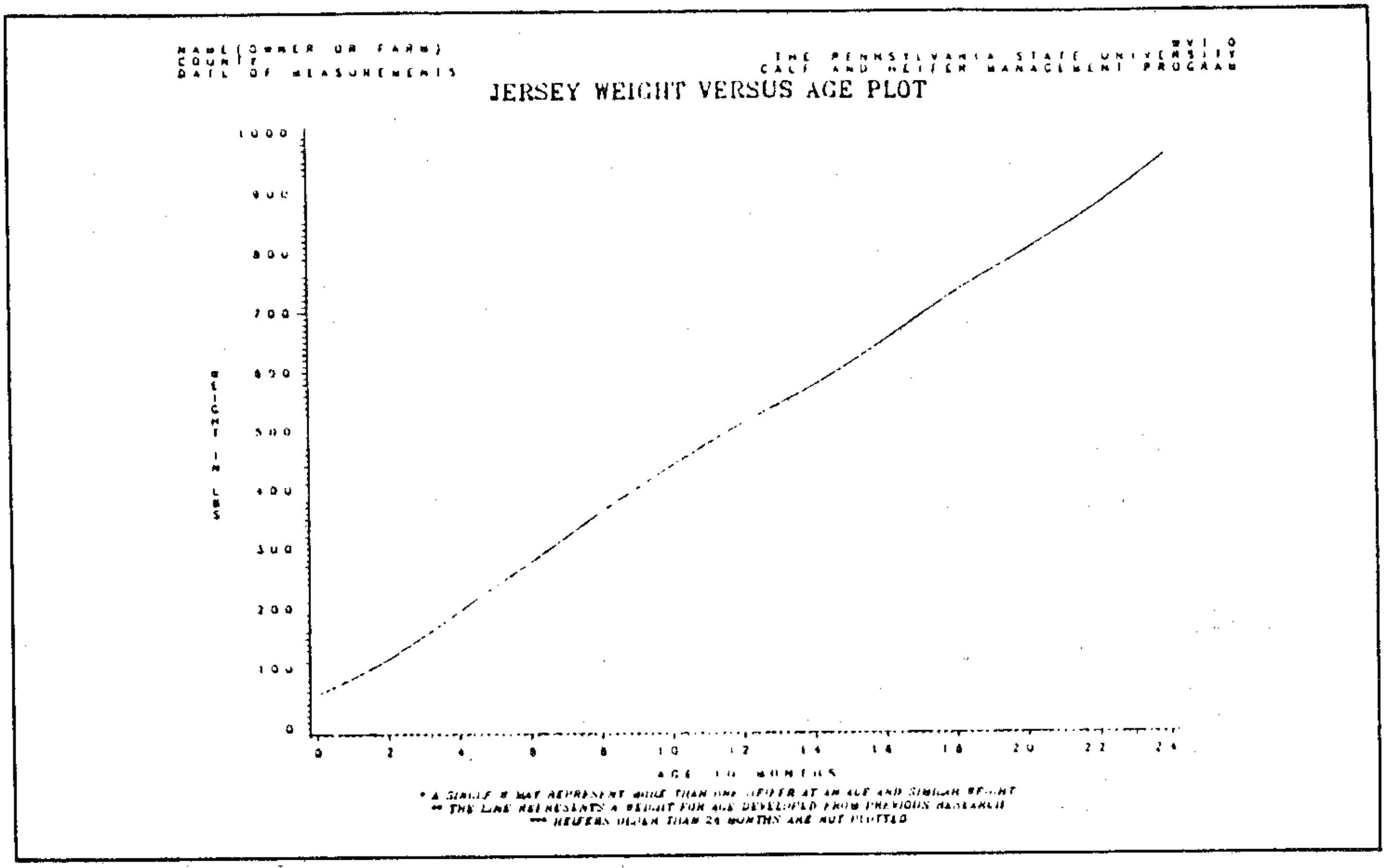
Calcium, phosphorous and sulfur guidelines are based on 1988 NRC. Sulfur concentrations are based on the concept of a 10:1 N:S ratio. A good trace mineral and vitamin pack is absolutely essential. Balancing for calcium and phosphorous is important. It is just as important to <u>not</u> <u>overfeed</u> as it is <u>not</u> to <u>underfeed</u>.

It is now absolutely essential that more emphasis be placed on replacement programs using charts like the ones in Figure 1, condition scoring and tape weighing animals and balancing rations intensively for the different groups. Because of the high levels of forage that are used it is particularly important to develop concentrate, mineral, and vitamin supplements that will balance all nutrients. Please note nutrient concentrations are based on assumed intakes. Know what your animals are consuming. It is further suggested that for a good nutrition program to be effective the animals must be in a clean environment and a good worming program be followed.

Table 1. Nutrient Requirements of Replacement Heifers

		3-4	5-8	9-12	13-17	18-24
Groups, Age, Months		3-4	5-8	9-12	13-17	18-24
Initial Weight,	large	180	290	516	722	956
	small	100	200	400	550	750
Final Weight,	large	290	516	722	956	1250
	small	200	400	570	750	900
Daily gain,	large	1.8	1.8	1.7	1.5	1.4
	small	1.6	1.6	1.4	1.3	1.3
Condition Score		3	3	3	3 - 3+	3+ - 4-
Dry matter intake, % BW		3.1	2.9	2.6	2.4	2.3
Nutrients						
Protein						
Total, % DM[1]		17.0	16.0	14.0	12.0	12.0
Soluble, % of total[2]		15.0	20.0	27.0	31.0	35.0
Degraded (DIP), % of total[2]		30.0	40.0	55.0	62.0	70.0
Undegraded (UIP), % of total[2]		70.0	60.0	45.0	38.0	30.0
Fiber, % DM[1]						
ADF (minimum)		16.0	17.0	19.0	19.0	19.0
NDF (minimum)		23.0	25.0	25.0	25.0	30.0
Energy, Mcal/lb[1]						
NE_m		0.77	0.74	0.72	0.63	0.60
NE_g		0.50	0.46	0.44	0.37	0.34
TDN		70.0	67.0	65.0	62.0	60.0
Minerals,(min) % DM[1]						
Ca		0.54	0.52	0.42	0.35	0.32
P		0.34	0.32	0.30	0.28	0.25
Mg		0.16	0.16	0.16	0.16	0.16
K		0.65	0.65	0.65	0.65	0.65
S		0.16	0.16	0.16	0.16	0.16
Na		0.10	0.10	0.10	0.10	0.10
Chloride		0.20	0.20	0.20	0.20	0.20
Iron, ppm		50	50	50	50	50
Cobalt, ppm		.10	.10	.10	.10	.10
Copper, ppm		10	10	10	10	10
Manganese, ppm		40	40	40	40	40
Zinc, ppm		40	40	40	40	40
Iodine, ppm		.25	.25	.25	.25	.25
Selenium, ppm		.30	.30	.30	.30	.30
Vitamins[1]						
Vitamin A, IU/lb		1000	1000	1000	1000	1000
Vitamin D, IU/lb		140	140	140	140	140
Vitamin E, IU/lb		11	11	11	11	11

[1] Adapted from 1988 NRC Requirements of Dairy Cattle
[2] Adapted from 1985 NRCNITRO using best estimates of possible ration ingredients.



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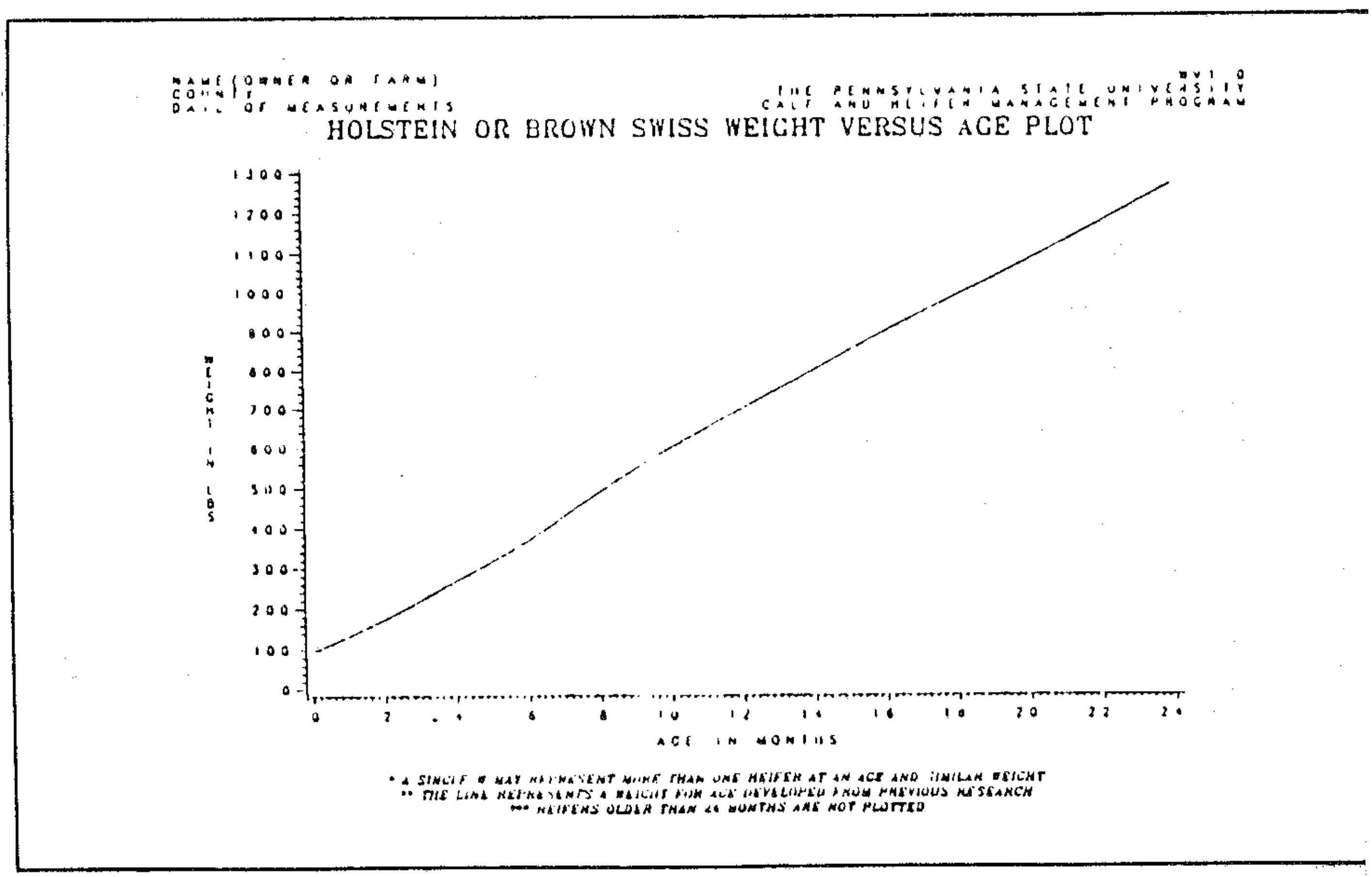

The Pennsylvania State University, Coll. of Agric., Ext. Service, University Park, Feeding Management for Conventional Systems

C. J. Sniffen and L. E. Chase

Daily Allocation of Feeds

Perhaps the single most important consideration in feeding dairy cattle is the allocation of feeds during the day. Normally, we discuss the acquisition and allocation of feeds for the feeding year and for the different production groups. When we look at high producing herds, we commonly attribute their success to feed quality, genetically superior cattle, and the combination of feeds being offered to cows. Little attention is given to the one area that many time sets these herds apart from others and that is how they feed during the day.

The objective is to feed the cow during the day in such a manner as to minimize fluctuations in the rumen, maximize digestion, and ensure a steady flow of nutrients to the bloodstream. The microbial mass requires a continuous supply of nutrients. The cow's tissues will also respond to a continuous supply of nutrients. This would mean feeding 24 times a day. This obviously is not possible. Feeding of dairy cattle is a intermittent process which is affected by physical limitations such as housing, feeding equipment, animal numbers, and labor availability. We have to work within the existing framework and try to achieve a situation where the fermentation is even and under control, the digestion maximum and nutrient requirements of the microbial mass and cow are met.

Grouping

Regardless of the type of physical facilities we should group animals. They should be grouped based on their physiological status at unique-points in their life cycle. We would suggest the following:

Replacement Program

Age (months)	Time	Final Weights		
		Jersey	Ayrshire	Holstein
0-1	Preweaning	90	130	180
1-9	Rapid Growth	400	475	575
9-16	Breeding	625	750	850
16-25	Pregnancy	850	1,100	1,250

Lactation/Dry Program

Period	Stage (days)	Condition Score
Fresh	0-14	3+ to 3
Early lactation	14-60	3- to 3
Peak	60-120	3- to 3
Mid lactation	120-210	3
Late lactation	210-305	3+ to 4-
Dry period	305-346	3+ to 4- (4- to 4 if 3x)
Prepartum period	346-360	3+ to 4- (4- to 4 if 3x)

In most cases it will not be possible to achieve grouping dairy animals based on the above physiological groups. However, it is most important to recognize the importance of the requirements of these groups. The rapid growth and early/peak lactation periods are similar in their high energy/protein requirements. This means that dry matter digestion in the rumen must be at a maximum. The allocation of forages and feeds becomes important. High quality forages are necessary for maximizing digestion, dry matter intake, and animal production. Mertens of Georgia has shown that alfalfa will give a 10-12 percent increase in dry matter intake and milk production when compared to corn silage. The reasons for this are involved in greater rumen microbial growth and faster fiber digestion creating "room" for more feed. Grouping cows allows you to allocate the excellent quality forages to the rapidly growing heifers and the early lactation cows. The other contrast is to allocate the intermediate quality grasses to the dry cow. Grass is low in protein and energy and high in fiber. This forage can be fed ad libitum to appetite and keep rumen volume to a maximum which is important for preparation for early lactation.

Feeding Behavior

The allocation of the forages over the lactation is very important. The previous discussion of the economic implications brings out the consequence of not doing this.

The advantages of grouping and proper allocation of forages can all be lost if the daily feeding management isn't in balance.

Until recently, we have just been worried about how much a cow will consume in a day. Work has suggested that the way she consumes her feed during the day might be of practical importance. Have you ever watched cows when you put fresh feed in the bunk? They will usually all line up to consume a considerable quantity of feed. If you go check in about an hour there will not be many cows at the bunk. This is called "feeding behavior".

What is the potential practical importance of this type of knowledge? One first must consider the rumen as a fermentation vat in which there is a large microbial population requiring certain daily amounts of nutrients. The microbial mass cannot be thought of as one species or in one growth phase. There are many species with a wide range of nutrient requirement and each species will be in a different growth phase.

To add to the already complicated picture, nutrients are being absorbed through the rumen wall and material is moving out of the rumen toward the lower tract. In addition, the materials that are being consumed are very much different. For example, a 1,300 lb. cow producing 100 pounds of milk per day might be consuming 48 pounds of dry matter which at least 50% is forage. The forage, relative to grain breaks down very slowly. As is known, the manner in which the grain and forage is fed varies diversely from farm to farm; all the way from a total mixed ration to a stanchion barn program where the grain is fed twice per day. Differing times of feed intake coupled with differing degradation of feedstuffs could at times lead to inefficient utilization of feed and reduce feed intake. The best feeding pattern for the rumen is probably many small meals per day as compared to fewer large meals. Each meal should have all the nutrients needed for a good fermentation.

What is normal feeding behavior in a cow? Work at Maine, using an electronic platform measured feed intake continuously. In Table 1 can be seen some typical ad libitum eating behavior of a cow consuming a corn silage total mixed ration fed once per day. It will be noted that a cow will consume about 12 meals per day and spend about 23 minutes per meal with about 94 minutes between meals. It should be noticed that rate of feed intake and duration exhibit a large variation among cows and could suggest some genetic influence.

What influences behavior? In Tables 2 and 3 it can be seen that stage of lactation, restricted or ad libitum feeding and diet type all can influence feeding behavior.

In another recent study (Table 4), Conrad at Ohio State measured intake behavior on either a urea or soybean meal diet. The cows on the urea diets consumed more meals per day with a concomitant reduction in meal length. This coincided with increased ammonia loads and its implications on nitrogen utilization in the rumen are significant, especially in the high producing cow.

Referring to our earlier discussion on maintaining a rumen balance, this means that there will be a high level of rumen fermentation in the first part of the day right after feeding, and as we have discussed earlier because of the more rapid growth, of the starch and sugar digesters when compared to fiber digesters there will be a tendency toward an imbalance of the rumen, resulting in lower pH, increased acidoses, low butter fat, and irregularity of feed consumption.

In order to minimize fermentation imbalances it is necessary to plan the daily feeding schedule carefully. A form to help you do this is shown in Table 5.

Increasing feeding frequency maximizes digestion in the rumen through reducing passage and also increasing frequency decreases peaks and valley in fermentation. However, the benefits of feeding frequency can be compromised by the <u>order</u> of feeding. The best examples of this are feeding finely ground high moisture corn first thing in the morning, feeding ground high moisture grain in parlor or feeding a high concentrate blended ration once per day to an empty bunk, the starch digesting bugs will predominate and protozoa will be absent.

The major challenge is when cows are fed individually, separate feedstuffs and where a part of all of the grain is fed in the parlor. The latter is particularly a problem because of a restriction of physical facilities.

The following recommendations (Table 6) are made based on the concept of controlling fermentation and maximizing feed retention in the rumen. The order of feeding is based on our knowledge of the relative fermentation rates of the fiber, starch, sugars, and proteins. The suggested orders can be repeated and the frequency of feeding needs to be incorporated as shown in Table 7. When you make feeding strategy (use feeding strategy chart) changes monitor the following:

1. Milk volume change.

2. Butter fat change (send milk sample to plant for testing at each pick-up).

3. Eating irregularity.

4. Manure consistency change and grain particle passage.

5. Change in dry matter intake.

Fine tune the feeding program based on the changes observed. Remember that feed should be in front of cows at all times and the daily ration <u>has</u> to be <u>balanced</u> for NDF, energy, protein, and minerals.

The major problem of grain feeding in the parlor is not getting forage into them before coming into the parlor and only feeding grain two times per day. Grain can be mixed with the forage in the bunk but should only be done if you can measure the amount mixed accurately. If a little hay or the bunk mix can be fed before going in the parlor it will be beneficial. The new electronic technology will be potentially a large advantage in controlling fermentation. Transponders can be put on each cow and grain intake set for production. The two major advantages are controlling feeding frequency and knowing what the cows are consuming. It is worth considering when physical facilities are limited. The important thing to remember is to balance the fermentation initially on adequate forage NDF (0.8 to .9 percent of body weight) in the ration and then combining degradation, productivity, and feeding frequency and meet the cows requirements for nutrients.

Some final suggestions for obtaining the requisite balance and the maximization of digestion and <u>quality</u> milk production are:

1. Feed 2-3 lbs good grass or 3-5 lbs alfalfa hay just before grain and/or protein supplements.

2. Mix protein supplements with energy sources or feed the energy source just before protein.

3. Feed concentrates several times per day to high producers.

4. Feed forages several times per day.

5. If feeding high moisture corn, control particle size (higher moisture just crack kernel - if dry crack kernel well).

6. Substitute commercial low solubility concentrates containing low degradability proteins in rations.

7. Chop forages coarse - theoretical cut greater than 3/8".

8. Harvest corn silage mid dough.

9. Feed more resistant grains and proteins in parlor (do not feed cracked corn, use corn meal).

10. If feeding a moist hay crop silage of high quality, feed corn silage first and then hay crop.

11. Balance rations - water, NDF, (ADF if do not have NDF) protein, minerals, vitamins.

12. Group cows by production level.

13. Feed buffers where feeds are:

    a) low in natural buffer capacity
    b) forages chopped too fine
    c) high moisture corn ground too fine

14. Group cows by stage of lactation.

There are probably many more. Remember, a balanced rumen leads to maximum intake and milk production. Some of the signs of an imbalanced rumen are:

1. Cows not ruminating.

2. Cows not eating.

3. Low butterfat content.

4. Low milk protein content.

5. Large change in body condition in early lactation.

6. Increased incidence of displaced abomasums and ketosis.

7. Sore feet and legs.

Write down the daily feeding strategy. Look at the DHI sheets. Knowing the principles and looking at the symptoms, you should be able to develop a strategy to enhance performance.

It becomes obvious from the above discussion that we need to reconsider grouping cows in the conventional barn. IT CAN BE DONE!! It will give you these advantages:

1. Keep on top of changes in fresh/early lactation cows
    a. reproduction - heat detection
    b. health
    c. better nutrition
2. Reduce feeding labor
3. Reduce feed costs
4. Don't overfeed the low producer and underfeed the high producer
5. Can allocate feeds more effectively

The following suggestions are made:

1. Cows remain in one place
    - Sort cows 1 or 2 times per year based on days in milk (DIM). Arrange so that cows will be located in adjoining stanchions by increasing DIM in a clockwise orientation
    - Make a small moveable 3/4" plywood manger divider to go between each group
    - Divide exercise area by electric fence into 2 or 3 areas so that cows can be let out in groups
    - Move plywood divider monthly based on DHI reports in a counter clockwise orientation - group to maximize uniformity
    - Balance rations each ;month for each group based on milk, body weight and body condition score change
2. Cows move in barn according to stage of lactation
    - Divide the barn into appropriate lactation areas such as:

Physiological Group	Days in Milk
Fresh cow	0-21
Early lactation	21-70
Peak lactation	70-150
Mid lactation	150-210
Late lactation	210-305
Dry cow	
Early	-60 to -21
Late	-21 to 0

Other groups to consider:

First calf heifers
Mastitis group

- Divide groups using a plywood manger divider - mark groups and barn area appropriately
- Divide exercise area into 2 or 3 separate areas
- Move cows by group in and out of barn - cows can stand in any stanchion in the defined area
- Move cows once per month based on days in milk - reformulate rations based on milk, body weight and body condition score change

Table 1. Intake Behavior Variance in Lactating Cows in Week 20 of Lactation[1/]

Parameter	Mean[2/]	Range
Meals, No./day	12.1	9.5 - 13.0
Rate,* g/min.	170.	120. - 200.
g/min/kg BW	.28	.20 .32
g/min/kg $BW^{.75}$	1.39	1.01 - 1.62
Size, kg	3.76	3.05 - 4.45
SD	2.6	
Duration,* min.	22.7	15.5 - 35.5
SD	16.7	
Interval, min.	93.5	74.3 - 120.5
SD	43.7	
Meal/Total Intake, %	8.4	7.7 - 10.5

1/Eight cows, *ad libitum* intake, 60:40 concentrate:forage dry matter ratio.

2/Meal definition: minimum 1 minute of eating activity with a minimum 20 minute intermeal interval.

* Among cows *vs* within cows (2 days) variance P < .01.

Sniffen *et al*. (6)

Table 2. Effect of Week of Lactation in Ingestive Behavior in Dairy Cows[1/]

Parameter	Unit	Week 3	Week 5	Week 20
N		4	5	13
Meals	No./day	12.9	11.8	12.3
Rate	$g/min/BW^{.75}$	1.07	1.20	1.47
Size	kg	3.32	3.84	3.83
Duration	min	26.0	31.0	23.6
Interval	min	86.0	88.2	91.7
Meal/Total Intake	%	8.52	9.02	8.6

1/ *Ad libitum* intake, 60:40 concentrate:forage dry matter ratio.

Sniffen *et al*. (6)

Table 3. Effect of Protein and Carbohydrate Solubility on Ingestive Behavior in Lactating Cows[1/]

Parameter	High Protein Solubility		Low Protein Solubility	
	High CHO	Low CHO	HighCHO	Low CHO
Meals[2]				
No./day, R[a]	5.17	5.60	4.17	2.78
A[b]	11.0	12.20	13.33	12.83
Rate				
g/min/W°^{75}, R[a]	1.50[c]	1.27[d]	1.62[c]	1.59[d]
A[b]	1.13[c]	1.15[d]	1.48[c]	1.29[d]
Size				
kg, R[a]	8.08	6.80	9.78	17.80
A[b]	4.46	3.48	3.57	3.55
Duration				
min, R[a]	43.0	45.9	49.0	91.8
A[b]	30.6	25.8	19.0	24.4
Interval				
Min, R[a]	67.6	63.1	65.1	48.7
A[b]	82.7	87.8	87.5	79.4
Meal/Total Intake[2]				
%, R[a]	20.8	18.2	26.5	53.1
A[b]	10.8	8.3	7.5	7.9

[1/] 60:40 concentrate:forage dry matter ratio. Restricted = 99.8% of NE_L; Ad Libitum = 110.9% of NE_L required.

[2/] Intake level by protein solubility significant (P<.01).

[a,b] Differences between restricted and ad libitum intake are significantly different (P<.01).

[c,d] Differences between means are significantly different (P<.01).

Sniffen et al. (6).

Table 4. The Number, Size, and Time Spent Eating Meals Containing Urea or Soybean Meal as the Nitrogen Supplement for Two Cows Weighing 449 and 533 kg, respectively.

	Urea	Soybean meal	Probability of difference[a]
No. of trials	5	5	...
Meals per day			
Initial, no.	2	2	...
Spontaneous, no.	23.0 ± .2	17.4 ± .2	.045
Weight of meals (DM)			
Initial, kg	1.8 ± .2	3.2 ± .2	.001
Spontaneous, kg	.36 ± .03	.30 ± .03	NS
Length of meals			
Initial, min	12.4 ± 1.0	24.3 ± .8	.001
Spontaneous, min	5.4 ± .4	6.0 ± .5	NS
Total feed consumed[b], kg/day	11.7 ± 1.3	12.0 ± .9	NS

[a] By Students test (23).

[b] Total dry matter summed for two initial meals and spontaneous meals.

Conrad *et al.* (3)

TABLE 5.

DAILY FEEDING AND ACTIVITY SCHEDULE

TIME		WHAT	FEED (#)	% DM	# DM	# REFUSED	# DM REFUSED
A.M.	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
NOON	12						
P.M.	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
MIDNT	12						
A.M.	1						
	2						
TOTAL					DM FED		DM REFUSED

Prepared By: David W. Arnold, Columbia County
12/81

Table 6. Fermentation Balance Chart

Group	Forage Allocation								Feeding Frequency of Feed						
	Alfalfa			Grass			Corn Silage		Forage Solubility[b]		Grain Solubility[c]		Grain/Suppl.[d]		
	20[a]	16/20	less than 16	14 +	11/14	less than 11	Low Grain	High Grain	High	Low	High	Low	High	Med	Low
Fresh	++	+	-	++	+	-	-	++	4	3	4	3	3	2	2
Early	++	+	-	++	+	-	-	++	4	3	4	3	3	2	2
Peak	+	++	-	++	+	-	-	++	4	3	4	3	3	2	2
Mid	+	+	+	+	+	-	+	+	3	2	3	2	2	2	1
Late	-	-	+	-	+	+	++	-	2	1	2	2	2	2	1
Dry	-	-	-	-	+	+	+	-	1	1	1	1	-	-	-
Prepartum	-	-	-	+	+	-	+	+	2	2	2	2	2	2	2

[a]Protein level.

[b]High protein solubility greater than 55 percent. Bunk - reduce by one or to one.

[c]High protein/carbohydrate solubility (moisture level over 30 percent or finely ground or rolled grain or barley or wheat as grain source. Bunk - reduce by one or if in bunk feed with forage frequency.

[d]Protein solubility: High > 30, undegradability <40%
Medium 20-30, undegradability 40-50%
Low < 20, undegradability >50%

If bunk feeding, frequency = forage frequency.

Table 7. Order of Feeding

Feeding Program	Forages to be Fed			Grain		
	Alfalfa	Grass	Corn Silage	Fermented	Dry	Protein Supplement
Individual Fed						
Dry forages	4	1	--	--	2	3
Dry grains	3	1	--	--	--	2
	--	1	3	--	--	2
	1,4[a]	--	--	--	--	2
	1,3	--	--	--	--	2
Wet forages	4	1	5	2	--	3
Wet grains	--	1	4	2	--	3
	1	--	4	2	--	3
	--	1,4[b]	--	2	--	3
	1,4	--	--	2	--	3

[a]First feeding not to exceed more than 2-3 pounds.

[b]First feeding should be long particle size and preferably dry hay. Feed 2-3 pounds of dry matter.

Feeding Management Considerations-Total Mixed Rations

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The use of total mixed rations is one method of feeding which is being used on dairy farms. The key concept here is that each mouthful of feed is a balanced ration. Numerous papers have provided the advantages and disadvantages of this feeding system. This paper assumes that you are familiar with the overall concepts of a TMR system.

As with any feeding system, the key to obtaining desired results with a TMR is MANAGEMENT. With proper management inputs, high levels of efficient and profitable milk production can be attained. However, extremely poor results will be achieved if management is less than desirable. These poor results should not be attributed to the TMR concept or system.

Putting Together TMR's

The steps in formulating TMR's are the same as used in formulating any dairy ration. These steps can be thought of as:

1. Forage and feed inventory

   - How much of each forage and other homegrown feeds are available?

   - How many milking cows, dry cows and replacement animals are to be fed?

   - How many days are in the feed planning period under consideration?

   - Determine how many pounds of each forage and homegrown feed are available per animal per day.

   - Are the different quality forages stored so that they can be allocated to specific groups? (If not, make plans to do this during the next harvest season).

2. Forage testing

   - Determine the nutrient content of the feeds which are available and sets the base for ration formulation.

   - It is preferable to obtain forage testing results which include dry matter, total protein, ADF-N, ADF, estimated energy and minerals. NDF and soluble protein will also be useful in many situations.

3. Feed programming

   - Determine body weight, milk production and fat test.

   - Evaluate body condition scores.

   - Determine the nutrient requirements and expected dry matter intakes.

   - Formulate the grain and mineral mixes to complement the available forages.

   - Consider both nutrition and cost in formulating rations.

4. Implementation

   - Follow the program developed in step 3.

   - Monitor changes in dry matter content of silages, other fermented feeds and wet by-product ingredients.

   - Keep track of the number of cows in the group.

   - Monitor the nutrient content of the bunk mix.

   - Don't change the program without repeating steps 1, 2 and 3.

<u>Feeding Management</u>

The area of feeding management in many cases represents the difference between average production and top production. Too often, we concentrate our efforts on individual cows or groups of cows. However, it is imperative that the cow be properly fed and managed throughout the entire lactation cycle. Figure 1 represents the various stages of the nutrition-reproduction cycle for the dairy cow. Proper nutrition and management during each phase are essential for optimum production. Specific comments about each group include:

1. Fresh cows - These cows are undergoing rapid changes in terms of rumen function, body weight and milk production. Intake is generally less than optimum while the nutrient demands for milk production are high. The key to this group is getting them on feed rapidly. This will enhance

milk production and lower the incidence of metabolic disorders.

2. Early lactation - Feed intake has peaked and body weight is beginning to reach equilibrium. Milk production is still high and the goal is to achieve persistency. At the same time, it is time to begin breeding the cow for the next lactation.

3. Mid lactation - Milk production, dry matter intake and nutrient needs are declining. Underfeeding can rapidly decrease milk production. Overfeeding costs money.

4. Tail end - During this period, nutrient needs are low. Usually some allowance is given for pregnancy and body weight gain. Avoid overconditioning.

5. Dry cows - These cows are replenishing body stores and rapid fetal growth is taking place. Don't let these cows get overconditioned. A medium quality forage or limited amounts of high quality forages can be used. Mineral nutrition is extremely important.

Grouping Strategy

As dairy herds become larger, there is a tendency to house and feed cows as groups. However, the question in this situation becomes the method of grouping, number of groups and moving cows between groups.

1. Method of grouping - A large variety of methods are used to group cows. Some of the more common methods include:

   - Milk production (actual)
   - Milk production (fat corrected)
   - Days in milk
   - Reproductive status
   - Age (i.e. 1st calf heifers)
   - Daily energy requirements
   - Required nutrient density of the ration

   All of these methods have worked well in various situations. If it is possible to group first calf heifers separately, they may respond with 5-10% more milk over the lactation. Nutrient density may be the best method since it accounts for a larger number of cow factors in making the grouping decision. Table 1 contains an example of the nutrient density requirements of different cows.

2. Number of groups - The minimum number on any farm is two. One group is the dry cows and the other is the milking cows. However, it is usually preferable to have at least 3 milking cow groups where possible. Factors to consider in determining the number of groups include the size and configuration of the barn, number of cows on the farm, the type of milking parlor and size of the holding area and the milk production level of the herd. In high producing herds, one group of milking cows may be adequate.

3. Moving cows between groups - A key consideration in moving cows is to minimize the shock of both changing rations and changing the social structure of the herd. Research work indicates that changes in milk production when moving cows between groups due to behavioral aspects are small and transitory in nature. However,, milk production changes due to nutritional alterations can be dramatic and long lived. The following ideas may be useful to minimize the depression in milk production often associated with group changes:

    - Move groups of cows rather than only 1 or 2 cows.

    - Minimize the difference in forage to concentrate ratio between the groups. The best way to accomplish this is to increase the number of groups in the herd. Agway research indicates that the decrease in nutrient density should not exceed 15%.

    - Move cows between groups at times of the day when social interactions will be minimized. One idea is to move cows after the afternoon milking rather than after the morning milking. Informal reports have indicated a benefit to this but we are not aware of research to confirm this. However, it may be worth a try.

The Fallacy of Ratios and Percents

How often has someone told you that the ration for the high group contains 16% protein on a dry matter basis and wants to know if that is satisfactory? With only that information, there is no logical way to answer the question. If we assume that the average weight of the cow is 1300 pounds and that the group is balanced for 75 pounds of milk with a 3.5% test, then the daily crude protein requirement is 7.2 pounds per day. If the cows are consuming 45 pounds of dry matter per day, then a ration containing 16% protein will supply 7.2 pounds of protein. However, if intake is only 43 pounds, then daily protein intake will be 6.9 pounds which will only support 71 pounds of milk.

A similar example could be made regarding the calcium to phosphorous ratio. The cows requirements are for grams of calcium and grams of phosphorous. Once the minimum daily requirements have been met, then the ratio can be checked. The ratio alone does not indicate whether daily intakes are adequate, inadequate or excessive.

Practical Feeding Management

The best formulated ration in the world is only as good as the daily management involved in implementing the program. The following points should be emphasized to your customers so that they can attain maximum benefit from complete rations.

1. Have scales on the mixing equipment and make sure the scales work - There is no reason to use a computer to formulate a ration and to then measure the feeds with buckets or forks. All mixers should have accurate weighing devices. Check the scales periodically with known weights to make sure they work. Inaccurate scales are the same as having no scales.

2. Keep fresh feed in front of the cows at all times- This maximizes daily dry matter and nutrient intake. As we move into the summer months, this takes on added importance. Feeding the ration more than once a day may be quite useful in stimulating and maintaining feed intake. Put your hand in the feedbunk. If you have to pull it out due to heat, would you expect the cow to consume large quantities of this feed? Don't feed to an empty bunk.

3. Feedbunk space - Is there enough room for all cows to get to the bunk? A minimum bunk space of 18-24" per cow is suggested. When bunk space is restricted, timid cows will only come to the bunk after the other cows have left. This may force them into a "slug" feeding pattern.

4. Water - Is a good, clean, fresh source available? Are there enough waterers? Is there adequate pressure to fill the waterers? The quickest way to depress milk production is to restrict water intake.

5. Feed consumed - Does the dairyman know how much feed the cows are consuming? This requires keeping track of

the amount fed, the amount refused and the number of cows in the group. A simple worksheet can be used to do this. If this is not done, you have no way of knowing if your program is working correctly. A weakness on many farms is not knowing how many cows are in the group.

6. Daily ration adjustments - Intake and the number of cows in the group will change daily. Thus, the dairyman will continually be adjusting the quantity of feed fed. When doing this, move <u>all</u> feeds up or down in proportion. Don't just add more or less forage to make this adjustment. Similar considerations need to be used when adjusting for changes in dry matter content of ration ingredients.

7. Feed timing - Pick the time of the day to feed when cows want fresh feed. This is usually just after milking. Work at California indicates that if feed is not available in the bunk after milking, that cows will tend to go to the stalls and lay down. This may depress total daily intake.

8. Ration samples and analysis - A quality control check is to have the bunk mix analyzed. Take 6-10 grab samples from the bunk, composite and analyze. If everything is going well, the bunk mix analysis should match the specifications of the ration formulated. If they don't match, it could be mixing problems or a change in feed quality. Find out why and correct it.

<u>Summary</u>

The use of complete, mixed rations is an effective and economical way to feed today's high producing dairy herd. The key to the successful use of this system is a high level of conscientious and consistent management. Proper formulation along with the management guidelines above can result in efficient and profitable milk production.

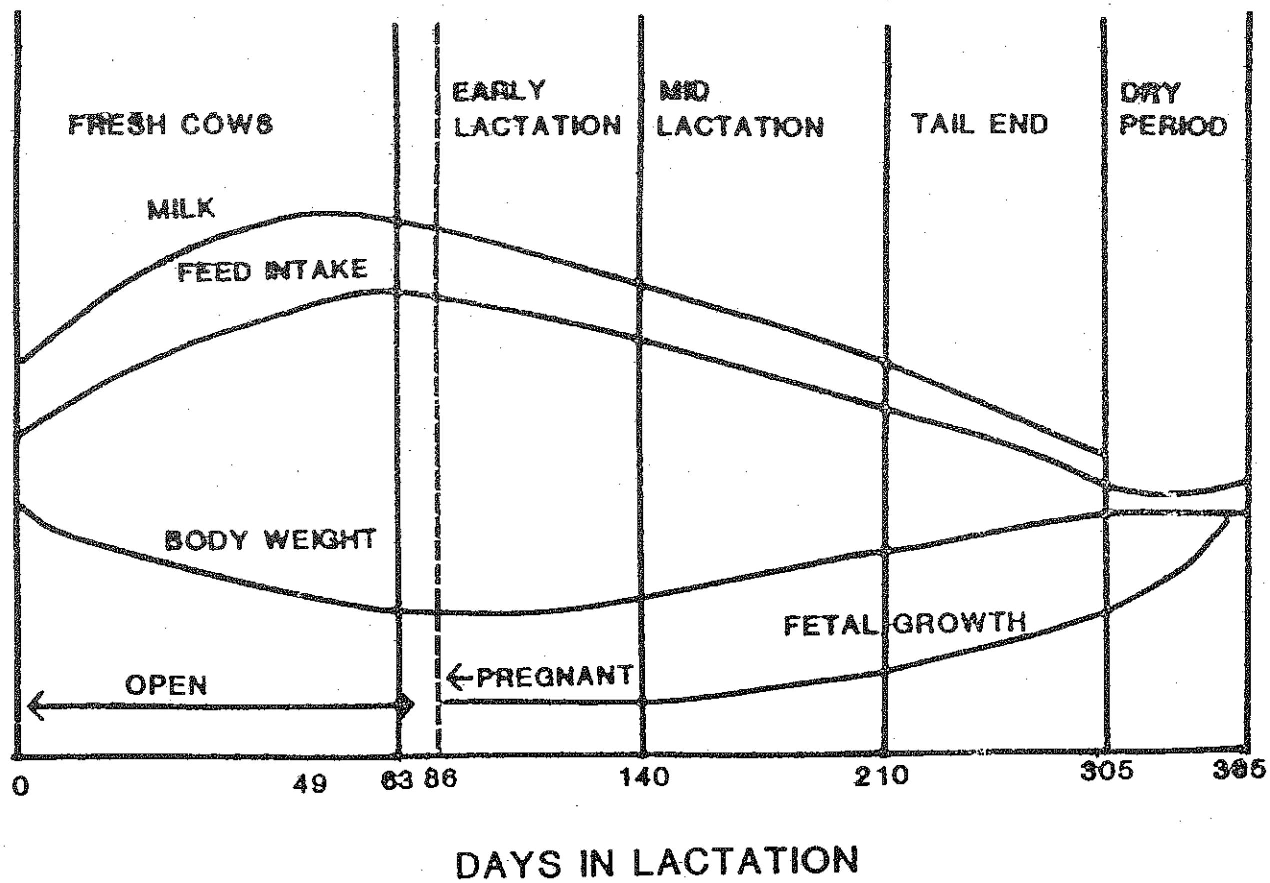
A key element to the overall success or failure is dry matter intake. Without an accurate value for dry matter intake, it is not possible to properly formulate rations. At the same time, problem solving cannot be done unless dry matter intake is known.

Table 1. Example nutrient density requirements of dairy cattle

Cow Information						Requirements		Nutrient Density	
Body Weight	Lactation Number	DIM	Milk	Milk Fat	DMI	NE_l	Crude Protein	NE_l	Crude Protein
(lbs)			(lbs)	(%)	(lbs)	(Mcal)	(lbs)	(Mcal/lb)	(%)
1100	1	30	60	3.5	31.7*	29.0	6.0	.91	18.9
1100	1	80	65	3.7	39.3	31.2	6.5	.79	16.5
1100	1	200	50	3.9	35.4	26.9	5.5	.76	15.5
1300	3	30	65	3.5	36.0*	30.0	6.3	.83	17.5
1300	3	60	85	3.6	48.5	36.8	8.0	.76	16.5
1300	3	180	60	3.8	41.7	29.3	6.1	.70	14.6
1500	4	30	90	3.3	44.5*	38.1	8.2	.86	18.4
1500	4	70	110	3.6	59.3	45.9	10.2	.77	17.2
1500	4	210	75	3.9	50.3	35.9	7.6	.71	15.1

*Intake depressed by 15% for early lactation cows

FIGURE 1. NUTRITION-REPRODUCTION CYCLE



Feeding Management Considerations-
Computerized Grain Feeders

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Computerized grain feeders offer the potential to more closely control and monitor concentrate intake of dairy cows. At the present time, units are available for installation in either stanchion or free-stall barns. The most common application in the Northeast, to date, has been in free-stall barns in which grouping cows is difficult.

A key factor which influences the results obtained from the use of a computerized grain feeder is management. The level of management required to use this equipment is usually greater than that required for other feeding systems.

The following factors are some of the key management areas to which attention must be given:

A. <u>Equipment Location and Installation</u>

The first step is to carefully read the installation and user manuals provided by the manufacturer. Even though most equipment is installed by a dealer, the dairyman needs to be familiar with installation procedures and guidelines. Equipment which is poorly located or installed may predispose the overall system to failure.

1. Feeding stall size - Follow the manufacturers guidelines. Generally, the stalls should be 32-34" wide and 7' long for Holsteins.

2. Feeding stall configuration - Stalls may be located individually or in groups of 2 or 4. Grouping two or more stalls in a row side by side will increase cow traffic in the area and may cause "traffic jams" that interfere with full use of the stalls. This is more likely if there are narrow alleys, high density housing and boss cow problems.

   Some type of side rail should be installed to prevent boss cows from bumping cows out of the feeding stall. Solid sides are often considered best and also restrict the view to minimize attracting other cows to bother a cow in the stall eating grain.

3. Feeding stall location - Stalls should not be located long distances from water but also not so near as to cause traffic congestion problems. The stalls should be in areas which can easily be accessed by cows

throughout the day. Stalls should be located in an area of the barn where cows can reach them after leaving the parlor. However, stalls should not be in the parlor holding area, return alleys or near any area where cow traffic needs to be maintained. As an example, don't place them so that they block the cross alleys between rows of freestalls or the feed bunk. It may be advisable to place one feeding station in the dry cow area to help make sure that cows know how to use them prior to the beginning of lactation. This also provides a way to begin some limited lead feeding prior to calving. Some people suggest placing a light above the feeding stalls to encourage use during the night.

4. Electrical considerations - Each feeder and stall should be grounded to eliminate the possibility of electrical shock or stray voltage. A lightning arrestor should also be installed to eliminate damage to the electrical components from lightning.

B. Equipment Calibration

Computerized feeder units operate on a timed feed delivery rate. Each cow is programmed for a certain number of minutes per day access. The total weight of feed delivered per cow per day is a function of the delivery rate (lbs/min) multiplied by minutes of access per day.

The feed delivery rate (lbs/min) can be adjusted in a number of ways depending upon the specific feeder used. However, basically the delivery rate is a combination of auger turns times feed density. It is extremely important to carefully calibrate the unit when it is initially installed and periodically thereafter. This can simply be done by having the auger turn for a measured number of seconds or minutes, collecting the feed delivered and weighing it on an accurate scale. The scale used should be accurate to 1/2 ounce. (Milk scales are probably not sensitive enough, especially in "two-feed" delivery systems where small amounts of a protein supplement are dispensed.) This must be done individually with each feed type and auger in dual feed systems. As a minimum, the system needs to be recalibrated each time a new load of feed is delivered. Changes in moisture of the feed can also alter the amount of feed delivered per unit of time. Each auger and motor should be checked individually. If calibration is not done or is done improperly, then the amount of grain fed may be above or below the desired rate.

It is extremely important to calibrate dual feed systems so that the correct proportions of energy and protein are delivered. If this is not done, an imbalance of protein and energy can occur and production may decrease.

An example of this potential effect is given below:

Situation: A dairy cow has access to a computerized grain feeder and the objective is to feed 24 pounds of grain per day. The feeder has been calibrated to deliver 0.8 lbs of feed per minute. This translates to 30 minutes of feeding time. The pelleted feed (A) used in the calibration procedure has a density of .79 g/ml. A new load of pelleted feed (B) has been delivered with a density of 0.72 g/ml. What impact does this have on feed consumption if the feeder is not recalibrated? Feed A - Feeder set to deliver 0.8 lbs of feed per minute with a feed having a density of .79 g/ml. Thus, if the cow uses the full 30 minutes per day, she will be given the desired 24 lbs of grain.

Feed B - If no recalibration is done, the new delivery rate would be .73 lbs/minute. Thus, if the cow eats for 30 minutes, she will only receive 22 lbs of grain per day. This problem can be corrected by either altering the minutes per day of access time or changing the rate at which the auger turns.

The rate of grain delivery in most situations should be set between .6 to .75 lb/min for "ground grain" or meal form and .75 to 1.0 lb/min for pellets. If higher rates are used, they may exceed the normal rate of ingestion and some feed may be left uneaten.

C. Number of Cows per Feeding Stall

The number of cows which can be accommodated by one stall is a function of:

- Feed ingestion rate
- Total time in stall (eating plus noneating)
- Minutes of feed allowance per cow
- Number of cows having access to a stall

Research work at the University of Illinois has suggested that when one feeding stall was programmed to deliver around 400-800 pounds of grain per day that average daily grain consumption was 96-98% of the programmed amount. In most cases, this is equivalent to 20-30 cows per stall.

D. Establishment of Concentrate Feeding Rates

Since forage is being separately from grain in these systems, many of the problems of grain allocation normally experienced in stanchion barns will be present in these systems. It is essential to have an index of forage quality and intake if appropriate and economical grain feeding schedules are to be derived. Many computerized grain feeders feed the energy and protein supplements separately. This provides a unique opportunity to utilize different proportions of energy and protein for individual cows. As a guideline, the following approach could be taken:

1. Estimate expected daily dry matter intake for each cow based upon milk production and body weight.

2. Determine ratio of forage to grain required on an energy basis.

3. Determine pounds of protein and percent protein needed in the grain mix.

4. Determine the proportion of energy and protein supplement needed to meet this protein need.

5. Make adjustments based on body condition status of the cow.

A key advantage of computerized grain feeders is the ability to feed each cow different quantities of grain based upon her requirements. There are 2 primary ways to use computerized grain feeders. One is to feed only forages in the bunk and all of the concentrate through the feeder. The second method is to use the feeder to topdress a bunk which is balanced for some level of milk production using both forages and concentrates. The following examples demonstrate the variation in grain feeding rates that could exist within a group of cows.

Situation 1 - a bunk containing a 50:50 blend of corn silage and alfalfa haycrop silage on a dry matter basis. The corn silage is 8.5% CP and has .71 Mcal NE_1/lb. The haycrop silage is 17% CP and .61 Mcal NE_1/lb. A dual channel computerized grain feeder is used. Shelled corn and a 38% CP supplement is fed through the feeder. All cows are producing 60 pounds of milk per day.

Cow Information

Body Weight	Lactation	Dry Matter Intake	Bunk Mix	Corn	38% Supp.
lbs		-----------(lbs/cow/day)----------			
1050	1	35.8	45.5	10.1	8.7
1250	1	40.1	54.0	12.2	7.4
1250	2	40.1	61.6	9.4	6.7
1200	3	38.5	55.7	10.0	7.0
1300	3	41.1	76.1	4.9	5.5
1400	3	43.1	90.7	1.4	4.5
1600	3	45.0	99.2	-	4.0

Situation 2 - A bunk ration is formulated to support 50 lbs of milk per day based on an average body weight of 1300 lbs for a mature cow. The bunk mix is 15% CP and contains 0.66 Mcal NE_1/lb. The bunk mix is composed of corn silage, alfalfa haycrop silage and a 38% CP supplement. Shelled corn and 48% CP soybean meal are available to be fed through the feeder. Again, all cows are producing 60 lbs of milk.

Cow Information

Body Weight (lbs)	Lactation	Dry Matter Intake	Bunk Mix	Corn	Soybean Meal
		(lbs/cow/day)			
1050	1	35.8	48	11.4	5.1
1250	1	40.1	50	12.6	4.7
1250	2	40.1	54	13.5	4.2
1200	3	38.5	52	12.3	4.1
1400	3	43.1	59	11.2	3.6
1600	3	45.0	65	8.5	3.2

Note that in both situations, the grain feeding schedules are quite different for different cows producing the same pounds of milk. If grain feeding guides are set solely on pounds of milk produced, the user will not be taking advantage of the technology which has been purchased.

E. Using Daily Grain Intake as a Herd Management Tool

Most computerized feeders on the market today provide a printout of the amount of feed programmed and the amount of feed actually consumed. The set point at which a cow comes upon the alarm list is variable depending upon the specific system used. However, there are some differences of opinion as to what extent or how useful appearance of a cow on the alarm list is as an indication of some health related problem. Only a portion of cows in heat will decrease daily grain intake to an extent that they appear on the alarm list.

At this point, it seems best to conclude that a cow on the alarm list is off-feed. This should alert the dairyman to go and look more closely at the cow to determine the reason for it. However, the alarm list should not be relied upon as the only indicator to spot cows in heat or detect herd health problems.

FEEDING FOR PEAK MILK PRODUCTION

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As the genetic potential of our dairy cattle population continues to increase, the management challenges and opportunities also increase. Many dairy cattle have the potential to produce in excess of 20,000 pounds of milk per year.

There are a number of important concepts which must be kept in mind as feeding and management programs are designed. Figure 1 contains an overview of the relationships of milk production, dry matter intake and body weight change over the course of the lactation.

A key factor related to total lactation milk production is the level of peak milk production achieved. Figures 2, 3 and 4 contain average lactation curves for Holstein. These curves were developed from Northeastern DHI data by Dr. J. Keown.

Even though these are typical curves, some key points are contained in these curves. These points are:

1. Higher producing cows have a higher peak milk production.

2. The decline after peak milk production is similar for all levels.

3. First-lactation cows tend to be more persistent than older cows.

4. Cows normally peak at about the second sample day.

Peak Milk Yield

Peak milk yield is one index of the potential production and profit in your herd. Previous work has indicated that each additional pound of milk attained at peak is equivalent to an increase of total lactation yield of 200-225 pounds. Plotting of lactation curves for your herd and comparing them with Figures 2, 3 and 4 can be a useful management tool. Look at both peak milk yield and persistency. Table 1 contains information relating peak milk yield and expected total lactation yield.

A second way to use this table is to determine the peak milk yield required if you are to attain some level of total lactation milk production. If you want your mature cows to produce 20,000 pounds of milk per year, then peak milk yield will need to be approximately 95 pounds.

Analysis of Lactation Curves and Persistency

Once you have plotted the lactation curves and done a persistency analysis, it is possible to examine the performance in your herd. Some of the questions to ask are:

1. Do the cows in your herd have distinct milk production peaks?

2. At which test period do the peaks occur?

3. Are first-calf heifers peaking within 15-20 pounds of the older cows?

4. How does persistency compare with the curves in Figures 2, 3 and 4?

5. Are persistencies similar for cows in different lactations?

6. Do peak milk and total lactation milk yield correspond? (Use Table 1).

By using the above questions you can determine the status of your herd. If peak milk or persistency reveal some differences from expected, then additional analysis will be required to define the reason and develop a plan to correct the problem.

Management Factors Affecting Lactation Curves

There are a large number of environmental and management factors which can influence either peak milk yield or the persistency of milk production in your herd. Some of the more common ones are listed below.

1. Dry matter intake - The level of dry matter intake is a key factor in determining the total nutrient intake which will be available to support milk production. Maximizing dry matter intake not only enhances milk production but may also lower feed costs per unit of milk produced. A second factor is enticing early lactation cows to achieve maximum feed intake earlier. This minimizes negative energy balance and should provide more opportunity for optimizing peak milk production (Table 2).

2. Energy intake - The amount of energy consumed is a key to attaining high levels of milk production. However, feeding higher levels of grain to achieve an increased energy intake is not always the answer. If excess grain is fed, alterations in rumen fermentation may occur and feed intake may be depressed. Milk fat test may also be lowered.

3. Ration fiber level - This factor is directly related to concentrate and energy intake. Enough coarse fiber must be included in the daily ration to permit 9-11 hours per day of chewing and rumination time. As a minimum, early lactation cows should have rations containing 17-18% ADF or 25-28% NDF. If fiber levels are too high, intake and production will be depressed.

4. Protein type and level - Inadequate protein intake in early lactation can limit milk production. Protein intakes must be formulated on and measured by pounds of daily intake <u>not</u> percent protein in the ration. The types of proteins in terms of solubilities, degradabilities and undegradabilities (bypass) must also be considered. This is most critical for early lactation cows. Rations which are either too high or too low in solubility, degradability or undegradability can depress milk production.

5. Feeding management - The manner in which balanced rations are fed can affect the level of milk production attained. The key concept is to provide feed inputs in a manner to even out rumen fermentation. Feeding more frequently assists by decreasing the amount of feed entering the rumen at any time. The sequence of feeding also has an impact on performance. Strive to feed some forage before grain and an energy source before a protein source. Improper feeding management practices can decrease daily dry matter intake and lower the efficiency of nutrient utilization.

6. Feed additives - In some situations, feed additives such as buffers, fat or niacin may be beneficial.

7. Ration dry matter content - There are good indications that wet, acid rations may lower feed intake and potentially milk production. The factors which are responsible for this phenomena seem to be nitrogenous compounds in the feed. Rations with less than 50-55% dry matter appear to be those in which intake is most likely to be depressed.

8. Body condition - The body condition of a cow at calving has a relationship to both peak milk production and persistency. Cows which calve thin will be limited in peak production potential and may drop in milk faster than desired. Overconditioned cows may have a slightly depressed early lactation feed intake. Strive for the following body condition scores in your herd:

Dry cows	3+ to 4-
Early lactation	3- to 3
Mid lactation	3
Late lactation	3 to 3+ (3+ to 4- at dry off)

9. Ration changes - Abrupt ration changes tend to upset rumen fermentation, depress feed intake and decrease milk production. In stanchion barns, try to increase or decrease grain in relatively small increments (1-2 pounds per cow per day). In free-stall herds, there are both nutritional and social factors involved when cows are moved between groups. Moving a number of cows at once rather than 1 or 2 cows can minimize the social impact. Avoiding wide variations in forage type and the forage to grain ratio between groups can minimize the nutritional aspect. Try not to have a difference of more than 15 units of forage between groups. An example would be if the high group has a 50:50 F:C ratio then the receiving group should not exceed a 65:35 F:C ratio.

10. Mastitis - Mastitis can affect either peak milk or the persistency of production. Use somatic cells as one index of the status of the herd. Establish milking management procedures and treatment policies which minimize the mastitis incidence in the herd.

Recommendations:

1. Late lactation cows

   a. Provide a feeding program which permits replenishment of body tissue reserves.

   b. Set a goal to attain a body condition score of 3+ to 4- at the time the cow is dried off.

2. Dry Cows

   a. The goal is to maintain body condition during the dry period.

   b. Balance the ration for energy, protein, minerals and vitamins.

   c. Try to include some dry coarse forage in the dry cow ration. Limit corn silage to about 40-50% of the forage dry matter intake.

   d. Watch mineral level. Try not to exceed 80 grams per day for calcium intake and 40 grams for phosphorous intake.

e. It may be desirable to introduce some concentrate during the last 10-14 days before calving. This is primarily to help adjust the rumen microorganisms to carbohydrates. A level of 0.5-1% of body weight as concentrate is adequate.

3. Early lactation cows

   a. Make ration changes as gradually as possible.

   b. Don't increase grain intake too rapidly. For most cows, an increase of 1-2 pounds per day is satisfactory.

   c. Try to maintain about 50% of the total dry matter as forage.

   d. Balance for total pounds of protein intake. Strive for 60% of the total protein to be degradable. About 50% of the degradable protein (or 30% of the total protein) should be in the soluble form.

   e. Avoid protein overfeeding. Excess protein intake can increase body weight loss and may lower reproductive performance.

   f. Stimulate cows to achieve maximum dry matter intakes as rapidly as possible. This will minimize the period of negative energy balance.

Table 1. Actual 305 Day Milk Production Based on Peak Milk Yield[a]

Peak Production	Lactation 1	2	3[b]
(lbs)		(lbs)	
35	8656	8317	8358
40	9845	9168	9291
45	11076	9971	10611
50	12196	11341	11347
55	13310	12381	12224
60	14439	13389	13230
65	15592	14561	14284
70	16630	15476	15358
75	17530	16437	16281
80	18355	17377	17230
85	19392	18324	18047
90	-	19178	19128
95	-	19938	20130
100	-	22033	22174

[a]J. Keown, Cornell University, 1984
[b]Third or greater lactation

Table 2. Relationship of milk production and weeks postcalving to attain maximum milk yield, dry matter intake and energy balance[a]

Milk	Maximum Milk Week	Maximum Milk lbs/day	Maximum DMI Week	Maximum DMI % of BW	Energy Balance
(lbs/cow/lactation)					(week)[b]
24226	7	110	14	3.75	21
15281	8	72.4	13	2.95	13
10036	6	60.7	13	2.78	10

[a]Smith, N. E., 1971, Dairy Day Proc., Univ. of California
[b]Week when energy intake first equalled estimated total energy requirement

FIGURE 1. NUTRITION-REPRODUCTION CYCLE

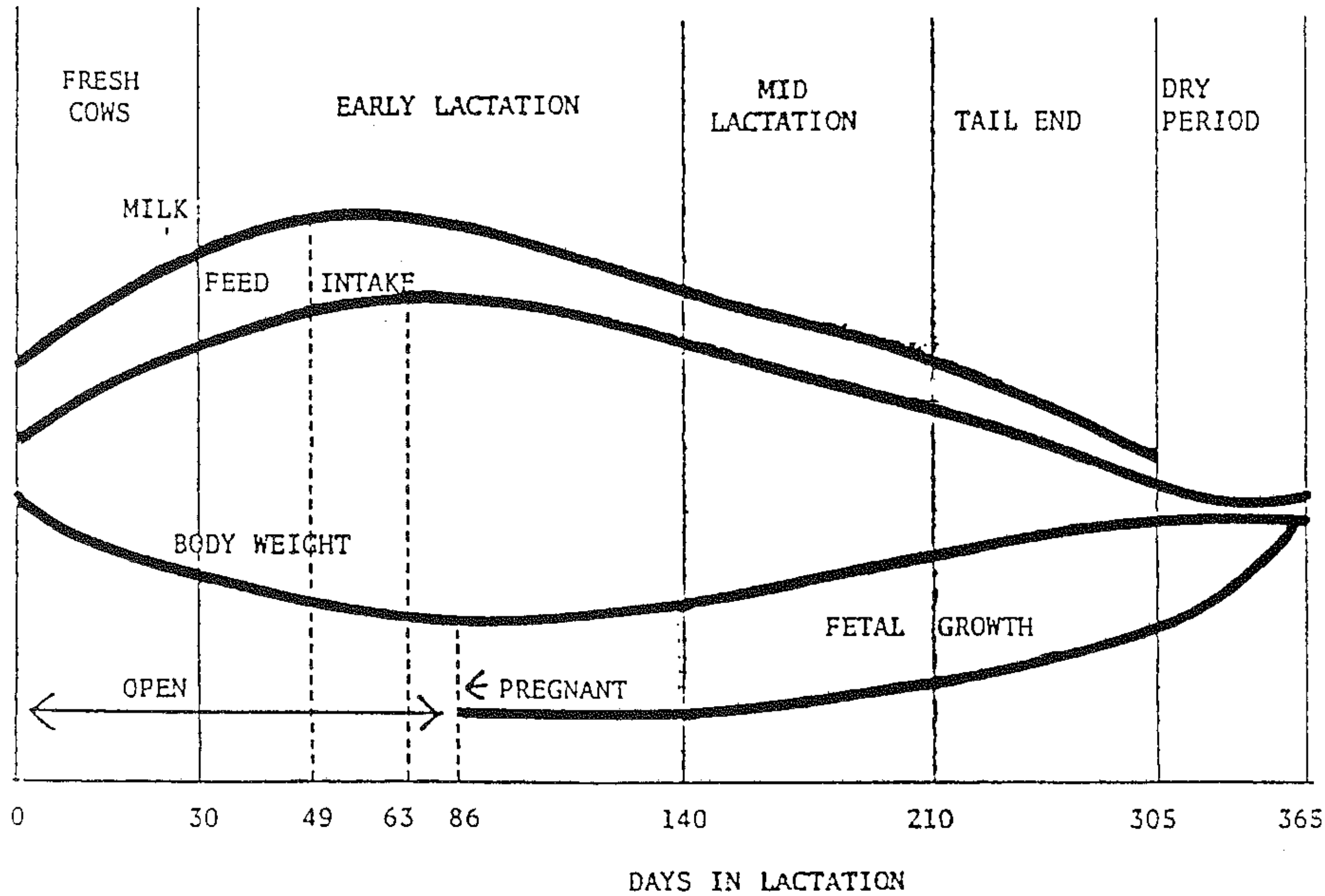


FIGURE 2.

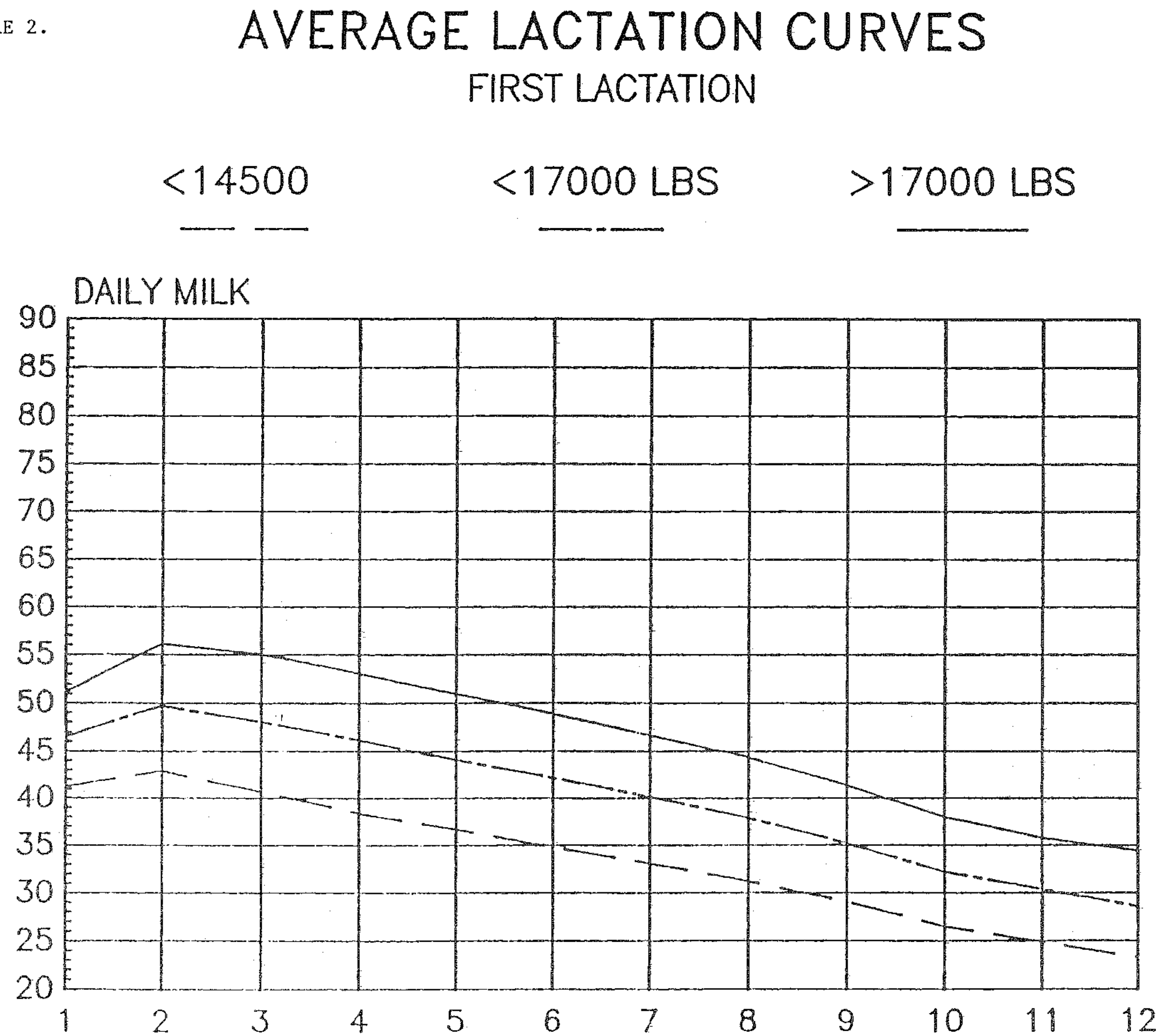

AVERAGE LACTATION CURVES
FIRST LACTATION
<14500
<17000 LBS
>17000 LBS
DAILY MILK
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 3.

AVERAGE LACTATION CURVES

SECOND LACTATION

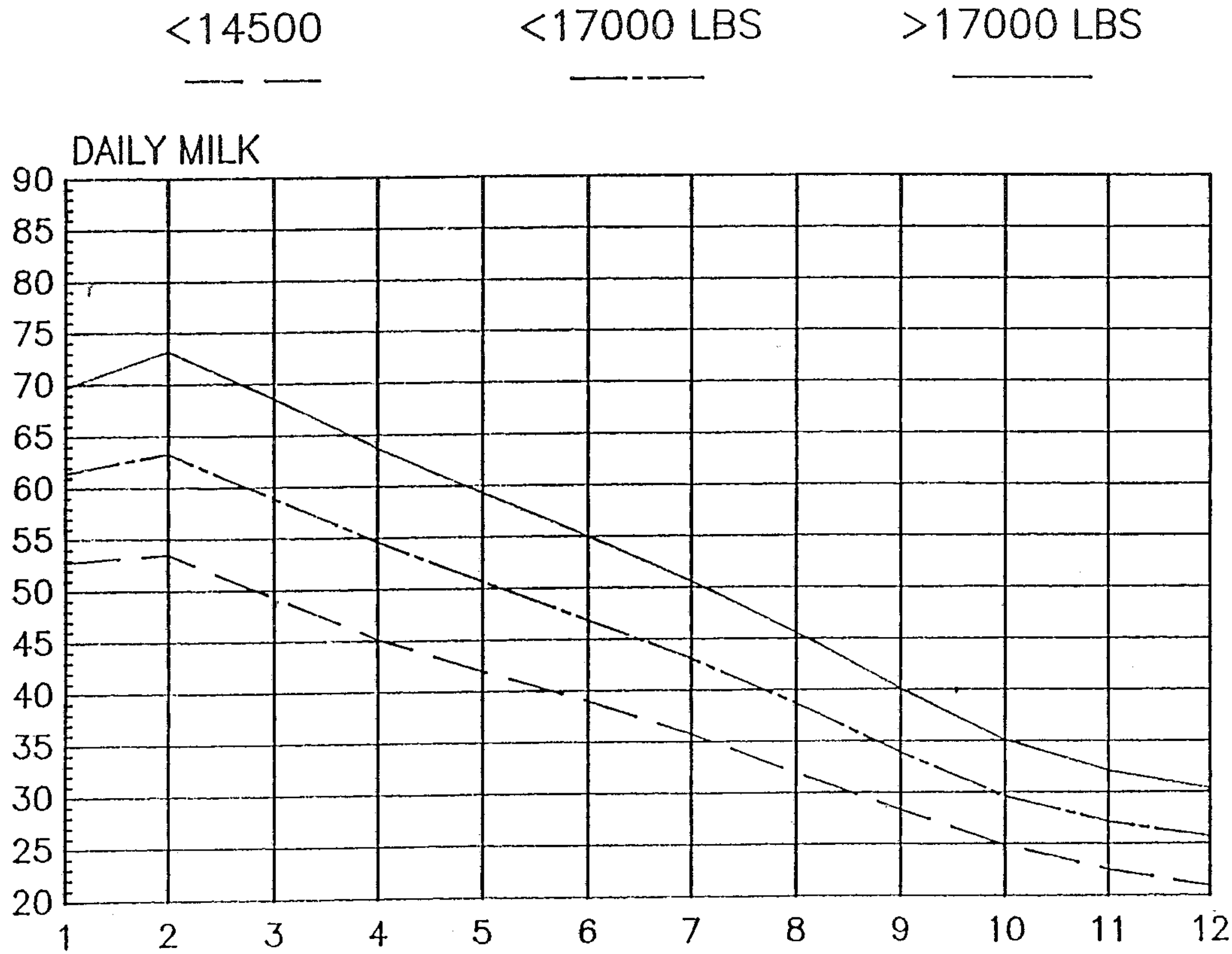
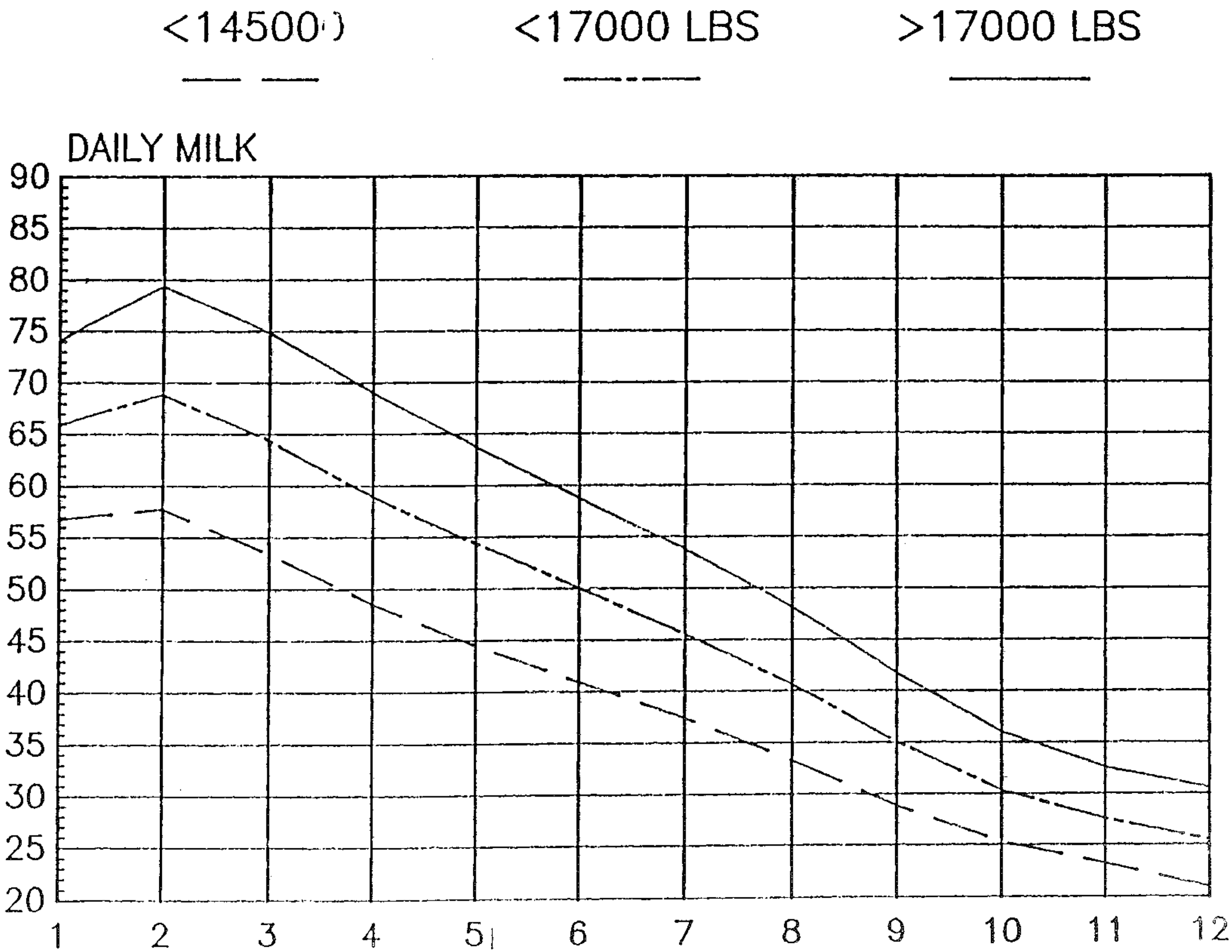


FIGURE 4.

AVERAGE LACTATION CURVES

3RD AND GREATER LACTATIONS



MAXIMIZING THE FEEDING PROGRAM IN HIGH PRODUCING HERDS

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When we balance rations we most always think in terms of today or within the next week or at most month. Rarely do we think about balancing rations for multiple lactations and/or multiple years. Why should we be thinking this way? How many times have you had the rations balanced and the cows have responded with increased milk. You walk away satisfied. Time goes by and although feeds and environment have not changed milk has dropped below where you were before the rations had been changed. Looking closer you see thin cows. This means a loss for the lactation and unless you do come careful reformulation you will have depressed output in the next lactation. If we had balanced rations for the "future" we would have avoided this problem.

What do we have to do to look to the future in managing feeding programs for high producing herds?

We would suggest that we need to divide the problem into general areas:

Herd definition - age distribution
- number in each age classification
- genetic potential

Farm Resources

Facilities
Feeding System
Concentrate Sources
Feed Storage
Harvesting Systems
Soil - Crop
Available Labor

We need to be able to evaluate each of these divisions. First we need to have a record system associated with each of these divisions. These record systems need to be developed in such a way that we can assess how efficiently this division is operating and, bottom line, is this division making money.

Herd definition -

In managing your feeding program it is absolutely necessary to know what the age (lactation no.) distribution in your herd is and what the change in this distribution is over time. For example your lactating herd might be composed of 35% first calf heifers, 30% second and 35% 3rd and above (really need to know breakdown of the older animals also). As you look at this distribution you might find that there has been an increase over time, in the percentage of first calf heifers and a decrease in older cows. This information is important from two aspects. First it is important to know the age distribution so that more exacting nutrient requirements for the herd can be calculated and formulated for. Second it is important to be able to diagnose a problem that may be occurring in the herd such as increased cow turnover.

Genetic information about the herd is important in terms of current production potential and in terms of increasing genetic improvement. This will define the potential lactation curves for each individual cow and for the herd and the change in that curve with each new animal coming into the herd. Information from DHI genetic/environmental profiles will be an important help in this respect. The genetic change from year to year increases the potential peak and the potential to mobilize tissue. This information is important in defining the ration changes on an annual basis.

Production needs to be quantitated in terms of total milk, fat and protein and the % fat and protein. Along with this you need to know the changes in days in milk and the lactation curves of each group of cows in the herd. Again your DHI or milk records will provide this information. From a diagnostic viewpoint the day to day fluctuation in milk sold/cow is also an important number.

We can summarize this area by pointing out that as we think to the future we need to be thinking about how to maximize return over cost. We can no longer afford to be sloppy in our feeding management. The better that we can define the dynamics of the herd the closer we can feed to requirement. It is not unusual for nutritionists to overfeed a nutrient in order to offset their degree of uncertainty about the herd dynamics and the management level. These excesses cost money. The poultry industry developed a high degree of accuracy in predicting the dynamics of their flocks. They have to - the margins are small. The margins are shrinking on the dairy farm also. Tighter controls are absolutely necessary.

The replacement programs on most farms can be improved. Few dairy farmers know the performance of their heifers. You should know the following information on your heifers:

Group Information

Preweaned

1-4 weeks
4-8 weeks

Weaned

2-8 months
8-14 months

Breeding/Bred

14-16 months
16-22 months
22-24 months

You need the following information during the grow out period:

1. Any health problems
2. Immunization record
3. Body weight and condition score at:

   Birth
   Weaning
   8 months
   14 months
   Calving

4. Calculated average daily gain
5. Feed consumed
6. Feed to gain

It is preferable to weigh heifers on a monthly basis. This is only possible if you have a scale and replacement handling facility. Electronic scales are now available for about $3000. The objective is to minimize the amount of feed needed to produce a lb of gain. Remember that it costs $1100-1300 to raise a heifer. Half of the cost is for feed. We need to make sure that there is a good return for the dollar invested for feed. Body weight and condition score information along with feed intake are needed so one can assess performance. We can no longer afford to do otherwise.

The health data are necessary for aiding in making culling decisions. Data are suggesting that early calfhood health problems can have negative life/time impacts on animal performances.

Dry cows and heifers 22 to 24 months need to be weighed at the beginning of the dry period and condition scored at least two times during the dry period. Age distribution is also important in this group. We must remember that we will have first calf heifers that have just dried off and first calf heifers that are about to freshen. These animals have a growth requirement in addition to fetal and reserve maintenance requirements. The age distribution and body condition information is important because we need to consider grouping the animals based on growth requirements <u>and</u> condition.

Facility Resources

Facilities, often times, provides one of the greatest restrictions in optimizing feeding management for high producing cows. Some examples of this might be:

1. Bunk space limited (less than 2.0'/cow)
2. Elevated bunks
3. Rough mangers
4. Poor ventilation
5. Poor parlor throughput (3X milking)
6. Smooth floors
7. Small stalls (stanchion barn)
8. Poor free stalls
9. Waterers poorly placed
10. Water flow slow and/or limited
11. Poor lighting

The reasons for the limitation on feeding management are two fold:

First, there can be a limited ability for cattle to feed freely due to restricted movement through overcrowding, difficulty in getting up and down and total unavailability of the bunk. The second aspect is environmental stress from heat and humidity or lack of water and poor water can increase the propensity towards slug feeding. It is absolutely important that facilities be designed that maximize cattle comfort. Little do we realize that the facilities that were designed 10 years ago for a 14-15,000 lb herd are just not adequate for today's 18,000+ herd. Animals have increased in size and in higher milk and because of this the facilities are no longer the right size. The increased feces, urine and heat production exceeds the capacity of the design of the system. We have also pushed these systems by overcrowding.

<u>Feeding Systems</u> - Feeding systems can provide significant restrictions in optimizing feeding management. In conventional systems we are feeding grain separate from forages. Grains are rapidly fermented and can cause metabolic problems. It is important that we be able to develop a feeding strategy that will allow cows to consume the feeds offered frequently. This often necessitates offering feeds 8-14 times per day. Manger size, availability of manger, cleanliness of the manger, and the ability to move feed carts in front of the manger become important items in optimizing productivity. It is important to note that the ability to group within the barn becomes important in optimizing the feeding system in conventional barns. If there is space for grouping and feeding cattle, and there is a good sized feed room it is possible to consider developing blended rations.

The blended ration in the conventional system can have several advantages:

1. Labor efficient
2. Less times around the barn
3. Balances carbohydrates and proteins
4. Minimizes changes that can occur in a silo due to variation among fields.
5. During heat stress periods reduces negative impact of slug feeding.

Caution should be followed before converting to a blended ration system. Things should be carefully "penciled" out in terms of space requirements, labor costs, flow of forages and concentrates into the mixer and finally who is going to formulate the rations and the ration changes. This last point is important. You have essentially taken away the cow's opportunity to choose. This means that each mouthful is the same and the balances need to be right and the grouping needs to be right.

Feeding systems in free stall systems are frequently a limitation. It becomes important that the ingredients in a mix be weighed and the ingredients be well mixed without significantly reducing particle size. In terms of time to mix ingredient input needs to be rapid. This is not possible with the slow unloading capability of many silo unloaders in upright silos. Time efficiency is important because there are conditions when the blended ration needs to be fed several times a day and if it takes 3-4 hours to feed the cows then it is impossible to feed frequently. When are the times when you need to feed more frequently? The following situations would dictate trying to increase frequency:

1. Silage unstable - heating up.
2. High moisture corn not processed correctly
    a) too wet and fine - flour. Rapidly fermented.
    b) too coarse and dry - slowly fermented.
3. Forages chopped incorrectly
    a) Hay crop too fine
    b) Corn silage dry and mature - too coarse
    c) Corn silage - immature - too fine
4. Limited bunk space
5. Barn ventilation limited - summer heat.

<u>Concentrate Sources</u> - Frequently you might feel that you can save money by producing your own grain and purchasing your own ingredients. Yes, there is potential for significant savings if you can meet the following criteria.

1. Growing your own grains
    a. Good storage facilities
    b. Planting and harvesting capability is synchronized with crop volume
    c. Soil resources/environment provide potential for high yield
    d. Labor availability
    e. Grain processing capability

2. Purchasing grains
   a. Volume purchase large enough to obtain dollar discount.
   b. Ingredient bins (5 spaces available).
   c. Dry, clean storage with capability to handle semi truck load.
   d. Reliable ingredient sources - quality
   e. Mineral and micro ingredient storage area

3. A excellent nutritionist to formulate rations or a top nutrition program with a good understanding of ration balancing.

You need to have the ability to handle at least two energy (high starch or high fat) sources and two or preferably three protein sources. This will allow you the flexibility to take advantage of price and to formulate rations for carbohydrate and protein degradability. If you do not have capability to meet many of the above criteria you are much better off to purchase premixed ingredients where protein and carbohydrate degradability are balanced for as well as minerals and vitamins. You will still need space for at least 2 premix concentrate in order to be able to formulate across the herd.

Feed Storage - Concentrate storage has been discussed above. We need to reemphasize the ability to be flexible. You need to think in terms of the whole herd. Plan your concentrate storage based on herd size and groups being fed. We need to be capable of taking advantage of price and being able to balance for protein and carbohydrate degradability for the different groups in the herd. Forage storage is one of the major imitations on the farm for optimizing productivity. We need to be flexible. The number of storage areas (hay bays or silos) is dictated by field numbers, cuttings and plant species (grasses, legumes and corn silage). We need to be able to have access to the different types of hays and silages for the various classes of livestock on the farm. For example we need to access the grass hay or grass silage for the dry cows. In the case of silages the working surface of the silo needs to be such that the material being taken out of the silo is fresh and cool.

Silo management is critical to optimizing productivity. The material ensiled needs to be brought to a low pH rapidly for stabilization and then the silo needs to be properly sealed (except the working surface) to minimize oxygen infiltration. The working surface needs to be smooth. If the ensiled materials are hot coming out of the silo or are hot in the bunk or manger after a few hours this will inhibit intake which will reduce productivity. This can be very substantial. The use of researched silage additives are a serious consideration.

Harvesting Systems - If you are going to run a crop operation to supply forage for your dairy operation then it must always produce high quality forages. Part of obtaining this is in having the right machinery complementarity. This must be carefully planned so that when it is time to plant or harvest it can be done rapidly without delay. Too often machinery inadequacy is the prime reason for poor quality forage. When deciding what the forage system is going to be you need to calculate what the cost per ton of forage dry matter stored is going to be. You might decide that it doesn't fit. We would also recommend putting in an electronic scale so that forage yields can be measured.

<u>Soil resources</u> - If you are going to manage a crop operation on your farm it is necessary to carefully assess your soil resources. Resources need to be examined in terms of yield potential if proper drainage is in place. Drainage means higher yields and timeliness which will translate in higher productivity per cow and per acre. You need to examine, carefully, your crop needs for each class of livestock and then plan the acreage accordingly. Trying to grow alfalfa on 100 acres of your land when only 50 of these acres will really give you the yields that you want is part of that planning.

<u>Labor Resources</u> - Labor resources play a large role in deciding on all that has been discussed above. For example in order to optimize productivity on your farm you need to have consistent, top quality forages. If you decide to go into high moisture corn that is one more operation that is going to require additional skilled labor from the soil to feed out. This requirement may impact the rest of the forage operation and the feeding management resulting in lower productivity. Managing the labor resources carefully and fitting all parts of the operation together becomes critical.

We have discussed many aspects of the farm operation with one purpose in mind. Each part of the operation comes together in defining what one can do in optimizing feeding management. One goal is to maximize the use of high quality forages whether grown or purchased, in such a way as to optimize milk production, growth, reproductive performance and reserve losses and gains. The management of reserves is critical. We need to look at this in terms of a multi lactation impact. We need to think in terms of feeding for reserves. That is to minimize loss in early lactation and to replace in late lactation and if necessary in the dry period.

This means that we need consistent quality feeds and a good environment. Feeding management then becomes the key to maximizing herd productivity. First we need to balance rations for all the important nutrients. The rations will always be fed ad lib.

Response needs to be monitored. Measure daily intake. Plot out milk shipped per cow from the tank weights. Have fat run on the tanks frequently. Examine manure for wetness, dryness, color and corn and fiber. Condition score monthly or more frequently for early postpartum animals. Plot out frequency of metabolic diseases. You can then use these responses to make adjustments. For example, if manure becomes very wet cut back on the protein and examine protein in the ration. Our challenge in the Northeast is to monitor and adjust for changes in the environment and the results of that environment.

LEAD FACTORS-A USEFUL TOOL IN GROUPING MANAGEMENT

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The shift to handling cows as groups rather than individuals presents a number of management challenges to the dairyman. How many groups should there be? How many cows should be in each group? What level of milk production should the group be fed for?

There are a number of factors which need to be considered to answer these questions. Herd size, milking parlor configuration and physical design characteristics of the barn need to be considered. At present, there are a wide variety of methods used by dairymen to determine in which group a specific cow should be located. Milk production, days in milk, lactation number, reproductive status, energy requirements and nutrient density requirements are some of the methods used to make this determination.

Once the groups have been established, the next question becomes what level of milk production should the ration be formulated to support? Commonly, rations are balanced for a level of milk production above the average for the group. However, in most cases, the actual level balanced for is a somewhat arbitrary decision.

The concept of lead factors to assist in this decision has been used in New York and Virginia for a number of years. The early work in development of the lead factor concept was done at Virginia Polytechnic Institute under the direction of Dr. M. L. McGilliard.

One approach to the use of lead factors is to use tabular guidelines. As an example, the suggested guidelines in the Newplan Program 31 manual are:

Type of Group	Lead Factor
Complete herd (1 group)	1.20-1.30
Two groups	
Top half	1.10-1.20
Bottom half	1.15-1.25
Three groups	
Top	1.10-1.15
Middle	1.12-1.17
Low	1.18-1.23
Four groups	
Fresh	1.05-1.10
Peak	1.05-1.15
Mid lactation	1.10-1.15
Tail end	1.10-1.15

A more logical approach would be to actually calculate the lead factor for a specific group based on the characteristics and distribution of animals in the group. This should result in a more accurate lead factor and a better opportunity for efficient and profitable milk production.

The Virginia workers define a lead factor as:

Lead factor = (Mean milk yield + one standard deviation)/(Mean milk yield)

The calculated lead factor is then used to determine the level of milk production for which that group's ration is balanced. As an example, let's assume a group with an average milk production of 60 pounds and a standard deviation of 9 pounds of milk. The lead factor for this group would be 1.15. Thus, the ration for this group would be balanced for 69 (60 x 1.15) pounds of milk. In a group with a normal distribution of milk weights, approximately 83% of the cows would have their nutrient requirements either met or exceeded.

However, the actual distribution of milk weights within a group can vary considerably. To further examine this point, let's use 2 actual groups with similar average milk productions. Each group contains 56 cows. Average daily milk production for Group 1 was 72 pounds while for Group 2 it was 71.4 pounds. The actual distribution of cows by milk production levels in these groups are in Table 1 and Figure 1. Note that the cows in Group 1 are clustered in a smaller range of milk weights.

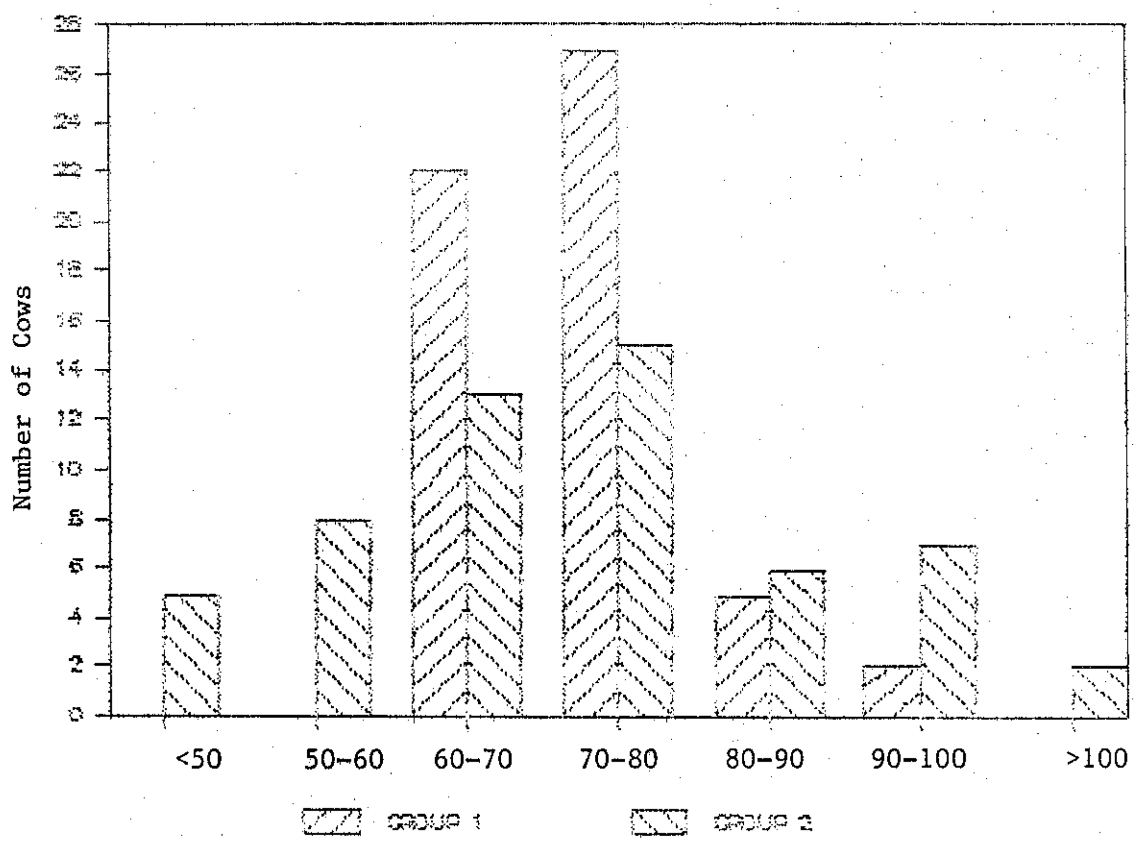
The standard deviations calculated for these groups were 7.2 and 16.5 pounds of milk for groups 1 and 2 respectively. The lead factors for these groups would then be 1.1 and 1.23. Thus, the level of milk production for which the rations would be formulated becomes 79 and 88 pounds of milk for groups 1 and 2.

The concept of using lead factors in formulating rations may be of value in fine tuning group feeding decisions. Lead factors are relatively easy to calculate and should assist in doing a better job of ration formulation to enhance milk production while controlling feed costs.

Table 1. Number of cows by milk production classes

Milk (lbs/day)	Group 1	Group 2
	- - (Number of cows) - -	
<50	0	5
50-60	0	8
60-70	22	13
70-80	27	15
80-90	5	6
90-100	2	7
>100	0	2

FIGURE 1. Distribution of cows by milk production levels



Feeding and Managing Dairy Cows During Hot Weather

L. E. Chase and C. J. Sniffen

The summer of 1988 was an excellent demonstration of the effects which hot weather can have on dairy cattle. Many dairy producers reported significant decreases in milk production and reproductive performance. On some farms, the effect of the heat was exacerbated by poor barn ventilation.

Dairy cows are able to adapt to a wide range of environmental conditions. However, prolonged periods of high temperature alter metabolism and depress feed intake, milk production and reproduction. As ambient temperatures rise above 75-80 F, feed intake begins to decrease and then declines sharply at temperatures in excess of 85 F. Milk yield will then be depressed as a result of this reduced nutrient intake. It has been estimated that the maintenance requirement is 20% higher for a cow in an environment of 95 F compared with a cow at 68 F. Dairy cows in hot environments tend to have elevated body temperatures, higher respiration rates and increased levels of electrolyte loss. High levels of humidity enhance the effects of high temperatures on the cow.

What can dairy producers do to counteract the impact of hot weather? There area number of options which can be utilized. These include a combination of both nutritional and management alterations. This paper will outline some of the adjustments which may be beneficial in minimizing the effects of hot weather on animal performance.

A. <u>Water</u> - One of the primary considerations is to make sure that plenty of fresh, clean water is available. The expected daily water intake will increase by 40-50% for cows in an environment of 80 F when compared with a temperature of 40 F. These figures assume that the animals are continuously exposed to these high temperatures.

A recent trial in England conducted by J. I. Richards (Tropical Animal Health Production, 17:209, 1985) examined the effects of shorter durations of elevated temperature on water intake. The control cows were subjected to temperatures ranging between 57-70 F with a relative humidity of 60-70%. The treatment cows were exposed to temperatures of 100 F with a relative humidity of 80% for 7 hours per day. During the rest of the day, the temperature was similar to the control cows. The cows used in this trial were in midlactation. Total daily water intake was elevated by 12% for the treatment cows. Table 1 contains data from this trial.

Another question relates to the possibility of enhancing water intake in warm weather by cooling the water. Dr. C. E. Coppock at Texas A&M University has examined this in some research trials (J. Dairy Science, 69:1004; 69:1013, 1986). These trials were conducted during the summer when daily maximum temperatures exceeded 95 F. The water offered was either 50 or 82 F. Water intake was 42% higher for cows receiving the cooler water. This represents the amount of water which the cows consumed in a 10 minute period. Cows receiving the cooler water also had higher dry matter intakes and milk production.

B. <u>Ration adjustments</u> - The challenge is to control or adjust the ration to minimize the depression in dry matter intake. Some of the points to consider include:

1. **Energy** - Quite often cows will voluntarily limit forage intake during hot weather. This can alter the total ration fiber content and may induce rumen acidosis and subsequent milk fat depression. High forage diets have a higher heat increment than high grain diets. The highest quality forage available should be used to minimize the heat increment from forage digestion. It may also be advisable to slightly increase the concentrate to forage ratio of the diet. However, minimum fiber levels of 18-19% ADF and 25-28% NDF need to be maintained. The addition of buffers, such as sodium bicarbonate or magnesium oxide, have been shown to be useful in minimizing milk fat depression in hot weather. Added fat is another possibility to consider. This elevates the energy density of the diet. Total diet fat levels should not exceed 7%.

2. **Protein** - Dietary protein content may also need attention to maintain an adequate protein intake. Overfeeding protein should be avoided since energy is required to convert and excrete the excess protein. Limited studies indicate that diets with high levels of soluble or degradable protein may increase the depression in milk production observed during heat stress. Diets should be formulated as tightly as possible for soluble, degradable and undegradable protein.

3. **Minerals** - During heat stress, body temperature and respiration rate increase. The losses of electrolytes also appear to increase due to sweating. Workers at the University of Florida have found that increasing the dietary content of potassium, sodium and chloride results in improved milk production in heat stress situations. They suggest increasing potassium to 1.3-1.5% of the total

diet dry matter and sodium to 0.5%. There is also some work to indicate that magnesium levels should be elevated to about 0.3%.

C. Feeding Management - The key here is to provide a continuous supply of high quality, fresh feed. Feedstuffs tend to heat and spoil more rapidly in warm weather. Increasing the frequency of feeding should be beneficial in warm weather. It may also be advisable to shift the feeding times so that fresh feeds are made available during the cooler times of the day.

D. Environment - Anything that can be done to increase cow comfort should be beneficial. Ventilation is a key factor which needs improved on many farms. Fans should be used to move the air and partially cool the cows. The sides of free-stall barns may need to be opened for air flow purposes. Insulation on the underside of metal roofed buildings may lower the heat load. Shade should be provided for animals on pasture.

The use of sprinklers or misters may also be worthy of consideration. These devices are used on a number of California dairies. The misters should be located above the feed manger so that the mist is directed towards the middle of the cows back. It may also be necessary to have fans above the misters to assist in cooling the cows.

SUMMARY

The key to feeding and managing dairy cows during hot weather is to keep the cow comfortable and minimize the depressions in dry matter intake and milk production. The following points should be beneficial in working with your customers:

A. A plentiful supply of cool, fresh water should be available at all times.

B. Feed the highest quality forage available.

C. Balance the ration to maximize energy intake. Added fat is a good possibility. Total ration fat content should not exceed 7% in most situations.

D. Balance rations for soluble, degradable and undegradable protein. Avoid overfeeding either total protein or high levels of soluble and degradable protein.

E. Increase ration mineral levels to about 1.3-1.5% potassium, 0.5% sodium and 0.3% magnesium.

F. Consider the addition of buffers.

G. Adjust feeding schedules to feed more frequently and during the cooler times of the day.

H. Adequate ventilation is a must. Pay special attention to putting together an effective system which includes both inlets and fans.

I. Consider the idea of misters over the feedbunk. This will help to cool the cows and stimulate dry matter intake.

J. Provide shade for cows on pasture.

Table 1. Effects of High Temperatures on Lactating Dairy Cows[a]

Item	Temperature Regime[b]		
	A	B	C
Rectal temperature, F	100.9	104.0	101.1
Pulse rate/minute	63	73	63
Respiration rate/minute	22	150	26
Sweat loss, l/day	9.9	12.9	10.0
Water intake			
gallons/day	21.3	23.8	-
gallons/lb DM	.52	.66	-
gallons/lb milk	.58	.70	-

[a]J. I. Richards, Tropical Animal Health Production, 17:209, 1985.

[b]Temperature regimes are:
A = 57-70 F, 60-70% relative humidity
B = 7 hours per day at 100 F and 80% relative humidity, 17 hours similar to A
C = Same as A

Problem Solving Techniques in Dairy Cattle Nutrition

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Introduction

The basic approach to problem solving in the area of dairy nutrition is a combination of observation, listening, information collection, data calculation and integration. The key is to be able to obtain enough accurate information to allow an evaluation to be made. An important part of this process is listening to the information provided by the dairyman. However, a more important item in many cases is asking questions to obtain additional information in some area or covering items which the dairyman neglected to mention. Unless accurate information is obtained, the rest of the evaluation process will be an exercise in futility.

The Tool Kit

1. Reference book

   - Nutritional requirements
   - Composition of feedstuffs
   - Listing and composition of the feeds and minerals commonly available in the area
   - Worksheets

2. Measurement tools

   - Scales
   - Pail or bushel basket
   - Moisture tester
   - Body weight tape
   - Measuring tape (50-100')

3. Sampling devices

   - Hay corer
   - Plastic bags or laboratory mailers
   - Containers for water or other liquids

4. Recording devices

   - Note pad, pens and pencils
   - Calculator

5. Other information

   - DHI records
   - Breeding and health records
   - Feed mixing and delivery slips
   - Feed tags

The Team

In many cases, your primary contact and source of information will be the dairyman. However, other resource people such as the feed dealer, nutritional consultant or the Extension agent can provide another source of input. In many cases, these individuals provide a different perspective to the situation which may prove to be very valuable. Don't hesitate to interact with these people if you feel that they can make a contribution to a particular problem situation. The net result of the team approach should be the provision of better advice and service to your clients. We have found the team approach to be an essential part of the total problem solving process

Observation

One of the first things which should be done is to walk through the herd and look at the cows, the physical facility, the feedbunks and the environment. Some of the items to be observed in these areas are:

A. Cow questions

   - Are the cows chewing their "cud" and exhibiting good, strong rumination activity (normal cud chewing time will be 10-11 hours per day)?
   - Body condition of fresh, early, mid and late lactation cows. Don't forget the dry cows
   - Size and body condition of first calf heifers
   - Hair coat
   - Consistency of manure
   - General appearance and cleanliness
   - Urine color, quantity, frequency
   - Feed and legs, lame cows

B. Feedbunk

   - Does the material look and smell fresh?
   - Is the feed warm to the touch?
   - Frequency of feeding
   - Time of feeding
   - Feedbunk space (ft/cow)

- Are magnetic feeders used? If so, how many cows per feeder and is the feed fresh?
- How often are bunks cleaned out?
- Does the feed appear to be uniformly mixed throughout the length of the bunk?

C. Environment

- Stall length, width and surface type
- Ventilation and air quality
- Bedding: amount and type
- Outside exercise area
- Water: source, number of waterers and general cleanliness
- Alleys: width, is the surface smooth and slippery?
- Calving area: size and cleanliness

D. Feeds

- Forages: particle length (minimum of 3/8" theoretical cut)
- Haylage: should be about 20% with a length of 1" or longer
- Corn silage: are kernels cracked? Can you see some pieces of cob?
- Grains: fed as meal or pellets? If pellets, look for fines.
- Do fermented feeds have a "silage" smell?
- Any visible mold or spoilage?
- Mineral feeding: how and how much?

Information Collection

The objective of this phase is to attempt to pinpoint the problem and to obtain information which will allow you to perform some calculations regarding nutritional adequacy of the ration. This phase can be divided into 2 parts:

Definition of the Problem

- What are the major complaints or problems?
- When did it start?
- If a metabolic or reproductive problem:
  - How many cows have been affected?
  - Do they respond to treatment?
  - What types of treatments have been used?
  - Have any changes in either feeding or management been implemented to try to minimize or alleviate the problem?
- If a production problem:
  - Are cows peaking normally? (See Table 1 for guidelines.)
  - Do cows peak normally but have poor persistency? (Plot some lactation curves on a form similar to Figure 1.)
  - When did the problem begin? (How long ago?)
  - Are all cows affected or is it a specific group of cows like first calf heifers?

To further refine the definition of the problem, you may need to spend some time with the DHI records or the herd health and breeding records. You may also want to talk with the herd veterinarian.

Background Feeding Information

The next step is to collect the feeding information which you will need for checking the ration. The "pieces" of information which you should collect include:

1. Forage test data
2. Feed tags from commercial feeds, minerals and supplements
3. Records of feeds fed (see sample worksheet below).

Feed	Lbs Fed	x	% DM	=	Lbs DM
____	______	x	_____	=	_____
____	______	x	_____	=	_____
____	______	x	_____	=	_____
____	______	x	_____	=	_____

If cows are grouped, how many cows? __________

________ DM fed - __________ DM refused = ________DM consumed

_______DM consumed ÷ ________ No. of cows = _____#DM/cow/day

4. Record daily feeding activity schedule (see attached form).

Ration Checking

The next step is to take the information on the types and quantities of feeds offered and refused and dry matter intake to calculate actual daily nutrient intake. This is done quite simply by the following method:

lbs DM consumed x % nutrient in feed DM = amount of nutrient intake

example: 45 lbs DM x 15% CP = 6.75 lbs CP

The "key" points which you are looking for include:

1. Daily dry matter intake

- Is reported dry matter intake quite low or high compared with expected (Table 2)?
- If reported dry matter intake is quite different (5-10%) than expected, verify the amounts of feed given to you by the dairyman. This may mean that you need to do some weighing of feed.

- If dry matter intake is lower than expected (5-10%), try to determine why and see if some changes in feeding or feeding management can be made to improve intake
- Make sure that any dry matter intake figures are corrected for refusal.

2. Nutrient intake

   - Do nutrient intakes match nutrient needs (compare with nutrient requirements from NRC or other sources)
   - Do this for all production groups and dry cows

At this point, you should have an idea of the strengths and weaknesses of the current feeding program. One factor which is most likely to be off in many situations is the estimated dry matter intake. Dry matter intake is the foundation of both the design and evaluation of dairy feeding programs. However, it is the value which is most difficult for a dairyman to quantify. Thus, special effort must be made to obtain the most accurate data possible. Without a reasonable estimate of dry matter intake, all other calculations may be an exercise in futility.

Use of DHI Records

A resource which contains a lot of useful information for both herd management and problem solving situation is the DHI records which are available. Some of the key areas of use on these records are:

1. Herd Summary and Management Report

   - Calving interval, days dry, s/c
   - Cows leaving the herd
   - Calving schedule
   - Feeding index and rate of roughage feeding
   - Concentrates fed, roughages consumed
   - Age of first calf heifers at calving

2. Concentrates indicated action sheets

   - How do concentrates fed and concentrates indicated compare?

3. Herd Summary

   - What has the progress been over time?
   - Changes in concentrates fed?

4. Dairy Herd Profile

   - Cows leaving herd, how many?, what reasons?
   - Length of dry periods
   - Peak production
   - % sample day production drop
   - Fresh cow persistency and production analysis

5. Sample Day Milk Weights Report

- When do cows peak?
- Any differences between older cows and first calf heifers?
- Persistency?
- Use this data to plot some lactation curves

It is essential that accurate input data is used to develop these reports. Unless you have confidence that the input data is correct, the value of the above reports is questionable.

Specific Troubleshooting Tips

There are a number of problems which may be related to nutrition. The questions for each situation may be somewhat different. The following is a list of some of the common problems and some key items to look for in the evaluation of each.

Problem	Items for Special Attention
Low feed intake	Too much grain (>60% of DM)
	Too little forage (<40% of DM)
	Poorly fermented silages
	High levels of NPN or soluble-N
	Limited water intake
	Dirty feedbunks
	Finely chopped forages
	Reduced cud chewing and rumination activity
	Ration imbalances
	Mineral deficiencies or excesses
	Inadequate feedbunk space
	Moldy feeds
	Overconditioned cows
	Toxic weeks
Low milk production	Not peaking properly
	Low persistency
	High incidence of mastitis
	Underfeeding grain to fresh cows
	Overconditioned cows
	Nutrient deficiency or imbalance (especially protein and energy)
	Sequence and frequency of feeding

Low milk fat test	Forage:grain ratio Finely chopped forages Total fiber intake Depressed rumen activity Too much grain Fine or pelleted feeds Protein or sulfur deficiency Thin cows Fat cows High qaulity alfalfa High somatic cell count
Ketosis	Overconditioned dry cows Low fiber ration Post-calving stress Limited grain in early lactation Too much grain for fresh cows Poorly fermented silages Protein or sulfur deficiency Sequence and frequency of feeding Rapid ration changes Depressed feed intake
Displaced abomasums	Overconditioned dry cows Rapid ration changes Lack of exercise Too little forage Finely chopped forages Ketosis Milk fever Depressed feed intake
Milk fever (and downer cows)	Too much calcium and/or phosphorous during the dry period Too little calcium and/or phosphorous during the dry period Low magnesium intake High potassium rations Narrow Ca:P ratio (1.5:1) Overconditioned cows Alkaline rumen pH (↓ cation absorption) Potassium deficiency Depressed feed intake

Table 1. Relationship of peak milk production on expected herd average[a]

Expected Herd Average (lbs)	Peak Milk Production: 1st Lactation cows (lbs)	Older cows (lbs)	Difference (lbs)
8,000	21.7	37.7	16.0
10,000	30.6	46.9	16.3
12,000	40.0	56.2	16.2
14,000	49.4	65.4	16.0
16,000	58.7	74.7	16.0
18,000	68.1	84.0	15.9
20,000	77.5	93.2	15.7

[a]Hutjens and Clark, 1980.

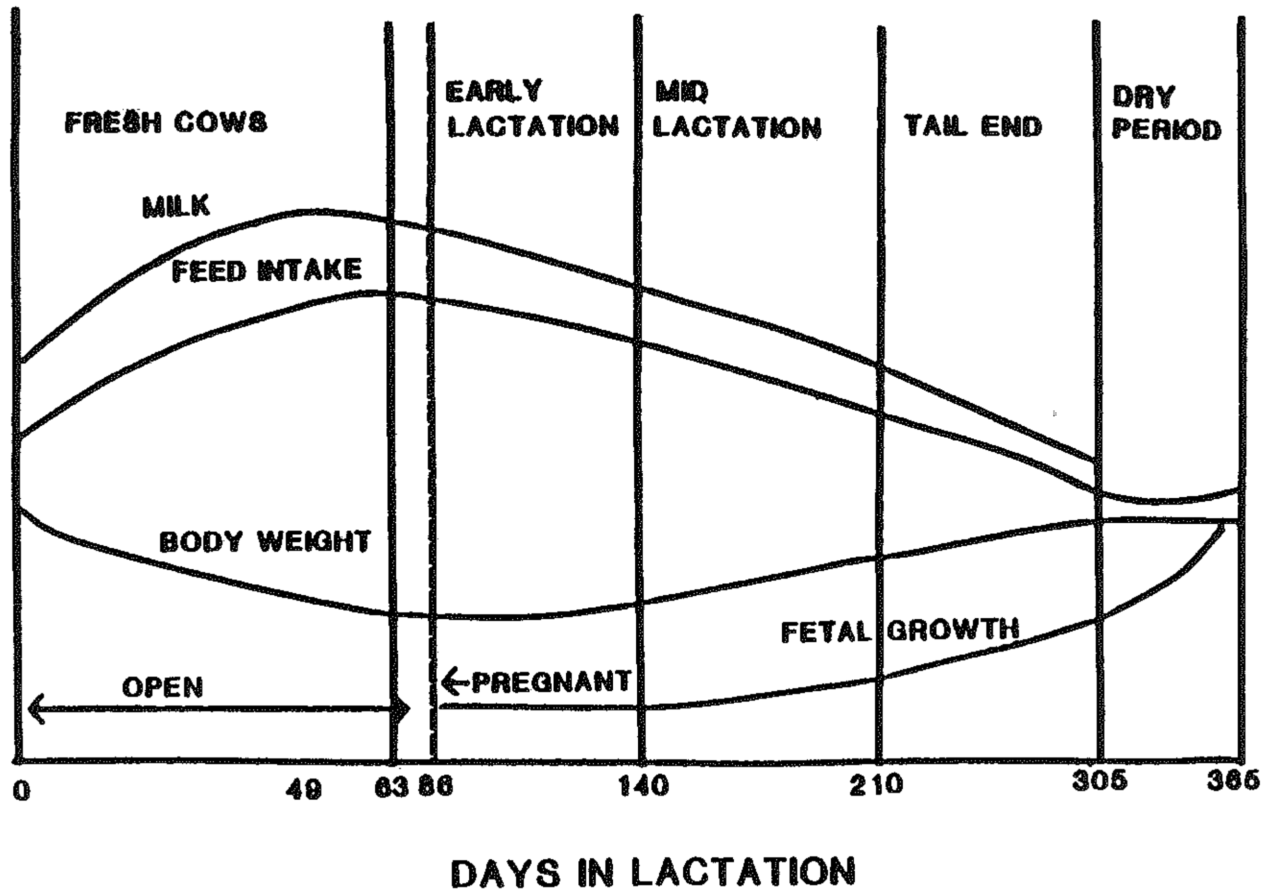
Table 2. Expected maximum daily dry matter intake

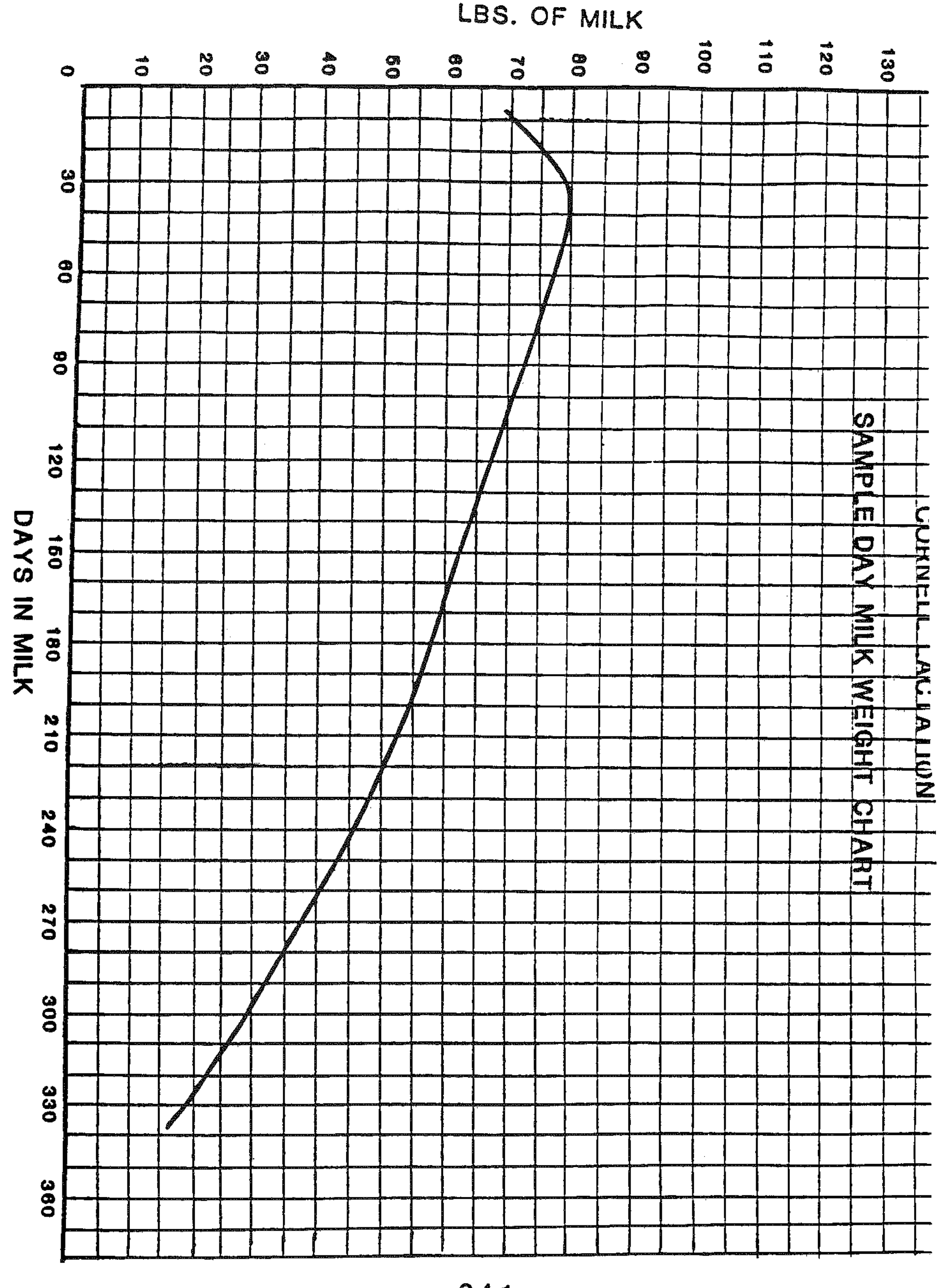
Body weight (lbs)	900	1100	1300	1500	1700
	Dry matter intake, % of body weight				
FCM[a] (lbs)					
20	2.5	2.4	2.3	2.2	2.2
30	2.9	2.7	2.6	2.5	2.4
40	3.2	3.0	2.8	2.7	2.6
50	3.5	3.2	3.0	2.9	2.7
60	3.9	3.5	3.3	3.1	2.9
70	4.2	3.8	3.5	3.3	3.1
80	4.6*	4.1	3.7	3.5	3.3
90	4.9*	4.3*	4.0	3.7	3.5
100	5.2*	4.6*	4.2	3.9	3.6
	Dry matter intake, lbs per day				
FCM (lbs)					
20	22.7	26.5	30.2	33.9	37.6
30	25.8	29.5	33.2	36.9	40.6
40	28.9	32.5	36.3	40.0	43.7
50	31.9	35.6	39.3	43.0	46.7
60	35.0	38.7	42.4	46.0	49.7
70	38.0	41.7	45.4	49.1	52.8
80	41.1*	44.8	48.5	52.2	55.8
90	44.1*	47.8	51.5	55.2	58.9
100	47.2*	50.9	54.5	58.3	62.0

[a] 4% fat corrected milk.

*May be higher than is normally achieved.

FIGURE 1. NUTRITION-REPRODUCTION CYCLE




CORNELL LACTATION
SAMPLE DAY MILK WEIGHT CHART
LBS. OF MILK
0
10
20
30
40
50
60
70
80
90
100
110
120
130
DAYS IN MILK
30
60
90
120
150
180
210
240
270
300
330
360

DAILY FEEDING AND ACTIVITY SCHEDULE

TIME		WHAT	FEED (#)	% DM	# DM	# REFUSED	# DM REFUSED
A.M.	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
NOON	12						
P.M.	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
MIDNT	12						
A.M.	1						
	2						
TOTAL			____		DM FED		DM REFUSED

DAILY FEEDING MANAGEMENT STRATEGIES

R. Clinton Young
Extension Specialist

There are any number of activities that need to take place every day in order for the feeding management on the dairy farm to reach and maintain an optimum level. Not only should they take place on a regular basis, but in most cases, in a given order to maximize their effectiveness. Each farm will have their own specific list of activities but, in all likelihood, there will be many similar activities on virtually every dairy farm.

The easiest way to establish this list and the times to perform the activities is to sit down and write all the different things that are done and when they are done, to manage the feeding program on your farm. Then look at the items and times you have listed and see if they are in an effective and logical order. Conferring with the person who works with your feeding program might help refine the list into a more logical order from a feeding standpoint, as your main concern might be utilizing labor effectively or simply doing things because of habit.

While not intended to be a complete list, and certainly not the only activity list to be monitored on a daily basis, the following items will relate to many dairy farms milking herd.

<u>Animal Input</u>

---check mangers and/or feed bunks for feedstuffs left

---sweep or clean mangers and/or feed bunks

---check and clean waterers

---check lighting

---inspect all feedstuff conveying and weighing equipment

---check roller mill settings if feeding HMC

---check ventilation

---check stall and/or stanchion area

---feed cows(each time some part of the feedstuffs are fed

--forage

--grain

--minerals

--additives

--total mixed ration

---check mixing times on TMR's

Feeds

---check feedstuff quality (mold, change in type, etc.)

---check forage particle size

Animal Output

---check and record number of cows fed

---check and record amounts of feedstuffs fed

---check automatic feeder operation

---check manure condition

---check and record daily milk production

---check and record number of cows milked

---check and record number of cows in tank

****
RECORD AND INITIAL ALL JOBS PERFORMED
****

Other activities that may or may not be done on a daily basis could include:

Feeds

---updating inventories of feedstuffs

---checking feedstuff moisture content

---checking densities of feedstuffs fed through volumetric feeders

---order supplements at appropriate times

Animal Outputs

---checking body condition scores

---monitoring milk composition (fat, protein, NPN, if available)

Animal Inputs

---make necessary grouping changes

---checking ration nutritional balance

This type of feeding management should be extended to the heifers and calves on the farm as well.

After listing feeding management activities, answer these questions.

1-Are you sure of feedstuff dry matter percentages?

2-Are you sure "as fed" amounts are correct based on #1?

3-Are you sure that is what is being fed?

4-Are the cows cleaning up what is being fed?

5-Could they consume more than is fed?

6-If a TMR is not fed, are protein and energy sources of feedstuffs fed in sequence to compliment each other?

7-Are you sure the feedstuffs fed are what you have analysis for?

8-Is the ration balanced for the nutritional requirements of the group?

Once the list is complete for the farm:

1-It should be made clear (preferably in writing) who is responsible for each activity.

2-The list should then be posted in a specific place.

3-The times each activity is performed should be recorded from the earliest to the latest in the day.

4-It should be initialed by the person completing the job each time the it is done.

How to

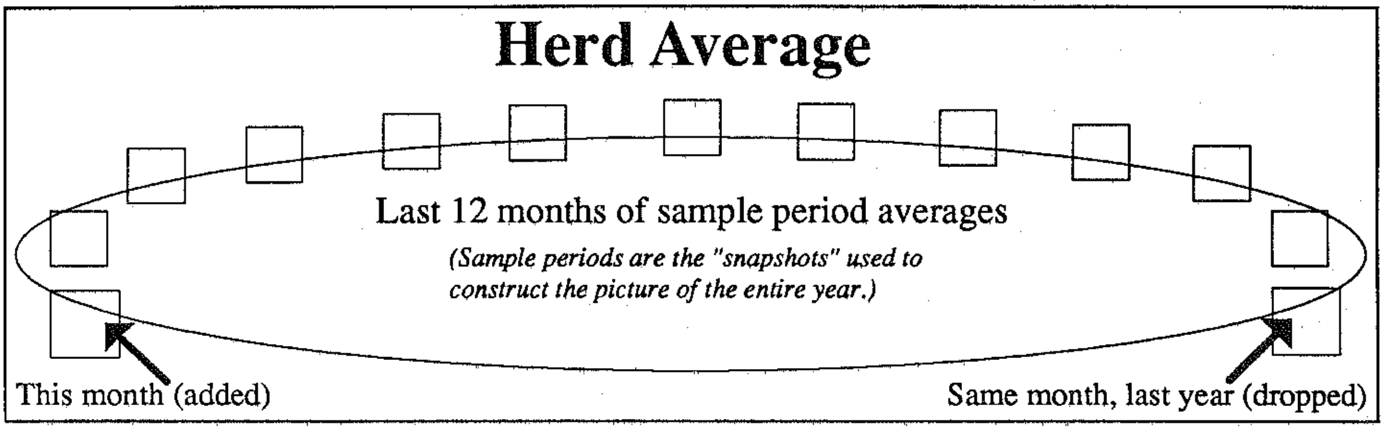
Increase your Rolling Herd Average

Dairy Herd Improvement Series DHI #119B 5/89

A higher herd average does not guarantee greater herd profitability, but it does increase the likelihood.

Summary
There is no better number to describe a herd's productivity than the DHI Rolling Herd Average (RHA.) It is the average pounds of milk produced for each day a cow was in the herd for the last year (including dry days) multiplied by 365 days.

You cannot change the RHA directly. You can manage factors that influence it. RHA is changed by managing the numbers that build it.



The herd yearly average changes as the new month's sample period average is included and the average from the same month last year "rolls off."

To increase your herd average:

- Increase the time cows are milking vs. not milking. (Increase the % days in milk.)
- Increase the pounds of milk the average cow gives each day she is milked.

1. Optimize percent days in milk three ways:

A. ***Maintain calving interval*** at 12-13 months and keep the days dry the same. The longer the interval between calvings, the more time the animal is milking vs. dry. Caution: If the lactation gets too long, the daily average milk production will start to suffer and you will begin reducing your herd average.

B. ***Reduce your days dry.*** The less time cows are making zero pounds of milk a day, the higher your herd average will be. Caution: If first lactation animals are dry less than 55 days and second+ lactation animals are dry less than 45 days, milk production in the next lactation will probably be reduced enough to hurt your herd average.

C. ***Increase your culling rate.*** If you cull animals going dry and bring in heifers ready to freshen, your percent days in milk will increase because of fewer days dry for the herd.
Caution: Too many first lactation replacements will lower your milk cow average enough to offset gains made by a higher percent days in milk. 30-40% culling rate is a safe range to work in. To improve your herd, you need to bring in heifers that are superior to the culls.

2. The **second way** to increase your yearly herd average is to increase the daily milk yield of the milking cows. For more on that, see How to Increase your Milk Cow Average Milk.

How do you figure annual average milking cow average milk?

Herd Average/% days in milk x 365

If your herd average is 16,000 lbs. with 85% days in milk, what is the average daily milk for cows while they are milking?

85% x 365 = 310 days milking for the average cow. 16,000 lbs./310 days milking = 51.6 lbs. per day milking.

The DHI **Herd Summary and Management Report** is the foundation for evaluating and monitoring your Herd Average as you work to increase it.

For the last 365 days, this herd accumulated 22,737 cow days, 1,252,953 lbs. of milk and 46,869 lbs. of fat.

Herd Summary and Management Report

DESCRIPTION		SAMPLE DAY AVERAGE OF MILKING COWS	DAILY AVERAGE PER COW THIS PERIOD	YEARLY HERD TOTALS	YEARLY HERD AVERAGES	
					THIS HERD	BREED
				DAYS ON TEST		
COWS		47	58	22,737	62.3	78.0
PERCENT DAYS	IN MILK		86		87	86
	3X					56
MILK POUNDS		72.2	58.6	1,252,953	20,115	16,590
MILKFAT	TEST	3.4	3.5	3.7	3.7	3.6
	POUNDS	2.45	2.06	46,869	752	605
PROTEIN	TEST	3.2	3.2	3.3	3.3	3.2
	POUNDS	2.34	1.88	41,371	664	532

Averages for cows milking this sample day. ie. 47 cows were milking this sample day and they averaged 72.2 pounds of 3.4% fat milk.

Averages for this sample period. ie. this herd averaged 58 cows for the month. 86% of the cow days this month were in milk. These 58 cows averaged 58.6 pounds of milk per cow day.

Herd averages for the last 365 days. Note: You can calculate from the totals. ie. 1,252,953 pounds milk/ 22,737 cow days = 55.11 pounds milk per cow day. 55.11 x 365 days = 20,115 pounds per cow year!

Sample Period Average Formula:

Lbs. of milk per milking cow for the month X **Percent days in milk (% cows milking)** = **Sample Period Average**

Factors influencing lbs. milk:

Lbs. Peak Milk
1 lb equals 220+ lbs. for the lactation

Persistency
Keep a "normal" lactation curve, maintain about 90% persistency.

Culling
Cull lower producers & replace with higher producers.

Average Days in Milk
Seasonality & calving interval effect

Udder Health
Herd average linear score below 3.4?

Factors influencing % days in milk:

Average Days Dry
Keep short. First lactation - need 55 days. Second + lactations - need 45 days.

Calving Interval
12-13 months.

Cull Rate (%New)
30-40% normal range

Percent Days in Milk and How it Changes

Variable	Approximate Change	Normal Range
Days Dry	5 days dry = 1% DIM	55-60 days
Calving Interval	1 month = 1% DIM	12-13 months
Cull Rate (% New)	15% new = 1% DIM	30-40%

Milk Cow Milk and % Days in Milk

Milking Cow Daily Average	% Days in Milk	All Cow Average		Rolling Herd Average Milk
55 lbs.	80%	44 lbs.	x 365	16,060 lbs.
55 lbs.	85%	46.8 lbs.	x 365	17,082 lbs.
55 lbs.	90%	49.5	x 365	18,068 lbs.

More from the Herd Summary and Management Report

Based on reported breedings these are the animals expected to calve.

YEARLY MANAGEMENT FACTORS

	NUMBER OF ANIMALS EXPECTED TO CALVE									
HEIFERS		3	1	7	2			1		
MONTH	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
COWS		6	4	3	6	3	2	4	3	12

Based on projected calving interval on all cows with fresh date and last bred date.

Average days dry last lactation for animals currently milking.

services divided by # cows confirmed pregnant and/or at least 60 days since last bred.

YEARLY MANAGEMENT FACTORS

PROJECTED MINIMUM CALVING INTERVAL	AVERAGE DAYS DRY	NUMBER BREEDINGS PER CONCEPTION	NO. OF COWS NOT BRED AFTER 80 DAYS	AVERAGE DAYS IN MILK 1ST SERVICE	AVERAGE DAYS IN MILK LAST SERVICE
13.8	61	2.8	3	89	141

17 first calf heifers and 2 others entered the herd this year representing 30% of this herd.

YEARLY MANAGEMENT FACTORS

COWS ENTERING HERD			COWS LEAVING HERD		
FIRST CALF	OTHER	PERCENT	DAIRY	OTHER	PERCENT OTHER
17	2	30	8	15	24

8 animals left the herd for dairy purposes and 15 (representing 24% of the herd) for other reasons.

In the last 365 days, this herd had 12 tests. If the herd was sampled one day sooner this year than last year, we call it 13 tests in 365 days.

YEARLY PERIOD

BREED OF HERD	NO. OF TESTS		MO.	DAY	YR.	NUMBER OF DAYS	NUMBER OF WORKERS	1000 LBS. OF MILK PER WORKER	$100 RETURN PER WORKER
		FROM	8	27	87				
3	12	THRU	8	25	88	365	3.0	418	322

Average ages and body weights as of the animals' last freshening.

SAMPLE DAY MANAGEMENT FACTORS

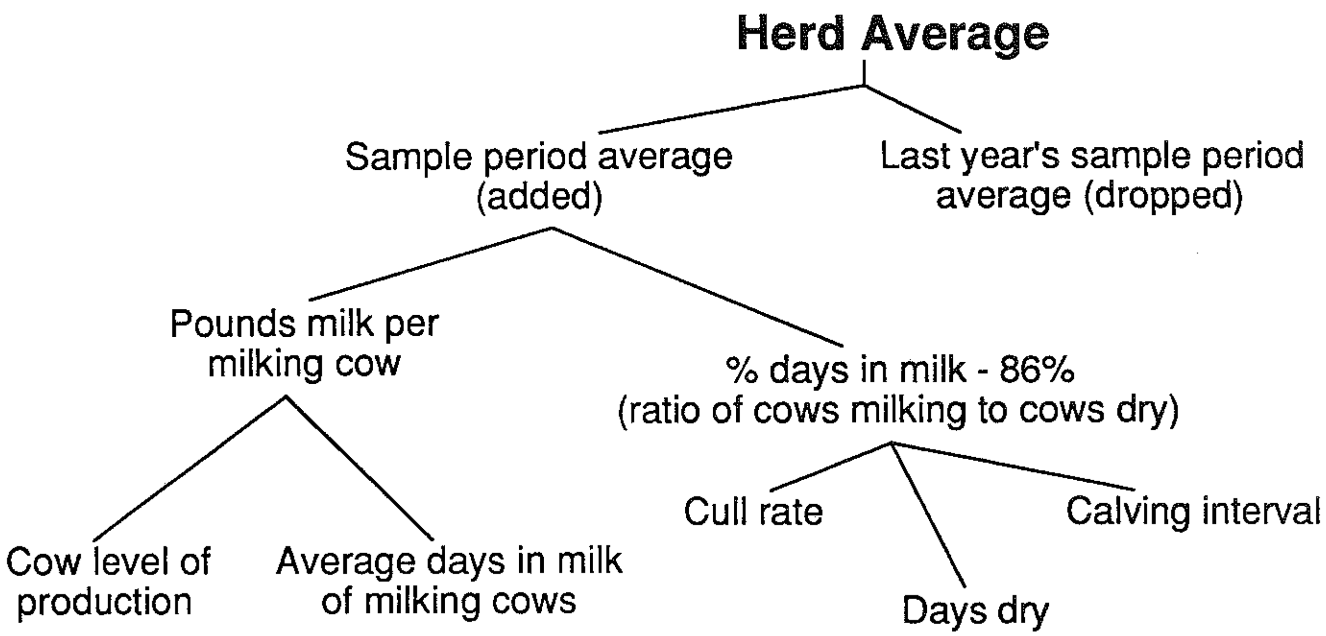
AVERAGE AGE		AVERAGE BODY WEIGHT		NO. OF COWS IN HERD WITHOUT REGISTRATION OR EARTAG NUMBER FOR	
1st CALF	ALL	1st CALF	ALL	SIRE	DAM
29	53	1280	1410		

SAMPLE DAY MANAGEMENT FACTORS

TOTAL COW MILK WEIGHTS SAMPLE DAY LBS.	TOTAL MILK SOLD PER DAY LBS.	PROD. PER DAY OF LIFE THIS HERD	PROD. PER DAY OF LIFE BREED	AVG DAYS IN MILK
		26.0	19.2	182
		TANK TEST MILKFAT	TANK TEST PROTEIN	SOMATIC
3392	3132	3.4	3.2	218

Average days in milk of the milking cows. As this goes down, expect pounds of milk per milking cow to go up.

Another picture of the Herd Average



Sort out which variables are currently making your herd average change.

The herd average is built from the year's Sample Period Averages. It changes as a result of the difference between the Sample Period Average added (the current month), and the Sample Period Average dropped (last year's corresponding month). If the period added is higher than the one dropped, the herd average will go up and vice versa.

Like the Yearly Herd Average, the sample period average is made up of the milk cow average pounds of milk and the % days in milk. If the milk cow average for the entire sample period is 60 pounds, but the % days in milk is 80%, the sample period average will be 80% of 60, or 48 pounds.

Sample date	Sample period milk	% days in milk	Avg. days in milk	Milking cow milk	% Fat	Rolling herd avg.	
08-25-88	58.6	86	182	72.2	3.4	20115	(now) added
07-26-88	56.7	84	194	64.3	3.6	20020	
06-22-88	59.4	84	193	72.2	3.6	19911	
05-24-88	59.7	88	192	68.5	3.6	19743	
04-21-88	57.0	86	177	66.7	3.8	19509	
03-23-88	54.8	86	184	65.8	3.8	19319	
08-25-87	55.3	88	136	61.9	3.8	18641	(last year) dropped

Finding out where production gains or losses originate

In the example on the previous page, the Herd Average went up from 20,020 last month to 20,115 this month. It is also above last year's August Herd Average of 18,641. The added Sample Period Milk (58.6) is higher than the dropped (55.3.)

1. The first place to look is % Days in Milk. This month, 2% less of the cow days are in milk than there were last year.

2. Next look at milk cow milk -- 72.2 lbs vs. 61.9 lbs last year.

This herd average is going up is because the cows are milking at higher level. The only other thing to determine is if those cows are milking more because they are fresher or because they have increased production.

3) The herd was fresher last year than now -- 136 vs. 182 days in milk -- so the increase must be from increased production.

The milk cow average milk changes based on the average days in milk and the herd "level" of production. The level of production is set by the pounds of milk on the cows' second sample day (peak milk) and the rate at which the production declines after peak (persistency.)

At any given level of production, daily milk will decline as the lactation progresses and average days in milk increases.

Management Milk

Milk gained from improvements in management verses the herd being fresher could be called management milk.

In the example, the milk cow average last year was 61.9 at 136 days in milk. This month it is 72.2 at 182 days in milk. The milk cow average is up, and we know it is not because the herd is "fresher." How much of the increase represents a gain in production?

136 days
- 182 days
-46 days x .15 pounds per day = 6.9 pounds approximate *loss* from the herd being less fresh.

It is not possible to precisely calculate how much the average pounds of milk should change as the average days in milk changes, but .15 pounds of milk per 1 day change in average days in milk is a good estimate.

The total gain was
72.2 lbs
- 61.9 lbs
10.3 lbs. 10.3 + 6.9 = 17.2 lbs

About 6.9 pounds loss in production can be expected from the herd being less fresh. The total gain in production is 10.3 pounds To gain this much *and* offset the loss from the herd being less fresh, production potential per cow per day must have increased 17.2 pounds over last year.

The herd average in our example herd went up this month because of an increase in productivity over last years' November test. That increase in productivity came from the cows producing at a higher level.

In the example we now know why the herd average went up. How did it change from last month? Did the herd gain that production last month or in a previous month?

Last month, the milk cows averaged 56.4 pounds at 194 days in milk. That's an increase of 2.2 pounds and a decrease of 12 days in milk.

About 12 x .15 = 1.8 lbs. of the gain was from the herd being fresher, and the rest (.4 pounds) must be a production level gain made through management improvement.

Changes in fat % will offset some changes in pounds of milk. One tenth of a percent of fat is worth about 1 lb. of milk, depending on production level. To calculate the effect of fat change, correct the two milk weights used to 3.5% fat corrected milk.

3.5% FCM = [(lbs. milk x .432) + (lbs. fat x 16.22)] x lbs. milk

Did we just trade fat for milk?

August '88 3.5% fat corrected milk
= [72.2 x .432] + [16.22 x (.034 x 72.2)]
= 31.2 + 39.8
= 71.0 pounds 3.5% fat milk

August '87 3.5% fat corrected milk
= [61.9 x .423] + [16.22 x (.038 x 61.9)]
= 26.7 + 38.2
= 64.9 pounds 3.5% milk

In this case, the fat correction does not explain the entire increase in milk production. It does reduce the difference in milk from 10.3 to 6.1 pounds, making the total gain from increased production potential 13 pounds instead of 17.2 pounds.

Actions

1. Compare your current Herd Summary Yearly Average Factors to target ranges:

Factor	Target	Mine
% Days in Milk	87 - 89%	____________
Calving Interval	12 - 13 mo.	____________
Days Dry	50 - 60 days	____________
% New Animals	30 - 40%	____________

2. Use the analysis outlined on page 6 to identify precisely why your herd average is changing the way it is.

3. Go to other parts of this series to lay out a plan for working on your key areas.

LACTATION CURVES - A DIAGNOSTIC TOOL IN DAIRY HERD MANAGEMENT

L. E. Chase

One method of monitoring milk production in a dairy herd is the use of lactation curves and persistancy analysis. This tool provides a graphic means of evaluating performance.

Figures 1, 2 and 3 are average lactation curves developed from about 470,000 DHI cow records. Cows were divided into 3 production levels based upon the average milk production of the herd. In addition, lactation curves were derived for cows in 3 lactation groups. This work was done by Jeff Keown while he was at Cornell.

In looking at these average curves, some key points are evident:

1. Higher producing cows have a higher peak milk production.
2. All cows produce less each day after peak.
3. The decline is similar for all levels of production within a lactation group.
4. First-lactation cows are more persistant than older cows.
5. Cows normally peak at about the second sample day.

The lactation curve provides a representation of both the genetic capability of the cow and the level of feeding and management. Thus, the plotting of lactation curves can be one tool used in monitoring herd performance. Lactation curves for your herd can be plotted using information from either the Sample Day Milk Weight Report or using the Remote Management System.

Peak Milk Yield

Peak milk yield is one index of the potential production and profit picture in the herd. Previous work has indicated that each additional pound of milk attained at peak is equivalant to an additional 200 to 220 pounds of milk for the full lactation.

One potential use of lactation curves is to compare peak milk production with total lactation yield. If a cow has a normally shaped lactation curve, there will be a high correlation between peak milk and total lactation yield. Table 1 contains information relating these two factors for cows by lactation groups.

Persistency of Milk Production

The evaluation of persistency of milk production throughout lactation is another use of lactation curves. This can be done by comparing the lactation curves in your herd with those in Figures 1, 2 and 3. This will permit a quick, visual appraisal of the rate of change of milk production over time. Another way is to calculate the actual persistency on a monthly basis. This can be done as follows:

December milk production = 73 pounds
November " " = 79 pounds
Persistency = (73 - 79) x 100 = 92.4%

Table 2 contains average persistency values for cows on DHI in the Northeast. Persistency analysis can be done using RMS or from the Sample Day Milk Weight Report.

Analysis of Lactation Curves and Persistency

Once you have plotted the lactation curves and done a persistency analysis, it is possible to examine the performance in your herd. Some of the questions to ask are:

1. Do the cows in your herd have distinct milk production peaks?
2. At which test period do the peaks occur?
3. Are first-calf heifers peaking within 15-20 pounds of the older cows?
4. How does persistency compare with the curves in Figures 1, 2 and 3 and Table 2?
5. Are persistencies similar for cows in different lactations?
6. Do peak milk and total lactation milk yield correspond? (Use Table 1).

By using the above questions you can determine the status of your herd. If peak milk or persistency reveal some differences from expected, then additional analysis will be required to define the reason and develop a plan to correct the problem.

Management Factors Affecting Lactation Curves

There are a large number of environmental and management factors which can influence either peak milk yield or the persistency of milk production in your herd. Some of the more common ones are listed below.

1. Dry matter intake - The level of dry matter intake is a key factor in determining the total nutrient intake which will be available to support milk production. Maximizing dry matter intake not only enhances milk production but may also lower feed costs per unit of milk produced. A second factor is enticing early lactation cows to achieve maximum feed intake earlier. This minimizes negative energy balance and should provide more opportunity for optimizing peak milk production.

2. Energy intake - The amount of energy consumed is a key to attaining high levels of milk production. However, feeding higher levels of grain to achieve an increased energy intake is not always the answer. If excess grain is fed, alterations in rumen fermentation may occur and feed intake may be depressed.

3. Ration fiber level - This factor is directly related to concentrate and energy intake. Enough coarse fiber must be included in the daily ration to permit 8-10 hours per day of chewing and rumination time. As a minimum, early lactation cows should have rations

containing 17-18% ADF. If fiber levels are too high, intake and production will be depressed.

4. Protein type and level - Inadequate protein intake in early lactation can limit milk protein reserves. Protein intakes must be formulated on and measured by pounds of daily intake <u>not</u> percent protein in the ration. The types of proteins in terms of solubilities and degradabilities must also be considered. This is most critical for early lactation cows. Rations which are either too high or too low in solubility and degradability can depress milk production.

5. Feeding management - The manner in which balanced rations are fed can affect the level of milk production attained. The key concept is to provide feed inputs in a manner to even out rumen fermentation. Feeding more frequently assists by decreasing the amount of feed entering the rumen at any time. The sequence of feeding also has an impact on performance. Strive to feed some forage before grain and an energy source before a protein source. Improper feeding management practices can decrease daily dry matter intake and lower the efficiency of nutrient utilization.

6. Feed additives - In some situations, feed additives such as buffers, fat or niacin may be beneficial. The accompanying paper on feed additives contains more specific information.

7. Ration dry matter content - There are good indications that wet, acid rations may lower feed intake and potentially milk production. The factors which are responsible for this phenomena seem to be nitrogenous compounds in the feed. Rations with less than 50-55% dry matter appear to be those in which intake is depressed.

8. Body condition - The body condition of a cow at calving has a relationship to both peak milk production and persistency. Cows which calve thin will be limited in peak production potential and may drop in milk faster than desired. Overconditioned cows may have a slightly depressed early lactation feed intake. Strive for the following body condition scores in your herd:

   Dry cows 3^+ to 4^-

   Early lactation 3^- to 3

   Mid-lactation 3

   Late lactation 3 (3^+ to 4^- at dry off)

9. Ration changes - Abrupt ration changes tend to upset rumen fermentation, depress feed intake and decrease milk production. In stanchion barns, try to increase or decrease grain in relatively small increments (1-2 pounds per cow per day). In free-stall herds, there are both nutritional and social factors involved when cows are moved between groups. Moving a number of cows at once rather than 1 or 2 cows can minimize the social impact. Avoiding

wide variations in forage type and the forage to grain ratio between groups can minimize the nutritional aspect. Try not to have a difference of more than 15 units of forage between groups. An example would be if the high group has a 50:50 F:C ratio then the receiving group should not exceed a 65:35 F:C ratio.

10. Mastitis - Mastitis can affect either peak milk or the persistency of production. Use somatic cells as one index of the status of the herd. Establish milking management procedures and treatment policies which minimize the mastitis incidence in the herd.

Summary

Lactation curves and persistency analysis can be a valuable tool in monitoring herd performance. Some of the management factors which influence these variables have been briefly mentioned. By using these management techniques, you will enhance your chances of attaining high peak milk production associated with a "normal" persistency of the lactation curve.

Table 1. Actual 305 Day Milk Production Based on Peak Milk Yield

Peak Production	Lactation 1	2	3
(lbs)	(lbs)		
35	8656	8317	8358
40	9845	9168	9291
45	11076	9971	10611
50	12196	11341	11347
55	13310	12381	12224
60	14439	13389	13230
65	15592	14561	14284
70	16630	15476	15358
75	17530	16437	16281
80	18355	17377	17230
85	19392	18324	18047
90	-	19178	19128
95	-	19938	20130
100	-	22033	22174

[a]J. Keown, Cornell University, 1984

[b]Third or greater lactation

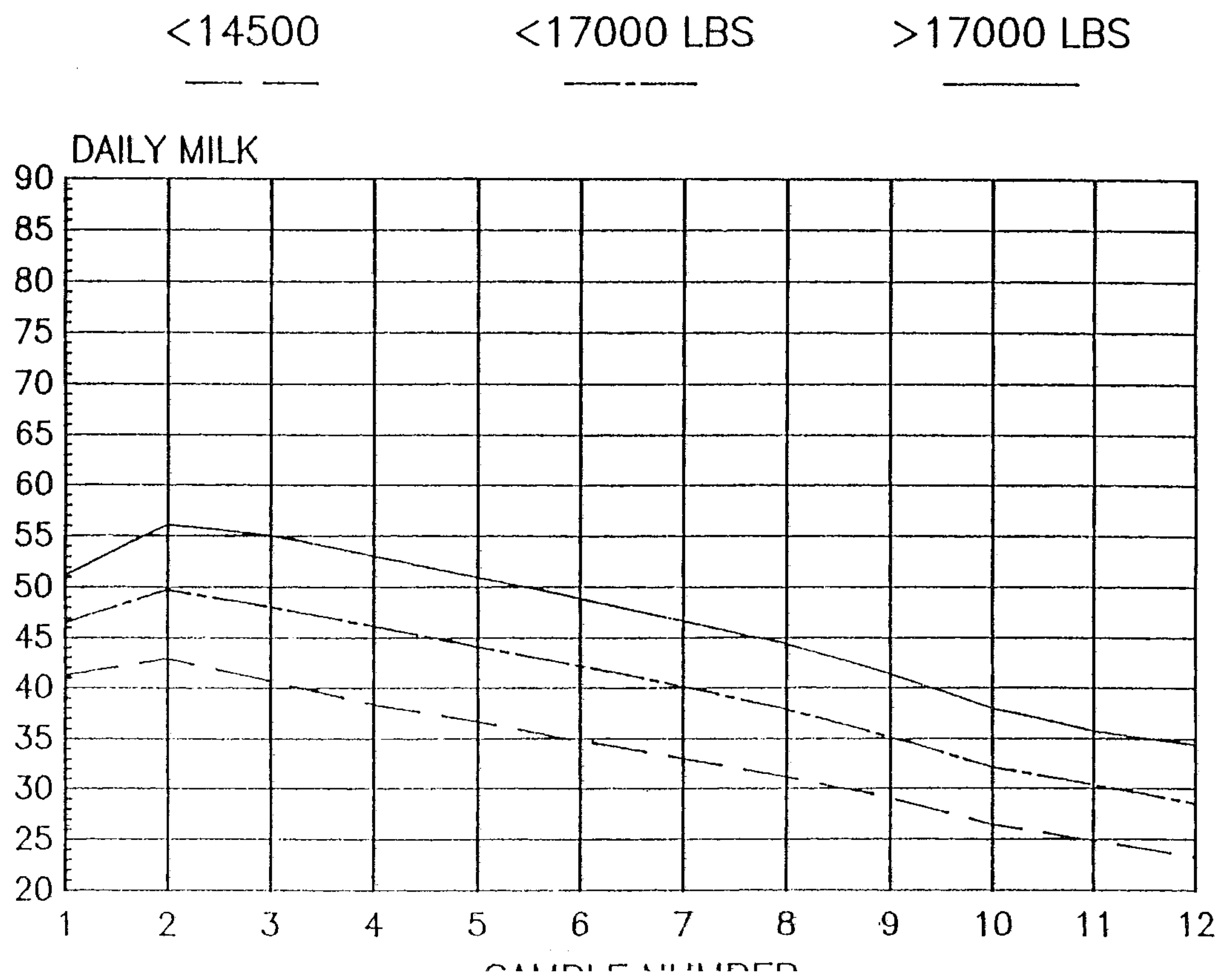
Table 2. Average persistency.

Sample Number	First Lactation	Second and Greater Lactation
1st to 2nd	106-109	103-107
2nd to 3rd	96-98	93-95
3rd to 4th	95-97	91-93
4th to 5th	95-97	91-93
6th to 7th	95-97	91-93
7th to 8th	93-95	89-91
8th to 9th	93-95	85-87
9th to 10th	91-93	85-87

[a]NYDHIC, 1985

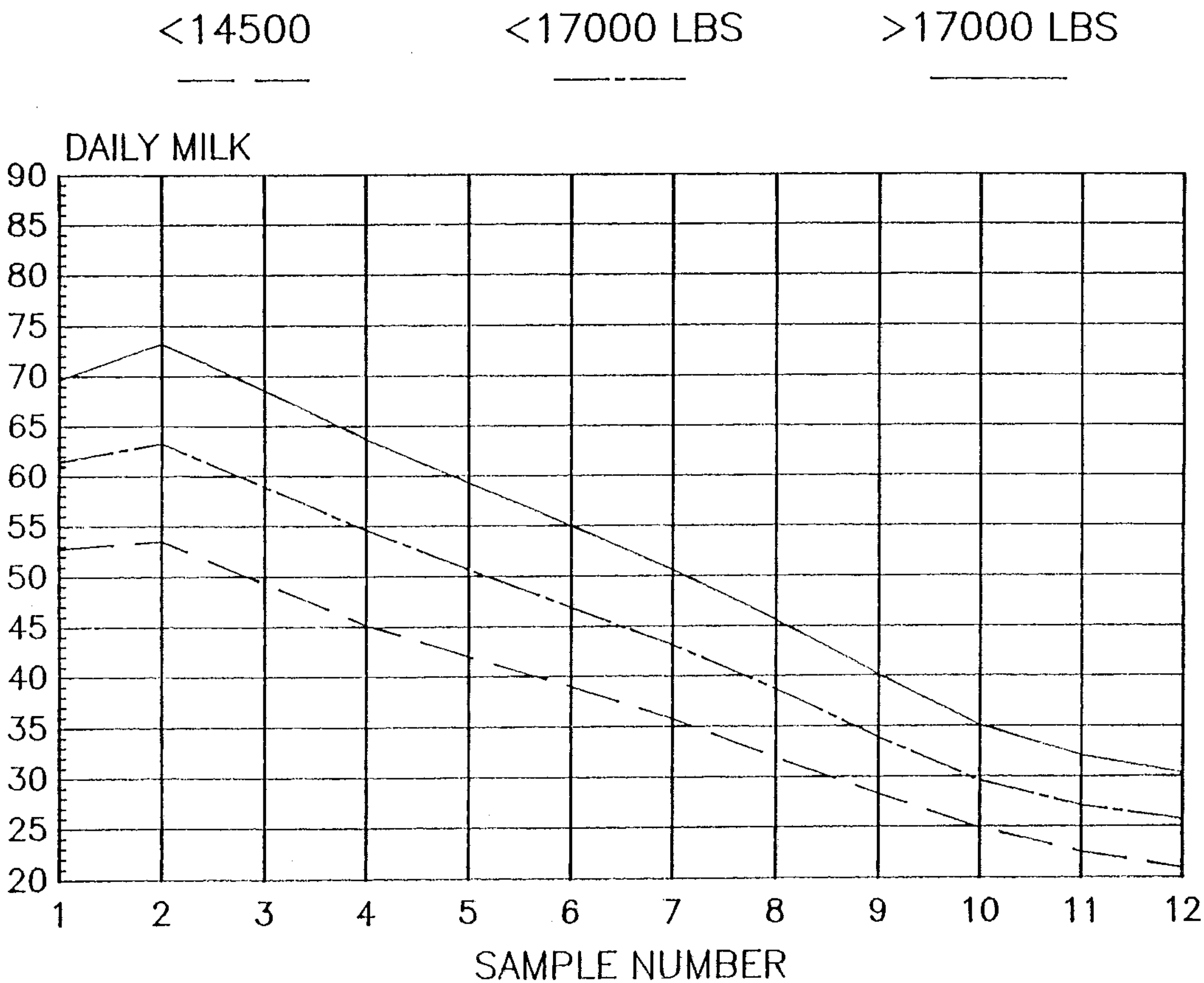
AVERAGE LACTATION CURVES

FIRST LACTATION



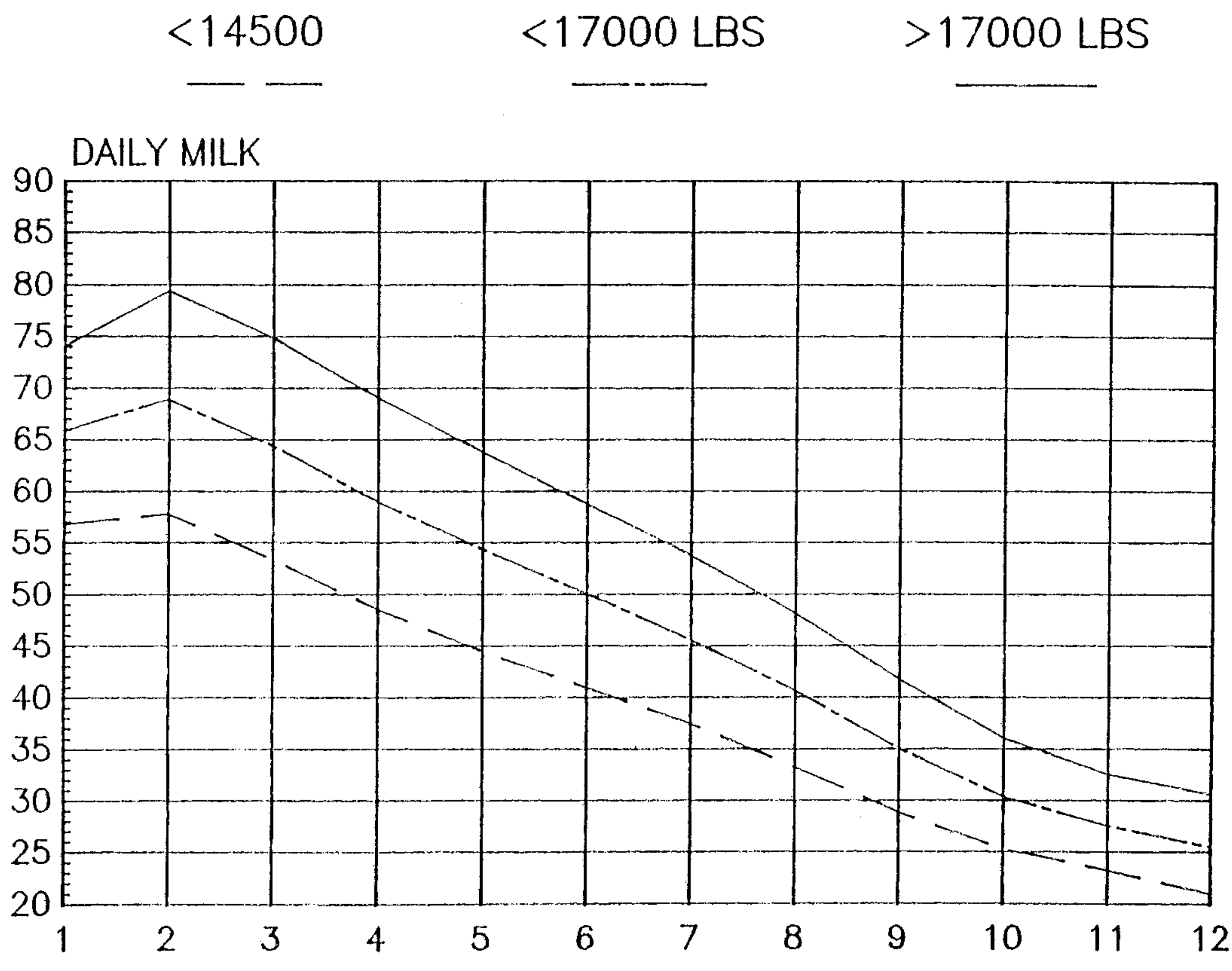
AVERAGE LACTATION CURVES

SECOND LACTATION



AVERAGE LACTATION CURVES

3RD AND GREATER LACTATIONS



How to
Reduce Herd Mastitis

Dairy Herd Improvement Series DHI #119 5/89

Goals:
- Increase milk production by improving herd udder health.
- Qualify for quality milk premiums.
- Reduce mastitis treatment costs.
- Make good cull decisions easier.

Use the DHI Somatic Cell Report to:

1. Determine if udder health is OK, better, or worse this month:
   - Overall
   - In the heifer program
   - During the dry period
   - In the milking environment

2. Manage the bulk tank count.

3. Decide what to do with cows with high somatic cell counts.

When is infection most likely to occur?

1. The first 2 weeks of the dry period is where the highest rate of infection occurs. The cow has stopped flushing out the alveoli, and milk accumulates in the udder for several days. Pressure builds and dilates the teat canal, making it easier for bacteria to enter. We stop managing the udder. Teats aren't dipped, housing is sometimes marginal. Teats should continue to be dipped for 4 or 5 days after milking is stopped.

2. At least 50 % of all new infections are accounted for between the first two weeks and the last week of the dry period. Pressure is building as milk accumulates, and bacteria can enter and stay in the udder. The last week before calving may be when heifers get infected if they freshen with a high count.

3. Early lactation is the third most likely time for infection to occur. Cows are stressed and teats are dilated.

4. Infection may be occurring long before clinical symptoms are visible.

5. Mid to late lactation is the least likely place for infection to occur. Marginal milking practices and/or equipment may raise the rate of infection during this stage of lactation.

The DHIA mastitis management program is based on measurements of somatic cells in milk. Somatic cell counts are your herd's udder health gauge.

Evaluate overall mastitis in the herd

Goal - find if a change in management methods is needed. If linear score is at an unacceptable level or is growing consistently, action must be taken.

• **Herd Average Linear Score**
The Herd Average LS (fig. 1) is the average of linear scores for the milking cows on that sample day. *The lower the better.* You clearly want a linear score of 3.6 or less. This is your first tip of the herd's udder health this month.

fig. 1

SAMPLE DATES	HERD AVG LS
8-25-88	3.3
7-26-88	3.2
6-22-88	2.6
5-24-88	3.2
4-21-88	2.9

• **Distribution of Cows by Linear Score**
The distribution of cows by linear score includes the number (NO) of animals in different linear score categories and the percentage (PCT) of the milking herd this number represents.

• **Estimated Infections (fig. 2)**
As the LS goes up, so does the likelihood of an animal being infected. If the LS is 4 or below, it's unlikely the animal is infected. If the LS is 5 or above, it's likely the animal is infected.

fig. 2

SAMPLE	ESTIMATED INFECTIONS			
	NEW		CHRONIC	
DATES	NO	PCT	NO	PCT
8-25-88	6	13	5	11
7-26-88	3	6	5	11
6-22-88	1	2	5	10
5-24-88	7	13	6	11
4-21-88	5	9	4	7

• **New infections (fig. 2)**
Animals who had linear scores less than 4 last month and just went over 5 this month. If more than 20 percent of the herd is newly infected or if there is a steady increase in new infections in the herd over the last few months, begin looking for specific problem areas in the management plan.

• **Chronic infections (fig. 2)**
Animals whose linear scores were 5 or greater last month <u>and</u> this month. This number will not likely change rapidly. Chronically infected animals are usually cured by culling them.

• **Milk Lost (fig. 3)**
A primary reason we use linear score is that it can be directly related to milk loss. We use that relationship to calcu-

late the potential lost for a herd on sample day. That loss is expressed as hundred weight of milk lost per 30 days for animals with linear scores over 2.

In the example at right, the herd lost 30 CWT in the last 30 days because of mastitis infections. If the milk price is $10.00 per CWT then the milk loss in dollars is 30 x $10.00 = $300.00.

fig. 3

SAMPLE DATES	100 LBS MILK LOST HERD/30 DAYS
8-25-88	30
7-26-88	25
6-22-88	18
5-24-88	28
4-21-88	25

Calculate your milk loss

CWT Lost per 30 days _____ x _____$/CWT = __________ dollars

Identify problem areas

Animals with high counts	Likely problem areas
Early lactation 1st lactation heifers	• Heifer program • Prep (Springer) program
Early lactation 2+ lactation animals	• Dry period • Prep management • Chronic mastitis
Later lactation Animals	• Milking herd environment • Chronic mastitis

(See also the diagram on the next page.)

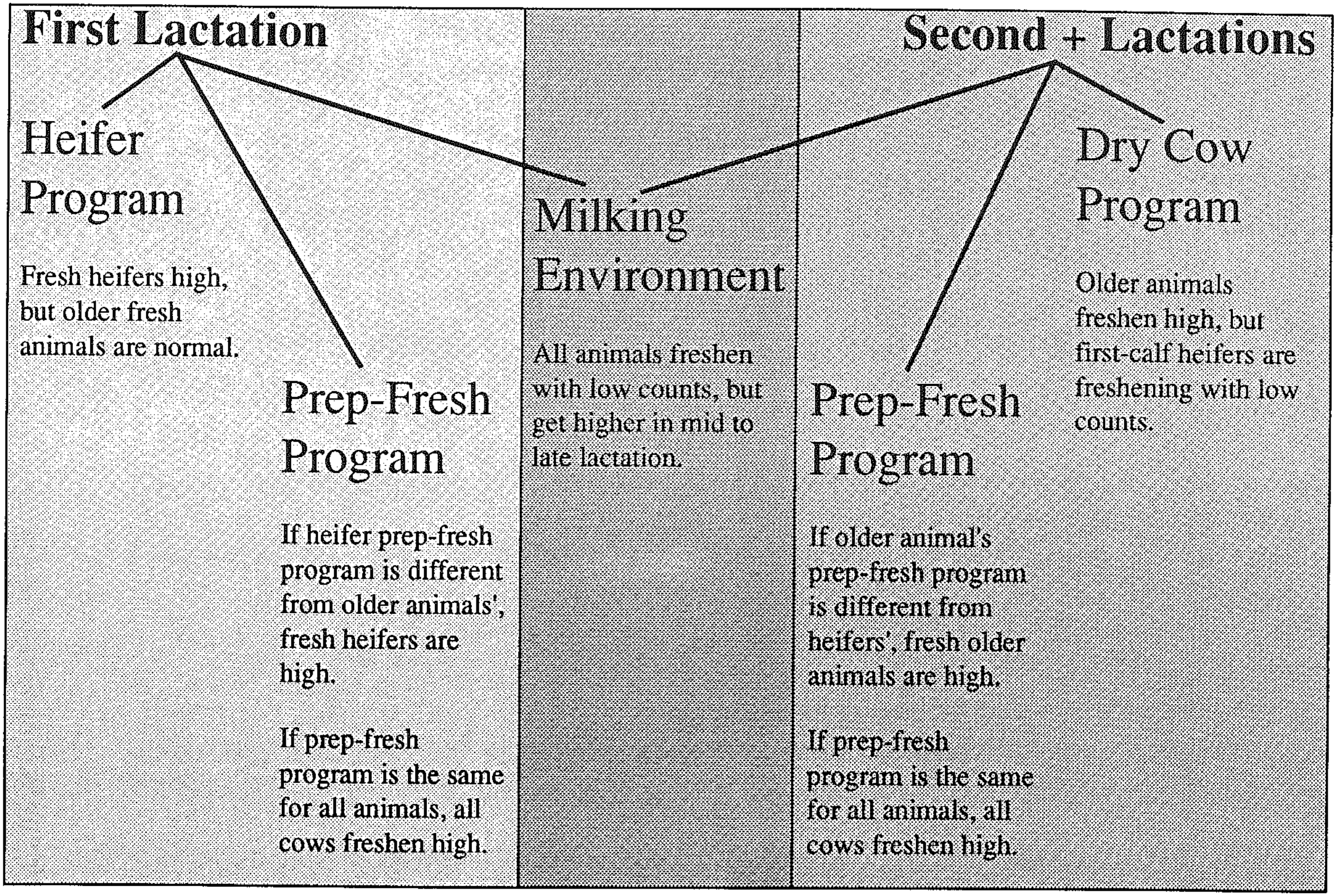
• Evaluate your heifer raising/springer program

Goal: Freshen heifers with a first sample day linear score of 2.5 or less. Determine the first month heifers begin freshening with infected udders.

The heifer enterprise should deliver healthy, ready to milk udders to the milking herd. If heifers are infected, begin looking for specific causes.

To evaluate how heifers' udders become infected, look at the somatic cell

Where Mastitis Begins



counts of early lactation heifers. These counts come from udders early enough in milk that it is not likely they were highly influenced by the milking environment.

fig. 4 LINEAR SCORE DISTRIBUTION BY LACTATION NUMBER AND STAGE
CURRENT SAMPLE

LAC NO.	- EARLY - NO COWS	LS AVG	LS 5+ PCT	- MID - NO COWS	LS AVG	LS 5+ PCT	- LATE - NO COWS	LS AVG	LS 5+ PCT	AVG LS
1	1	4.8	100	1	0.5	0	10	1.8	0	1.9
2	0	0.0	0	4	3.0	25	4	3.8	25	3.4
3+	7	3.2	14	9	4.3	56	11	3.8	18	3.8
AVG		3.4			3.6			3.0		3.3

Goals:
- Average linear scores of 2.5 or less.
- Less than 20 % with linear scores of 5 or greater.

The Linear Score Distribution by Lactation Number and Stage (fig. 4) shows 1 first lactation animal in early lactation (45 days fresh or less), with an average linear score of 4.8. This heifer is probably infected. Based on only 1 case, it is difficult to tell if the heifer program did it's job in bringing healthy udders to the milking herd this month.

How would we differentiate between a problem in the heifer program and the Prep to Freshen program? It may not be possible, but if heifers getting ready to freshen are managed with the older cows and the older cows freshen with low linear scores while the heifers freshen with high linear scores, you can bet the problem is not in prep manangement. If older animals and heifers are freshening with high linear scores, the problem may be the prep program or it may be two separate problems — heifer raising and dry cow management.

- **Evaluate the dry period this month**

Goal - Identify the first month the dry period infects udders so corrections can be made before enough animals are infected to increase the tank count.

In the linear score distribution (fig. 4) look at early lactation 2nd and 3+ lactation animals. These are the ones coming out of the dry period. They should have low scores — 3.5 or less linear score average and less than 20% with linear scores of 5 or more.

This month, this herd has 0 second lactation animals less than 45 days in milk averaging a 0 linear score with 0% likely infected. GREAT! There are 7 third and greater lactation animals with an average linear score of 3.2 and 14% likely infected. As a group of older animals, this is an acceptable number.

We can give the dry cow program a passing grade this month. No changes are called for.

- **Dry cow vs. prep problem**

A high score on recently fresh older animals might mean a dry period problem - but it might not. Suppose first lactation recently fresh animals were also high. Remember, they would not have been in the dry cow program. Check the facilities where you get cows ready to freshen.

- **Milking environment**

If linear scores are getting higher in later lactation animals, there is something wrong with the milking herd environment. Housing, milking routine, milking equipment, general sanitation, ect. should be checked.

Compare mid (46-180 days in milk) and late (181 and higher days in milk) lactation animals in the current month with the same groups for last month and the fresh cow groups. If mid and late lactation animals have higher linear scores than fresh cows this month and mid to late lactation animals last month, and their linear scores are always higher than 3.9, you can improve the milking environment.

It is true older animals and later lactation animals tend to have higher somatic cell counts. Those animals have had a greater chance of infection, just because they've been around longer. But, late lactation animals shouldn't run one full linear score higher than mid lactation animals, nor should third and greater lactation animals run one full point over second lactation animals.

The first step is to identify which cows are getting new infections and fix whatever is broken so more animals don't get infected. This is also known as fixing the fence. Besides fixing the fence, we obviously have to catch the animals that got out.

Determine actions for infected animals

Step one:
Is the animal newly infected (score got high this month) or chronically infected (score has been high)?

Step two: What's the score?

Is she:		
	More than 150 days open?	- one strike
	Still not confirmed pregnant?	- two strikes
	Below herd average projection?	- three strikes
	Infected all last lactation?	- four strikes
	Unpleasant to work with?	- five strikes
	Contributing 5% or more of the herd's somatic cells in the tank?	- six strikes

How many strikes it will take to get a cow on the cull truck will depend on just how many voluntary culls you get and how much competition there is in your barn for stalls.

The High Linear Score Cows list on the second page of the Somatic Cell Report (fig. 5) makes it easier to determine which actions are appropriate to consider.

From right to left this list includes:

COW CCN	Cow computer control number
BARN NAME	Cow barn name or number
LACT NO	Cow lactation number
DAYS IN MILK	Days since the cow calved
MILK LBS	Pounds of milk the cow gave last sample day
305 DAY ME MILK PROJECTED	Estimated amount of milk a cow would give if she were mature (6 years old) by the time she milked 305 days in this lactation. It is adjusted to 3.5 milk and for season of the year she freshened and is probably the best way to compare animals' production potential at any one given time.
DAYS SINCE LAST BRED	The number of days from the cow's last bred date to the current sample date. If the cow is pregnant, it is also her days carried calf.
CURR S D	Current sample day somatic cell linear score
LAST S D	Last sample day somatic cell linear score
CURR LACT AVG	Current lactation average linear score
LAST LACT AVG	Last lactation average linear score
PERCENT OF HERD SCC	Percent of the bulk tank somatic cell this animal would have contributed last sample day if all animals' milk was put in the tank.

The High Linear Score Cows list (fig. 5) will include all cows in the herd with a linear score of 4.0 or greater on the current sample day listed from low to high. Some possible actions for infected cows follow.

fig. 5 - High Linear Score Cows

COW CCN	BARN NAME	LACT. NO.	DAYS IN MILK	MILK LBS.	305 DAY ME MILK PROJ.	DAYS SINCE LAST BRED	LINEAR SCORES CURR S.D.	LAST S.D.	CURR. LACT. AVG	LAST LACT. AVG	PERCENT OF HERD SCC
505	BETH	3	45	57			7.7	3.6	5.7	5.6	15
405	JEN	7	117	64	18,720	2	7.7	3.3	5.0	3.1	17
416	SEGIS	7	243	35	15,607	103	6.9	5.3	4.4	3.5	5
530	GREY	2	75	82		10	6.5	6.1	5.6	2.9	10
417	RUBY	7	137	104	24,168	5	6.0	6.3	6.5	5.8	8
511	BONNY	3	49	86			5.4	3.9	4.7	3.5	5
457	GENIE	5	85	102		18	5.4	3.4	4.5	2.8	6
486	EILEEN	4	93	93	20,765	23	5.0	3.2	3.7	3.0	4
466	MAE	4	371	47		168	4.9	6.2	4.5	4.5	2
554	NANCY	1	35	54			4.8	NA	4.8	NA	2

- **Actions to consider**

Chronically infected (note: these animals do not typically heal and remain a source of infection for the rest of the herd)

- Cull
- Milk last
- Code not to breed, cull later
- Dry off early

Recently infected

- California Mastitis Test (CMT) - Is animal still infected or has her immune system spontaneously healed her?
- Consult veterinarian and culture
- Dry off early
- Cull
- Milk last

IMPORTANT - Treatment on the basis of somatic cell count alone has not been shown to be an ecomical management practice.

Review the list and information about each animal. JEN is likely having a clinical case of masitis. The current sample day LS of 7.7 is up significantly from the last sample day and the last lactation average. You would probably CMT, culture, and treat this animal.

The actions to take on RUBY are not as clear. This cow makes milk -- 104 pounds on the last sample day and a 305-day ME projection of 24,168. Yet she has a chronically high somatic cell count. She also had a little trouble breeding back this lactation. What would you do with an animal that is doing well, but clearly not reaching her full potential?

Manage your Tank SCC

Determine which animals to exclude from the tank to reduce your tank count. The Percent of Herd SCC column shows how much you can reduce your tank count if you exclude an animal. If the list says the cow contributes 5 % of the count, restrict her and the tank should score 5 % lower. To reduce the tank count 20%, just select animals whose percent totals 20.

Note: The actual percent will vary from day to day. The more consistently an animal has scored, the more likely their "percent contributed" is correct. An animal that was a 3.2 last lactation, has been a 3.3 this lactation and was a 3.1 last sample day but jumped to a 9.1 this sample day is not a good bet.

If a cow was high last lactation, this lactation to date, last sample day and this sample day, excluding her milk will probably lower the tank count.

The last section of the Somatic Cell Report, Individual Cow Linear Scores, serves primarily as reference. You may not even look at it each month, but it does have one unique use. As well as listing identification, days in milk (DIM), sample day pounds of milk and somatic cell history for this lactation, it shows current lactation 305 ME milk projected and last lactation 305 completed ME milk.

It's interesting to run down the two ME columns and look for animals that are projected for 2000 or more pounds less than they completed last lactation. It may pay to further investigate animals down more than you realized.

Summary

The somatic cell program can make you more profit by:

- helping you make more milk to sell by reducing mastitis.
- showing where cows get infected.
- detemining if management action is necessary.
- evaluating actions taken.

The somatic cell program makes it easier and quicker to identify problem cows and take profitable actions and helps you manage tank count to qualify for plant premiums.

Actions to take

Take your somatic cell report and run through the check list we started with.

The next time your veterinarian is on your farm, review actions appropriate for your herd in response to different infection situations.

Mastitis basics

Milk is produced by cells which line the alveoli in the cow's udder. "Let down" is initiated when the cow releases oxytocin, and the alveoli squeeze out the milk made since the last milking. The milk collects in ducts and drains into the udder cistern, then to the teat cistern. The last leg of the milk flow is from the teat cistern through the keratin-lined streak canal and finally through the teat sphincter.

Udder infection occurs when bacteria, or some other causative agents such as mycoplasms, get into the alveoli and start causing trouble. These organisms reach the alveoli through the teat end (through the teat sphincter, keratin lined streak canal and ultimately to the alveoli.) Keeping the udder healthy must center around managing the first line of defense — the teat end.

As infection of the alveoli occurs, the bacteria produce poisons which harm the milk producing cells. Injured cells send out a signal to the body calling for help. The body sends out its anti-infection army — white blood cells.

When the white blood cells arrive via the blood stream, they force their way through the alveoli, actually destroying some milk producing cells as they pass. Once in the alveoli, the white blood cells engulf and destroy the bacteria. If the white blood cells are successful, the infection may stay subclinical without you suspecting there was an infection.

If the bacteria overpower the white blood cells, the case will become clinical and you'll see hard swollen udders, mastitic, perhaps bloody, milk, and a sick cow. Either way there was a battle in the alveoli and milk producing cells were permanently damaged — *production potential was lost.*

Key points

- Infection originates at the teat end.
- Milking is a form of defense. It flushes out some of the bacteria.
- The white blood cells (also called leucocytes) are a secondary form of defense.
- Damage of milk producing cells occurs two ways: through the toxins from the bacteria and from the leucocytes themselves.

- **General types of infections**

Subclinical - The first line of defense is breached, but bacteria can't completely overcome the second line of defense (leucocytes.) Damage is being done, leucocytes are stopping the bacteria, but cannot completely defeat them. There are no visible signs of the infection outside the teat end. SCC increases.

Clinical - Bacteria have breached the first line of defense and are winning the battle with the second line of defense. Symptoms are visible and SCC is high.

Chronic - An infection which persists for a long time with little or slow change in the animal's state.

• **Importance of somatic cell counts**

1. They indicate the health of the udder. Once measured, the udder health of the herd can be managed.

2. They have an economic impact on the milk industry. Low somatic milk has a longer shelf life in the store. High somatic milk has lower yields for cultured products. As milk handlers realize the costs of high SCC milk, they are paying premiums for low SCC milk.

• **Ways to express somatic cell counts**

Raw Count

The number of cells per milliliter of milk, normally in the hundred of thousands. ie 100,000, 200,000 etc.

Linear Score

A calculation from the raw count.

"If linear score is just calculated from the raw count, why bother with it?"

1. Linear score can be related directly to milk loss from infection (see fig. 6). An increase of 1 linear score unit equals 1.5 pounds of milk per day lost, or 400 pounds for a lactation. (Loss is half that for first lactation animals.)

2. The linear score is more repeatable than the raw count. Monthly variations in indivduals is small.

3. The average linear score gives a better picture of a lactation than the average raw count.

fig. 6 - Linear score relation to milk loss

Raw cell count in thousands	50	100	200	400	800	1,600
Additional pounds milk lost per day	0	1.5	1.5	1.5	1.5	1.5
Linear score	2	3	4	5	6	7

Notice when a count goes from 50,000 to 100,000 (a gain of 50,000 cells) there is a loss of 1.5 lbs milk per day. Linear score increased 1 unit from 2 to 3. If the count goes from 800,000 to 1,600,000 (a gain of 800,000) there is another loss of 1.5 lbs per day. Linear score increased 1 unit, from 6 to 7.

Raw count can be deceiving. Milk loss relative to change in raw count is greater at lower counts than higher counts! Linear score has a consistent relationship with milk loss, however high the count.

A better lactation picture

Cow 1		Cow 2	
Raw count	Linear score	Raw count	Linear score
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	1,143,000	6.5
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
207,000	4.0	103,000	3.0
Lactation average cell count			
207,000		207,000	
Lactation average linear score			
	4.0		3.4
Milk loss over lactation			
800 pounds		560 pounds	

Although both cows have the same average raw count, their average linear scores show that cow 1 had more milk loss for her lactation than than did cow 2.

Stay Below 5 to Stay Alive!

A high percentage of animals over a linear score of 5 (400,000 cells per milliliter of milk) will culture positive. Stay below 5! Each one change in linear score unit represents a doubling or halving of the raw count.

LS	Raw Count
2	50,000
3	100,000
4	200,000
5	400,000
6	800,000
7	1,600,000

How to
Get Your Cows to Calve Regularly

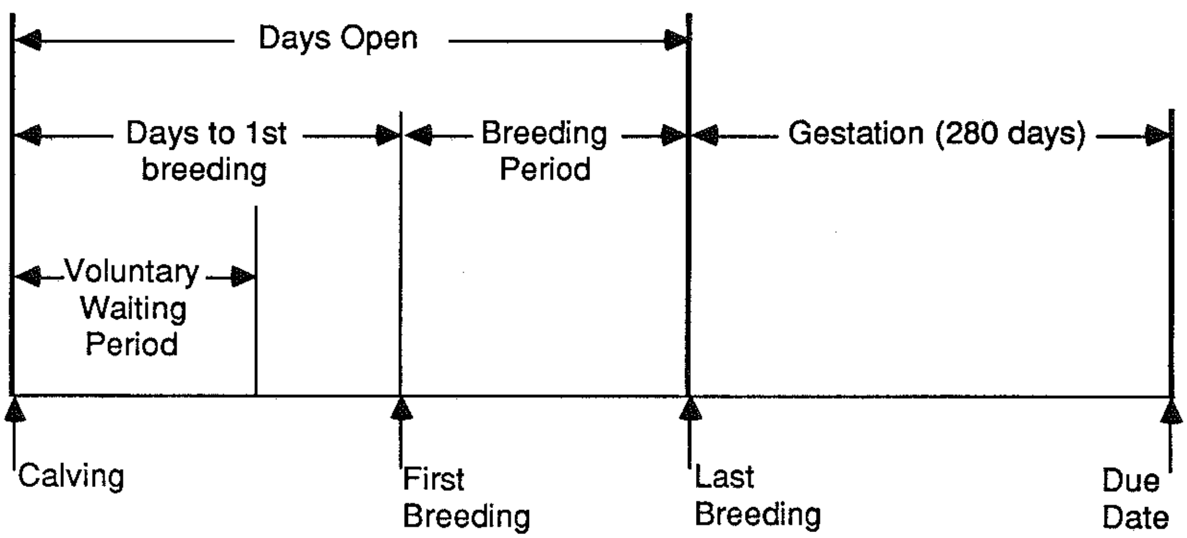
Dairy Herd Improvement Series DHI #119A 5/89

Profitability comes from maximizing the time cows spend at higher production levels and minimizing their time at low production or dry stages.

Goals:
- 12 to 13 month calving interval
- 50-60 days dry
- 85-115 days open (Figure a loss of $2 to $5 per cow per day open over 115.)

The calving interval has nothing to do with herd profitability. Having the cows in milk at high production levels and having plenty of good replacements does.

The Parts of a Calving Interval



If Days Open is too long, use this check list to find the problem:

- ☐ Is the voluntary waiting period (number of days you intend to wait after calving to start breeding) too long? (Should be 40 to 60 days.)
- ☐ Is actual days to first breeding too long? (80 to 85 days is good.)
- ☐ Are breedings per conception too high? (1.5 to 1.8 services/conception is good.)
- ☐ Is heat detection OK? (If days to first breeding is OK, services per conception is good, and days open is still too long, heat detection is a problem. Also, see the AIM report on page 5 and compare the number of heat cycles with the number of services reported. If the number of services is less than half the number of cycles, heat detection is a problem.)

Days to First Breeding is the number of days from the calving date to the date the animal was first reported bred.

If your voluntary waiting period is 50 days from calving and you see all heats, the average animal will be between heats on day 50, and you will first breed at 50 + (21/2) = 60.5 days. If you see only 50% of the heats, you would add another 1/2 of a cycle, or be at 71 days to first breeding.

Breeding efficiency is the % of heats you have bred. It is calculated by starting to count heats once animals reach the days in milk you have set on your To Breed Action sheet to start breeding. The number of theoretical heats is divided by the actual number of services reported.

If an animal had time for two heats between her to-breed date and last-bred date and was bred once, the heat detection index would be 50%. (Available on AIM1 reports only -- code 133.)

If you are not certain at what value your to-breed dates are currently set, look at the top right section of your To Breed Action Sheet. To change this, tell your Supervisor what number best reflects your current practices.

Breedings per conception is the number of breedings reported on animals considered pregnant divided by the number of pregnant animals. Animals are considered pregnant if they haven't been bred for 60 days or are reported confirmed pregnant.

DHIA Tools

There are five powerful tools in the DHIA program to help you organize your reproduction program — Action Sheets, AIM Reports, the Peak & Persistency Report, the Ladder of Progress, and the Dairy Herd Profile.

Action Sheets

Action Sheets are a standard part of the DHIA program. The reproduction Action Sheets are convenient, specific lists of animals to breed, to check pregnant, to dry off, and to calve.

To Breed

This list includes animals ready to be bred, based on the To Breed Option Value listed at the top right of the sheet, and animals who were once bred but were reported to the Supervisor as confirmed open.

From left to right the list includes:

- Cow computer control number
- Cow barn name or number
- Date to start looking for heats to breed
- A place to record the date the cow was bred
- A place to record the sire used

(Note: the asterisk next to the date points out dates already past.)

Once you report an animal bred, they go on the Check Pregnancy Action Sheet.

Check Pregnancy - Cows

This list includes animals bred less than 90 days and not yet reported confirmed pregnant. The date listed is the bred date plus the number of days you indicate you'd like to wait before having your veterinarian check them.

This list also has the number of services reported so far this lactation, the service sire used, the date the animal was last bred, and a place to make a mark if the animal is confirmed pregnant. Note the Option Value in the upper right corner. Let your supervisor know if you would like to change this.

TO BREED - COWS OPTION - 45

COW CCNB	BRN NM	DATE MO	DA	COWS SIRE NAME	BRED SIRE	M-D-Y REG. NO.
458	2	05	08*			
478	13	05	18*	FIRECRACKER		
528	7	08	06*	STREPHON		
499	16	08	15*	SEXATION		
498	3	09	05	MARC		

To Dry Off

This action sheet alerts you when to dry an animal off to achieve an adequate dry period. Not getting a long enough dry period can cost you over 15% of an animal's next lactation — 2,700 pounds for an 18,000 pound cow. A 45-50 day dry period is probably adequate for a mature animal. First lactation heifers may need more, and DHIA allows for this.

This sheet has animal computer control number, barn name or number, date to dry the animal off, the animal's due date, and last milk weight. There is also an area to record the actual dry dates. The "Option" value first lists the current target days dry for 1st lactation animals, then the target for 2nd+ lactation animals.

CHECK PREGNANCY-COWS OPTION - 50

COW CCNB	BRN NM	DATE MO	DA	NO. SRV	SERVICE SIRE	BRED MO-DA	PG
2	4	05	08*	1	WARDEN	3-19	
3	5	05	11*	1	WARDEN	3-22	
13	9	06	07	2	WARDEN	4-18	
12	10	06	23	3	BANNER	5-04	
11	51	07	10	1	MARS	5-21	

To Calve

This sheet lists computer control number, barn name or number, and date to begin calving preparation (you can choose from 10-30 days before due as a prep date.) The actual due date is followed by a + sign if a sire was reported and an AI sire code name or NAAB num-

TO DRY OFF					OPTION 60-50	
COW CCNB	BRN NM	DATE MO - DA		DUE MO-DA	LAST MLK WT	DRY MO-DA-YR
4	6	06	29	8-28	47	

ber if the sire is in the Dairy Records computer sire file. There is an area to record actual calving dates and calf eartags to report to the Supervisor.

Assuming the cow is in good body condition, the next lactation is made or lost in the first 40-70 days in milk. To give the cow for a running start, introduce the milking ration 14 days before freshening to get the rumen ready for it's job.

Animals must freshen in an environment that minimizes the risk of uterine infection, which pulls body resources away from milk production and causes delayed breeding. These animals may leak milk, which begs mastitis. Watch them and consider teat dipping or even pre-milking to reduce the chance of udder infection.

The Action Sheet system works well with the special clip boards provided by DHI. When not on the clip board, the sheets are easily carried in the pocket for checking the status of a cow and recording relevant dates and activities.

AIM Reports

AIM Reports (custom-made listings of your animals) are another powerful tool for getting your cows to freshen regularly. The AIM report on the next page is for reproduction management and can be used for several jobs. It is especially useful in larger herds.

TO CALVE - COWS						OPTION - 15
COW CCNB	BRN NM	PREP MO - DA		DUE DATE	DATE CALVED	CALF EARTAG
18	8	06	09	06-24+CAVALIER		
20	18	06	13	06-28+BACHELOR		

AIM Report Key

Column heading	Definition
BARN NAME	Barn Name or Number
DATE 1ST-BRED	Date the animal was first bred
DAYS 1-BR	Days between fresh date and date first bred
DATE LST-BRED	Date last bred
DAYS OPEN	Days open (fresh date - date last bred)
NO SRV'S	Number of services reported
PRG CNF	Pregnancy confirmed (reported to supervisor)
NOT BRD	This animal reported "not to breed"
PROJ CF-INT	Projected minimum calving interval (projected months between fresh dates)
HEAT CYLS	Theoretical heat cycles between voluntary waiting period and last bred date or last sample date
TFT	This animal "too fresh to test" (in milk less than 7 days last sample day)

Animals are first sequenced by date first bred, and second by days open. Cows not yet bred are listed first, and those most recently first-bred are listed last.

AIM Report - Herd Reproduction Status

HERD REPRODUCTION STATUS SAMPLED 4/20/88

001 BARN NAME	101 DATE 1ST-BRED	127 DAYS 1-BR	102 DATE LST-BRED	305 DAYS OPEN	106 NO SRV'S	108 PRG CNF	122 NOT BRD	130 PROJ CF-INT	132 HEAT CYLS	223 TFT
408				225		NO	YES		0	
348				112		NO			3	
571				106		NO			3	
609				92		NO			2	
557				90		NO	YES		0	
515				59		NO			1	
492				26		NO			0	

These cows are not yet bred. Pick out the problem animals.

001 BARN NAME	101 DATE 1ST-BRED	127 DAYS 1-BR	102 DATE LST-BRED	305 DAYS OPEN	106 NO SRV'S	108 PRG CNF	122 NOT BRD	130 PROJ CF-INT	132 HEAT CYLS	223 TFT
540	03-06-87	49	10-11-87	268	8	YES		18.0	11	
576	05-14-87	57	09-22-87	188	3	YES		15.4	7	
575	05-19-87	67	04-10-88	394	8	NO		22.2	17**	
581	06-23-87	85	02-21-88	328	8	YES		20.0	14	
584	06-24-87	79	09-22-87	169	2	YES		14.8	6	
478	06-26-87	102	08-14-87	151	2	YES		14.2	5	
593	07-23-87	71	09-22-87	132	2	YES		13.6	4	
589	07-30-87	100	10-05-87	167	2	YES		14.7	6	
461	07-30-87	131	07-30-87	131	1	YES		13.5	4	
599	10-09-87	35	01-01-88	119	3	YES		13.1	4	
597	10-20-87	52	10-20-87	52	1	YES		10.9	0	
595	10-22-87	97	12-18-87	154	2	YES		14.3	5	
600	11-02-87	54	03-23-88	196	4	NO		15.7	7	
596	11-08-87	72	11-28-87	92	2	YES		12.2	2	
554	11-23-87	107	11-23-87	107	1	YES		12.7	3	
547	11-24-87	66	11-24-87	66	1	YES		11.4	1	
559	12-03-87	63	12-03-87	63	1	NO		11.3	1	
602	12-06-87	67	01-19-88	111	3	YES		12.9	3	
603	12-23-87	80	12-23-87	80	1	YES		11.8	2	
604	01-22-88	96	01-22-88	96	1	YES		12.4	2	
558	01-25-88	110	04-16-88	192	4	NO		15.5	7	

These cows <u>should</u> be pregnant. Look for the problems.

001 BARN NAME	101 DATE 1ST-BRED	127 DAYS 1-BR	102 DATE LST-BRED	305 DAYS OPEN	106 NO SRV'S	108 PRG CNF	122 NOT BRD	130 PROJ CF-INT	132 HEAT CYLS	223 TFT
556	01-28-88	81	01-28-88	81	1	YES		11.9	2	
468	02-05-88	53	02-05-88	53	1	YES		11.0	0	
608	02-21-88	69	02-21-88	69	1	YES		11.5	1	
521	02-27-88	72	02-27-88	72	1	YES		11.6	1	
522	03-19-88	80	03-19-88	80	1	NO		11.8	2	
482	03-21-88	65	03-21-88	65	1	NO		11.3	1	
555	03-26-88	88	03-26-88	88	1	NO		12.1	2	
607	04-11-88	120	04-11-88	120	1	NO		13.2	4	
498	04-14-88	49	04-14-88	49	1	NO		10.8	0	

These cows were recently bred for the first time. Watch days to first breeding.

(Major sequence is ascending by date first bred, intermediate sequence is descending by days open.)

Use this report to:

- Quickly identify animals overdue and due for a first service.
- Find cows not confirmed pregnant.
- Track your success at managing days to first breeding.
- Evaluate the number of heats you are breeding vs. the number of cycles cows should have. On average, you want at least 1 breeding for every 2 cycles.

This is only one example of an AIM reproduction report. You could design something different, perhaps by adding string number to this AIM report, or sequencing by date last bred. Then you could use the list to watch conception rate and as a reproduction check list for your veterinarian.

The Peak & Persistency Report

To spot problem breeders quickly and easily, use the Peak & Persistency Report. This sequences the herd by month of freshening. (See example on the next page.)

The far right of the report has due date, pregnancy confirmed and days in milk. Look down the days in milk field to about 85 days and draw a line across the report. Animals listed below this line without a "Y" in the pregnancy confirmed column are becoming problems. The further down the list you go, the greater the problems. If the animals don't have a due date, you know they haven't even been bred yet.

The Ladder of Progress

The Ladder of Progress is one good place to evaluate your overall herd reproduction. Sometimes *how your performance is changing* is much more important then the actual numbers for any given test day. The Ladder of Progress is designed to make it easy to see how your herd reproductive performance is changing.

This report is sent to you each April and September. It compares key reproductive parameters in your herd to Northeast breed averages for herds of similar size.

See the Ladder of Progress example on the next page.

The Dairy Herd Profile

Another report for monitoring overall reproductive performance is the Dairy Herd Profile. Averages can be misleading. To really take your herd apart and compare, for example, heifers' breeding performance to the older animals, the Dairy Herd Profile is what you need. The Profile uses distributions of averages to give a better picture of group performance.

Actions to Take

Update Action Sheets: Review your Action Sheet Options for voluntary waiting period before breeding, days to confirm pregnant, and fresh cow prep date. If they are not correct, update them with your DHIA Supervisor.

Check Reporting Procedures : Go over reporting procedures for breeding dates, sires, animals not to breed, confirmed pregnancies, and all other status changes in your herd with your Supervisor.

PAGE	DATE SAMPLED
1	08-25-88

FARM NAME
DOE, JOHN
ANY STREET
ANY CITY
NEW YORK 12345

PEAK AND PERSISTENCY REPORT

	NORMAL PERSISTENCY 0-65 DAYS	65-200 DAYS	OVER 200 DAYS
1ST LACT	106	96	92
2ND + LACT	106	92	86

(CURRENT PERSISTENCY ADJUSTED TO REFLECT A 30 DAY INTERVAL)

CCN	BARN NAME	LACT NO	FRESH MO DA YR	SMP -01-	SMP -02-	SMP -03-	SMP -04-	SMP -05-	SMP -06-	SMP -07-	SMP -08-	SMP -09-	SMP -10-	SMP -11-	CURR. PERS	DUE DATE MO DA YR	PREG CONF	DAYS MILK
542	DIANA	1	08-20-88					TOO FRESH - TO TEST										
555	DORIS	1	08-24-88					TOO FRESH - TO TEST										
463	GAIL	5	08-11-88	82														15
480	LETA	4	08-11-88	97														15
556	SLEEPY	1	08-22-88					TOO FRESH - TO TEST										
557	SUE	1	08-20-88					TOO FRESH - TO TEST										
	AVERAGE-1ST CALF																	
	AVERAGE-OTHER			90														
505	BETH	3	07-12-88	49	57										116			45
511	BONNY	3	07-08-88	75	86										115			49
543	CLEVER	3	07-24-88	107														33
499	DI	3	07-01-88	94	105										112			56
488	JANA	4	07-24-88	97														33
554	NANCY	1	07-22-88	54														35
498	PEACH	3	07-22-88	104														35
489	SI	4	07-13-88	77	97										126			44
	AVERAGE-1ST CALF			54														
	AVERAGE-OTHER			86	86										117			
457	GENIE	5	06-02-88	92	98	102									104	05-15-89		85
530	GREY	2	06-12-88	90	83	82									99	05-23-89		75
528	JENNY	2	06-22-88	95	94										99			65
	AVERAGE-1ST CALF																	
	AVERAGE-OTHER			92	92	92									101			
501	EDIE	3	05-07-88	113	111	98	103								105	04-10-89		111
486	EILEEN	4	05-25-88	68	83	93									112	05-10-89		93
405	JEN	7	05-01-88	85	88	82	64								78	05-31-89		117
	AVERAGE-1ST CALF																	
	AVERAGE-OTHER			89	94	91	84								98			
524	CLEAR	2	04-05-88	86	98	97	82	79							96	05-21-89		143
526	DUTCH	2	04-29-88	99	88	69	70								101	05-28-89		119
478	MAY	4	04-03-88	107	117	113	101	96							95			145
417	RUBY	7	04-11-88	65	97	98	86	104							121	05-28-89		137
	AVERAGE-1ST CALF																	
	AVERAGE-OTHER			89	100	94	85	93							103			
458	DUSTY	5	03-24-88	113	108	96	91	94							103			155
552	PAMMY	1	03-29-88	71	81	81	62	62							100	04-29-89		150

Ladder of Progress

HERD SIZE GROUP BREED AVG.
HOLSTEIN

HERD SIZE GROUP BREED AVG.					ACTUAL 6 MONTHS CHANGE
	YOU WERE HERE ON	4-30-85	10-31-85	4-30-86	
	YOU WERE LAST SAMPLED ON	3-28-85	9-17-85	4-18-86	
	BREEDING				
12.9	PROJ MINIMUM CALVING INTERVAL	13.0	13.1	12.4	.7-
66	AVERAGE DAYS DRY	66	60	61	1
1.6	NO. BREEDINGS PER CONCEPTION	1.7	2.1	1.9	.2-
2	NO. COWS NOT BRED AFTER 100 DAYS	0	0	0	0
101	DAYS OPEN COWS NOT BRED	78	60	60	0
112	DAYS OPEN ALL COWS	112	110	90	20-
	AVG. PRED DIFF OF AI SERVICE SIRE	634	333	933	600
	NO. OF RECORDS TO CALC PRED DIFF	16	6	12	

Review Current Situation: Using the Herd Summary or Ladder of Progress, review current calving interval, days to first breeding and conception rate. Write a "+" next to those within good ranges and a "-" next to those out of good ranges. How have these values changed in the past 6 months?

Identify Problem Breeders: Look down your Peak and Persistency report for problem breeders and sign up for the Reproduction Aim report we reviewed. Identify animals not to breed again and note your days to first breeding.

FEEDING FOR LACTATION PERSISTENCY IN FIRST AND SECOND LACTATION ANIMALS

C. J. Sniffen and L. E. Chase
Department of Animal Science
Cornell University

The use of lactation curve analysis with DHI records has allowed us to examine lactation performance by parity within a dairy herd. We have noted that many times second lactation animals may peak adequately (often below expectations) but will have poor persistency. Also, although not observed as frequently, we will find first calf heifers with poor persistency. Sometimes when we examine the records closely (using RMS or Dairy Herd Profile information), we detect a seasonal effect, e.g. there is one part of the year when milk decline is more pronounced than at other times. This lack of persistency results in a considerable loss of both milk and income. What are the factors contributing to the problem?

Replacement program. We have found the second lactation "slump" most frequently occurs when first calf heifers are undersized at calving. In addition, if the rations during the first lactation are marginal then there will usually be a poor performance in second lactation. Why is this? We need to understand nutrient demand priorities. The growing, lactating animal has the following nutrient priorities high to low: growth, lactation, pregnancy, reserve repletion.

Undersized heifers have a high growth requirement resulting in a low peak but they are usually quite persistent. The result is that they grow moderately well, and replete only a limited amount of their body tissue reserves. They still have a considerable amount of growing to do. Unfortunately they may have conceived on the first service and will often have short dry periods of 40-45 days. The dry period will not be long enough to allow repletion of additional reserves and depending on the season may even deplete the reserves put on in the tailend of lactation. We must remember that normally the first calf heifer is genetically superior to her herdmates and has not been environmentally compromised. As a result, she will grow and produce closer to her genetic capability if she is fed a ration that is well balanced.

It is not a given fact that small framed lactating heifers will be the only ones suffering in second lactation. If the ration is not balanced properly, there can be a lack of persistency in the second lactation even for the larger heifers.

<u>Keys to maintaining persistency in first and second lactation</u>

Replacements -

1. Balance rations for optimum gain.
2. Ensure condition score 3 for the total growth period until 60 days prior to freshening.
3. Achieve a 3+ to 4- in last 60 days prior to calving.
4. Weigh heifers at regular intervals-at least at birth, weaning, 8 months, 15 months, 24 months (after calving).
5. Use Rumensin or Bovatec.
6. Develop a good preventative health program with your herd veterinarian.

Lactation

Freestall

1. Ensure adequate bunk space and free stall space.
2. Place 1st calf heifer in high group for full lactation.
3. If herd size and pens allow, group 1st calf heifers separately.
4. Consider grouping 2nd calf heifers separately.
5. Allow for a 50-60 day dry period.
6. Balance rations for frame size, gain and reserve repletion in addition to production.
7. Weigh first calf and second calf heifers at second test (Condition Score 3).
8. Condition score monthly.

Conventional

1. Group 1st calf heifers separately.
2. If possible group second calf heifers separately or ensure that their ration includes a growth component.
3. Weigh first and second calf heifers at second test (Condition Score 3.)
4. Balance ration for growth as well as tissue repletion.
5. Condition score monthly.

The objective is to optimize growth in the first and second lactations while managing energy reserves. The management of reserves is critical for obtaining maximum productivity, herd health and reproductive performance.

NUTRITION
Butterfat Depression

Dairy Management

COOPERATIVE EXTENSION • NEW YORK STATE • CORNELL UNIVERSITY

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Feeding Management and Butterfat Depression

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Butterfat depression is a common recurring problem that frustrates all dairy owners today. It is of significant economic interest as long as the marketing structure of milk continues to be dependent on butterfat content. The income lost through butterfat depression on an annual basis to dairy owners could be significant.

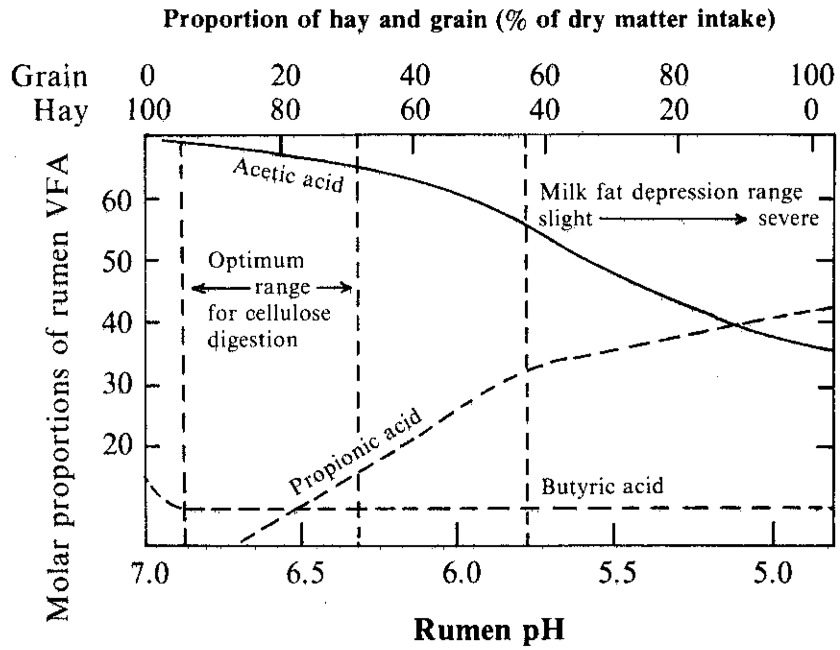

Figure 1. Effect of rumen pH and fermentation on butterfat depression. Redrawn from C. L. Davis, *Use of Buffers in the Rations of Lactating Dairy Cows, Regulation of Acid-Base Balance* (Piscataway, N.J.: Church and Dwight, 1979), p. 51.

Principles of Butterfat Depression

Some of the underlying principles relating to butterfat depression must be understood to correct the problem. A low milk fat test can be caused by such mechanical things as poor sampling of the milk from the tank or the mixing of the milk in the tank before sampling, poor sampling techniques by the tester, inaccurate butterfat measurement in the milk, and potential mechanical separation of the fat from the milk before sampling. Heat, stage of lactation, season of the year, and genetics are additional contributing factors in butterfat depression. These factors may or may not be related to the diet being fed or actual feed being consumed by the dairy cow.

Butterfat depression related to diet is mainly a function of rumen fermentation. Butterfat depression usually occurs in cows in early lactation. Such cows are normally on very high grain diets. A delicate balance exists between bacteria that digest fiber and those that digest starches and sugars. A good rumen environment must be maintained for the fiber-digesting bacteria. The acidity (pH) in the rumen must be controlled by buffering. The major natural source of buffer is from the cow's saliva. Saliva production is stimulated by the cow's chewing or rumination. When the chewing is reduced and acidity becomes high, or pH low, in the rumen, the bacteria that grow rapidly on starch and sugars begin to predominate in the rumen. The bacteria that digest fiber are inhibited, and the result is a decrease in acetic acid production with an increase in propionic acid production (fig. 1). When this occurs, there is a butterfat depression.

Chewing Time and Buffering

During the course of the day, a cow normally produces 1 to 2 pounds of sodium bicarbonate through the saliva. This source of buffering is extremely important to ensure normal rumen fermentation. In addition, forages differ in their natural buffering capacity; for example, alfalfa hay is high in its ability to buffer the rumen. In contrast, corn silage is very low in its ability to buffer the rumen. Further, highly fermented forages have a lower buffering capacity than nonfermented feeds. Dairy cows chew or ruminate as much as 10 to 14 hours a day. To maintain normal rumination, the dairy cow must be fed forages that are coarse enough to stimulate cud-chewing activity. Sometimes, even though the forages are coarse enough, the particles are pliable or soft. Their rapid disintegration decreases rumination time. Additionally, legumes such as alfalfa have a leaf structure that breaks down rapidly in comparison with grasses, which have long blades and require more chewing time.

Often dairy owners are advised to feed their cows a few pounds per cow per day of long first-cutting hay, placed in a hay rack or some other location accessible to the cows. The response varies: some cows are hay eaters and others often shun hay. The cows that do not consume hay are often the very low butterfat producers. A coarse forage or early cut forage must be included in the ration in such a way as to ensure consumption by all cows.

A balanced ration is essential. If, in addition to degradable energy, not enough degradable protein or enough minerals (such as sulfur) to meet microbial requirements for growth are in the ration, an inhibition of bacterial growth with a depression in fiber digestion can result.

The factors and mechanisms leading to butterfat depression are complex and still not fully understood. Most likely the involvement of the rumen is mediated through the production of volatile fatty acids (VFAs). A trouble-shooting chart to minimize the occurrence of butterfat depression follows:

Guidelines to Minimize Butterfat Depression Incidence

1. If your milk plant fat test is lower than your DHI test, then mechanical milk handling or sampling procedures should be suspected as the cause of the discrepancy.
2. If on DHI, check the records to determine which cows have low butterfat tests. Write the numbers of these animals down and note the group in which they are and the pounds of grain that they are being offered.
3. Calculate the amounts of forage and grain being offered to the cows with low butterfat tests.
4. Calculate the percentage of the total dry matter that is fed as forage. If the percentage of forage in the total dry matter being offered to the cows is less than 50% for corn silage diets or high-quality hay-crop silage diets, readjust the forage-to-concentrate ratio to 50:50.
5. If the hay crop silage is 18–22% alfalfa, it may be necessary to adjust the forage-to-concentrate ratio to 60:40.
6. If the forage is a low protein material of 13% or less, forage-to-concentrate ratio could be 40:60.
7. If protein or sulfur is low in total ration, increase the amount.
8. Determine the fineness of chop of the forage. Look for uniformity of chop.
   a) Corn silage should be greater than ½-inch theoretical cut.
   b) Grass-silage intermediate-quality theoretical cut should be greater than ½ inch.
   c) Alfalfa high-quality theoretical cut should be greater than ⅜ inch.
9. Observe cattle at a time between milkings and 3 to 4 hours after offering feed.
   a) Observe those cows that have been determined earlier to have low butterfat tests.
   b) Determine the percentage of those cows that are ruminating or chewing their cuds.
   c) Palpate for rumen action or contractions. Do this on the left-hand side of the cow, as you stand behind her, at the hollow indentation under her processes. There should be good, strong rumen contraction.
10. Determine feeding management.
    a) If feeding grain and hay or forage separately, feed the forage before feeding grain.
    b) If feeding long hay in addition to a total mixed ration or bunk mix, discontinue feeding the long hay and change the forage-to-concentrate ratio of the bunk mix. Or if hay is to be fed, ignore it in terms of nutrient and forage-to-concentrate calculations for the bunk.

Buffers

Many times the forage either is chopped too fine or is highly fermented with very low natural buffering capacity or is both. Further, there may be no opportunity to either purchase or include forages with better buffering capacity or a higher theoretical length of cut. In this event, buffers become a potential means of correcting a butterfat depression. Buffers should be used only after factors such as forage-to-concentrate ratio and the proper balancing of nutrients have been checked. The most commonly used buffer is sodium bicarbonate. The current recommendation calls for 0.8% to 1% of the total dry matter being fed to the animal. This would represent 1.6% to 2% of the concentrate mix or approximately 8 ounces per cow per day. Magnesium oxide has also been used and usually in combination with sodium bicarbonate. Magnesium oxide does not act as a buffer but rather as a material that changes the rate at which liquid flows out of the rumen. This decreases the amount of propionic acid being produced. The current recommendations call for .2% to .4% of dry matter intake, in combination with sodium bicarbonate. It should be pointed out that the chances of response from the addition of buffers are about 50:50 and only at butterfat concentrations of 3.2 and below. The buffers can be included in the concentrate or supplement or as a part of the total mixed ration at mixing time. This is a short-term corrective procedure only and should not be considered for the long term.

Summary

Several environmental factors influence butterfat concentration in milk, the major factors being the feed and the means of feeding. The major related effect occurs in the rumen with the production of excess propionic acid or the depression of acetic acid or a combination of both. How this brings about lower butterfat synthesis in the mammary gland is not entirely known. However, butterfat depression is highly correlated with the volatile fatty acids, namely, acetic and propionic, produced in the rumen. A basic understanding of how the rumen functions and feeding management are the key to keeping incidences of butterfat depression to a minimum.

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Cooperative Extension, the New York State College of Human Ecology, and the New York State College of Agriculture and Life Sciences, at Cornell University, Ithaca, N.Y., and the U.S. Department of Agriculture, cooperating. In furtherance of Acts of Congress May 8, June 30, 1914, and providing equal opportunities in employment and programs. Lucinda A. Noble, Director.

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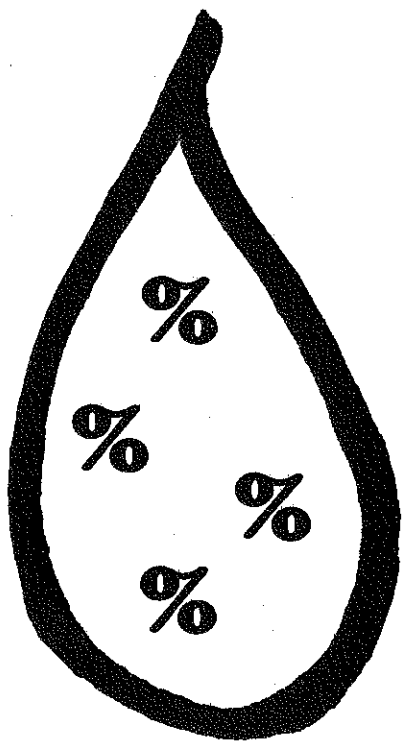
Trouble-Shooting Problems in Dairy Nutritio

Butterfat



By Mary Beth Rymph

August 1986

This pamphlet is designed to help you to find solutions to butterfat problems in dairy herds. On the first page is a listing of all topics covered -- items on what may influence butterfat production. The last two pages contain questions which may help to describe the herd situation along with references to topics that pertain to the given situation. In working on butterfat problems, remember that the problem may involve a variety of factors and that it could always be something else.

Thanks go to Dr. Charles Sniffen, Dr. Larry Chase, Dr. Marvin Coburn, William Menzi, Kathryn Baxendell, and Michael Brown for their help with this piece.

INDEX OF BUTTERFAT TOPICS

BUTTERFAT

Butterfat is affected primarily by genetics and rumen fermentation. If the fermentation is healthy with rumen pH not too acidic and fiber digestion unimpaired, there is a greater likelihood that butterfat will be high within the boundaries set by genetics. Overall milk composition, including butterfat, is affected 55 to 60% by genetics and 40 to 45% by environment. Environment includes feeding and management.

FACTORS AFFECTING BUTTERFAT PRODUCTION

NOT DIRECTLY NUTRITION RELATED

1.Season -- Fat test tends to decrease in spring and summer and increase during the cooler seasons. Decline during warmer, more humid weather may be due to a decrease in roughage intake. This decreased roughage intake may be due to the cow attempting to avoid feeds with a high heat increment. More heat is produced in the cow's system from the digestion of forages than from other feeds. In the hot weather cows will also tend to "slug feed" more (eat large quantities at a time instead of taking numerous, smaller meals). The herd's slug feeders will be most severely affected in hot weather.

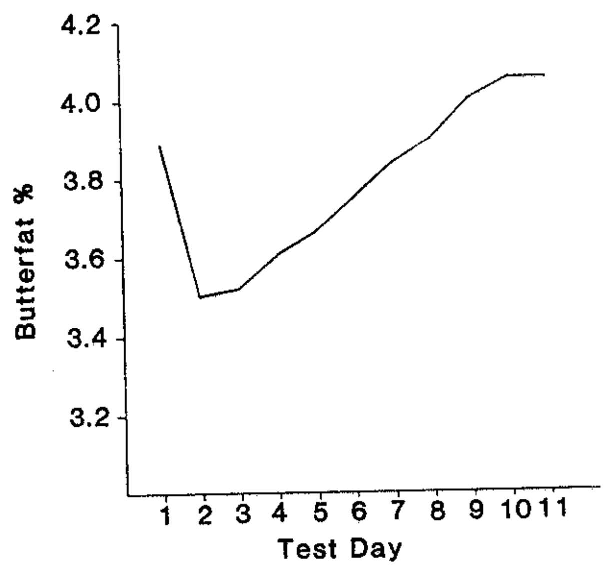


Figure 1. Average percent butterfat curve over lactation. (Source: Thomas J. Cannon, Alfred Agricultural & Technical College, Alfred, NY)

2.Stage of Lactation --Generally, there is a negative relationship between stage of lactation and fat test. A cow's fat test is likely to be lowest at her peak production and highest towards the end of her lactation. If fat test is low in a herd, check to see what percent of the cows are 1 to 120 days fresh; if they peak in milk production together, test may be low until they are past peak. If a herd's test is low (3.5%) in late lactation, check for other causes of fat depression. (See Figure 1.)

3.Genetics -- If a farmer breeds for milk or type only and ignores butterfat, test may remain low. Fat test must be fed <u>AND</u> bred for.

Generally, there is a negative correlation between milk production and fat test. Genetics accounts for 55 to 60% of what affects fat test.

4.Breed -- Dairy breeds differ in fat test: Jersey>Guernsey>Ayrshire> Brown Swiss>Holstein.

5.Daily Variation -- There is considerable day to day variation in fat test in individual cows which may be due, at least in part, to differences in daily feeding habits. This is usually balanced out in the bulk tank over a large number of cows.

6.Milking Practices -- The shorter the period between milkings, the higher the fat test and the smaller the volume of milk per milking.

7.Milking Practices -- Generally, the first milk drawn from the udder has the lowest test and the last milk drawn has the highest test. If a cow is not milked out completely (she doesn't let her milk down; the milking unit is removed too soon) her test may be lowered. Testers should wait until the end of milking to take representative milk samples.

8.Handling Milk -- Freezing or churning of milk in the bulk tank lowers the tank test. Clumps of butterfat seen after emptying the bulk tank indicate such a problem. Freezing can occur if cooling plate temperature is too low or if milk is inadequately agitated.

9.Handling Milk -- Excessive agitation in the pipeline or a malfunctioning pump may reduce fat test due to churning of milk.

10.Taking Milk Samples -- Milk samples must be collected and handled properly to give an accurate sample (for fat%, bacteria, etc.). The tank must be agitated for at least 5 minutes. Dippers and containers must be clean and dry.

11.Mastitis -- Mastitis (clinical or subclinical) may depress fat test and can be a factor in low testing herds.

12.Ketosis -- Ketotic cows (acetonemia) may drop in milk production but show an increase in butterfat. Cows that are borderline ketotic may maintain a high level of milk production as well as an unusually high percent butterfat.

BUFFERS & FEED ADDITIVES

13.Rumen pH -- Rumen pH should remain relatively neutral to provide the proper environment for fiber digesting microbes. If pH becomes too acidic, fiber digestion and overall rumen digestion may be negatively affected. Increases in rumen acidity have been related to decreases in butterfat production. A healthy rumen pH for early lactation cows falls between 6.2 and 6.4, and between 6.7 to 6.8 for later lactation animals.

14.Saliva -- Saliva is the cow's main natural source of buffer (sodium bicarbonate) which helps maintain the proper rumen pH and fermentation (high acetate vs. high propionate). Feeding adequate amounts of fiber of the correct length encourages rumination (to decrease particle

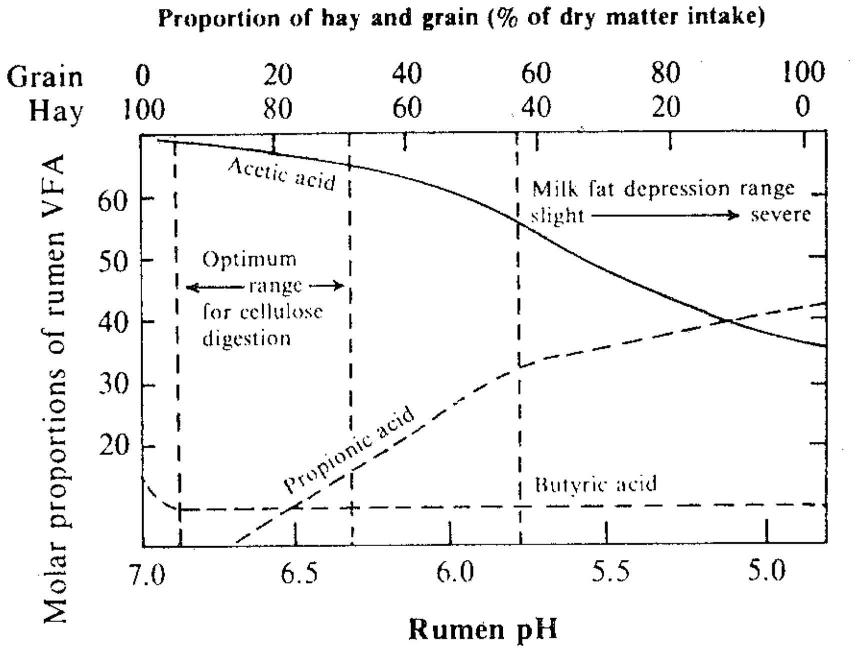


Figure 2. Effect of rumen pH and fermentation on butterfat depression. Redrawn from C. L. Davis, *Use of Buffers in the Rations of Lactating Dairy Cows, Regulation of Acid-Base Balance* (Piscataway, N.J.: Church and Dwight, 1979), p. 51. (Source: L.E. Chase and C.J. Sniffen, Cornell University.)

size), which causes the cow to produce more saliva, which gets more sodium bicarb into the rumen which helps buffer the rumen's pH. A cow may produce 400 pounds of saliva or more per day.

15.Amounts of Saliva -- Different feedstuffs cause different amounts of saliva to be produced:

Feedstuff	Relative Saliva Production
Hay	4X as much compared to grain
Mature forage	greater than immature forage
Feeds with large amounts of water	less saliva than with dry feeds
Finely ground feeds	less saliva than with coarse feeds
Pelleted feeds	less saliva than with ground feeds

16.Buffers -- Sodium bicarbonate, potassium bicarbonate, and sodium sesquicarbonate have good buffering capacity. They act by increasing the rumen pH with the aim of maintaining a desirable rumen fermentation. Use of buffers may be recommended if the fiber level of the ration is not adequate, but is not drastically below what is needed, in rations which contain large amounts of grain, or in rations containing fermented forages (See 21.When Buffers Won't Work, 22.Buffers, Acidic Rations & High Moisture Shell Corn). Sodium bicarb should be top dressed at a rate of 0.8% of ration dry matter per cow per day. Palatability is not very good, but not as bad as magox. Palatability problems may be overcome by mixing buffers into feed, such as with a total mixed ration. As with all feed additives, one may or may not see a response to buffers when they are fed.

17.Magnesium Oxide -- This is not a buffer per se, but instead helps to raise butterfat by increasing uptake of acetate and fat from the blood by the mammary gland. Magox should be fed at a rate of 0.4% of ration dry matter per cow per day. Warning: magox is highly unpalatable when top dressed straight. Cows may reduce feed intake when this is first added to the ration. Manure may become loose while magox is fed.

18.Bicarb & Magox -- These work by different mechanisms to improve fat test and consequently there may be an advantage to using them both. It is recommended that they be fed in a 2:1 ratio (at their recommended rates).

19.Sodium Bentonite -- This is a palatable inert clay that is commonly used as a pellet binder, but which may have positive effects on fat test as well. When fed with a balanced ration, it will not increase test. With feed related fat test problems, it may be fed at 1lb/cow per day and may bring the test back to 90% of normal.

20.10% Delactosed Whey -- In the grain mix it is said to help increase or maintain fat test. More research is needed on it.

21.When Buffers Won't Work -- Buffers may work when the fat depression is nutritional in nature (insufficient roughage or fiber in the diet, fermented forages fed). They will have little or no effect otherwise and will not raise butterfat above the level the cows are genetically capable of acheiving.

22.Buffers, Acidic Rations & High Moisture Shell Corn -- Buffers may not work well in rations that are composed almost exclusively of fermented feeds and high moisture shell corn. The acidity of the silage and the rapidity with which high moisture shell corn is degraded to acid in the rumen may contribute more acid to the rumen than several ounces of a buffer can overcome. Fermented forages are lower in buffering capacity than are dry forages.

23.Grass Hay vs. Buffers -- If at least 3 lbs. of average quality grass hay per day is fed to a cow, she should not need to be fed a buffer. The bicarbonate in her saliva should be sufficient to buffer her rumen.

24.Limestone -- Normally does not improve fat test. It is a buffer which acts primarily by improving starch digestion in the small intestine. High corn diets supplemented with limestone may be digested to a greater extent and milk production may improve.

25.Methionine Hydroxy Analog (MHA) -- Is said to increase fat test by enhancing rumen microbial activity. It is said to be most effective in early lactation when fed at rate of 25 to 30 grams/cow/day. It is very unpalatable and may cause cows to back off feed.

26.Yeast Culture -- Yeast is said to improve fat test by improving fiber digestion due to as yet unknown factors. It is also said to improve dry matter intake. As with many other additives, response has been variable.

27.Antibiotics in Feed -- Oxytetracycline fed in the ration at allowed levels has been shown to increase butterfat, increase milk production, decrease somatic cell count and decrease incidence of mastitis.

FORAGES & FIBER

28.Fiber in the Ration -- The cow's ration should contain 15 to 17% crude fiber or 17 to 21% acid detergent fiber (ADF) on a dry matter basis. Fiber levels any lower than this can affect butterfat as well as overall rumen fermentation.

29.Roughage : Concentrate -- Rations high in concentrate, low in roughage may depress fat %. These rations are usually low in fiber and will not stimulate adequate secretion of saliva (due to less ruminating) to buffer the rumen. Generally, the lowest one would want a roughage to concentrate ratio to go would be 40:60. Generally, it is preferable to have more than 40% roughage in a ration.

30.Rumination -- If a herd of cows are watched for 10 minutes and not one eats or chews her cud, something probably is wrong with the ration. One will probably see low fat tests at all production levels in the herd. Check the ration for adequate fiber and fiber length. Lack of rumination is a sign that a cow is frightened or ill. Generally, a cow may ruminate for 8 or more hours out of 24 hours.

31.Finely Chopped Roughages -- Finely chopped roughages may depress fat test. Not enough rumination will take place (no need to break down particle size much further) and so not enough saliva will be secreted to buffer the rumen. Even though the amount of fiber in the ration looks adequate, the physical form will lessen its effectiveness (particle size needs to be longer). Chopper knives should be set at 3/8 inch cut to get larger particles, or let the knives go dull (great for fiber length, hard on machinery), or feed some long stem hay to correct this. Keeping feed in front of the cows at all times (not feeding to an empty bunk) may help.

32.Finely Chopped Corn Silage -- Feeding corn silage that has been chopped so finely that most of the kernels have been broken may depress fat test. The moist corn in corn silage is a grain that is readily broken down by microbes in the rumen with acid produced as a result. The rumen pH may become too acidic, a possible cause of butterfat depression.

33.Coarsely Chopped Corn Silage -- Corn silage that has been chopped too coarsely has been known to depress fat test. Cows can sort out the more digestible portions and leave the larger pieces of cob, which reduces the fiber content of the feed consumed. A case of a ration working on paper but not in the cow.

34.Dry Forage vs. Fermented Forage -- Acidic, fermented forage rations may depress fat test (mostly silage with little or no hay). Dry forage has a greater buffering capacity than does fermented forage. Where silage or haylage is being fed as the only roughage to fat-depressed cows, feeding 5 - 10 lbs/cow/day of long hay will often help.

35.Excellent Quality Roughages -- Some of the excellent quality roughages, particularly the alfalfa hay and haylage, might just as well be concentrates. Their low fiber content and high digestibility may contribute to a milk fat depression if they make up a major portion of the ration forage. If high quality forages are not given adequate credit for their nutritional content, more grain may be fed than is needed, possibly compounding the low fiber problem.

36.Grass vs. Legumes -- Grass generally has more fiber (ADF) in it than do alfalfa or the other legumes. Feeding a limited amount of good, average quality grass hay may have its benefits in a ration of all high quality forages. It's a relatively inexpensive source of long stem fiber.

CONCENTRATES

37.Effect of Grain on the Rumen -- When grain reaches the rumen, rumen microbes will start to degrade it (especially the starches) and acid will be formed. The acid can lower rumen pH, and so, may depress fat test. The larger the amount of grain "dumped" in the rumen at one time, the greater the drop in pH, and the longer that pH remains low. To avoid the large drops in rumen pH, grain should be fed in smaller quantities several times a day, especially to cows that are getting large amounts of grain.

38.Volatile Fatty Acids (Acetate & Propionate)-- Decreases in butterfat have often been associated with a decrease in the ratio of acetate to propionate in the rumen. Rumen propionate levels increase when grain is fed. Production of high levels of propionate and production of lactic acid from propionate cause rumen pH to drop. With high levels of rumen propionate production, fat tends to be deposited in fatty tissue instead of in the milk (See figures 2 and 4).

39.High Moisture Ensiled Grain -- High moisture shell corn, barley, etc. are converted to acid in the rumen much more rapidly than their dry counterparts. It is advisable to break up the feeding of these grains into more than two times a day, and to feed a long stem fiber source (preferably not an acidic source such as silage) before feeding the grain to avoid causing a sudden drop in rumen pH. The amount and rapidity of the release of acid from these grains is such that, if large quantities are fed, buffers may do little to counteract fat depression caused by them.

40.Pelleted Grains -- The heat and pressure that grains are subjected to as they undergo pelleting can alter the soluble starch present. The starch will be converted to acid in the rumen more rapidly than it would if it had not been pelleted. For this reason, pelleted grain may have a more negative effect on butterfat and rumen fermentation than a grist would. This effect is not always seen, particularly when ration fiber is adequate and feeding management is good.

41.Cotton Seed -- This is a feed that may help to raise butterfat (may be good for a 0.2% increase), but may also cause milk protein to decrease at the same time. The suggested upper limit of whole cotton seed to feed per day is 7 lbs./cow. Cows may reject cotton seed that is not mixed with other feed.

42.Beet Pulp -- This can be a good source of fiber (34% ADF) but is usually too expensive to consider in a ration for fiber value alone.

43.Wet Brewers Grains -- This is a decent source of fiber (21.5% ADF) and some farmers swear by it for maintaining butterfat, but it can be a mess to handle, and is still "fine chop fiber". It can be a fairly inexpensive feed, but can vary from 17 to 26% crude protein. Suggested upper limit of brewers to feed per day is about 8 lbs. dry matter, or about 40 lbs. wet basis per cow.

FEEDING MANAGEMENT

44.Balanced Ration -- To acheive the best fat test, the ration must be balanced. Fiber, protein (total amount and of different solubilities), energy, vitamins, and minerals should all be provided in adequate amounts to fill the cow's and the rumen microbes' needs. Make sure to double check that the ration on paper is what the cow is actually eating. She may be refusing the coarser, high in fiber forages if allowed and may not get the fiber she needs. Make certain that the production levels and body weights that are being fed for are accurate. Use scales and a weigh tape, not an eyeball analysis.

45.Inadequate Soluble Protein (Rumen Degradable) -- Rumen microbes require rumen degradable protein to supply their protein needs. If not enough of this protein is included in the ration, rumen microbes may become starved for protein. In such a case, digestion of fiber may be decreased and butterfat production may decline as well. Degradable protein levels may be inadequate in rations composed primarily of hay, heat damaged haylage and feeds such as corn gluten, corn distillers grains, or brewers grains which are high in rumen undegradable protein.

46.Sulfur -- Sulfur is a mineral required by rumen microbes in production of microbial protein from soluble protein. If adequate amounts of ration sulfur are not provided, the net result may be starving the rumen microbes for protein (see 45.Inadequate Soluble Protein).

47.Changes in Feeding Program -- eg. Grazing lush pasture after months of barn feeding. The butterfat decrease may be due to a lowered fiber intake and/or an increased amount of sugars in the forage. Feeding a few pounds of dry, coarse (but palatable) hay may help in such a case. Changes in the feeding program should be made gradually if possible, to maintain a balanced ration and to avoid having the cows go off feed.

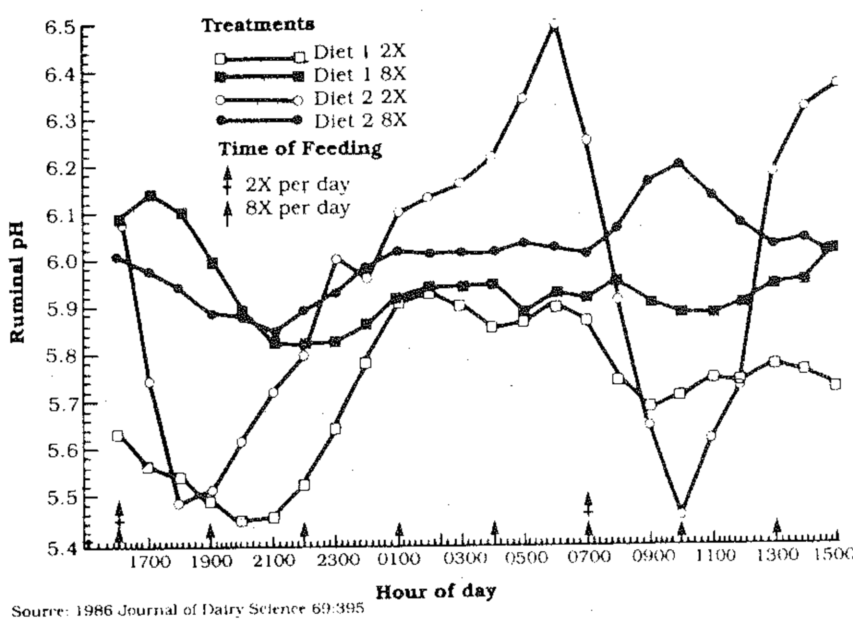


Figure 3. Effect of diet and frequency of feeding on rumen pH. Holstein steers were fed one of two 40% corn silage, 60% concentrate diets, and were fed 2x or 8x a day. (Source:"The Normalizer", 1986, 8:1, Arm & Hammer, Princeton, NJ.

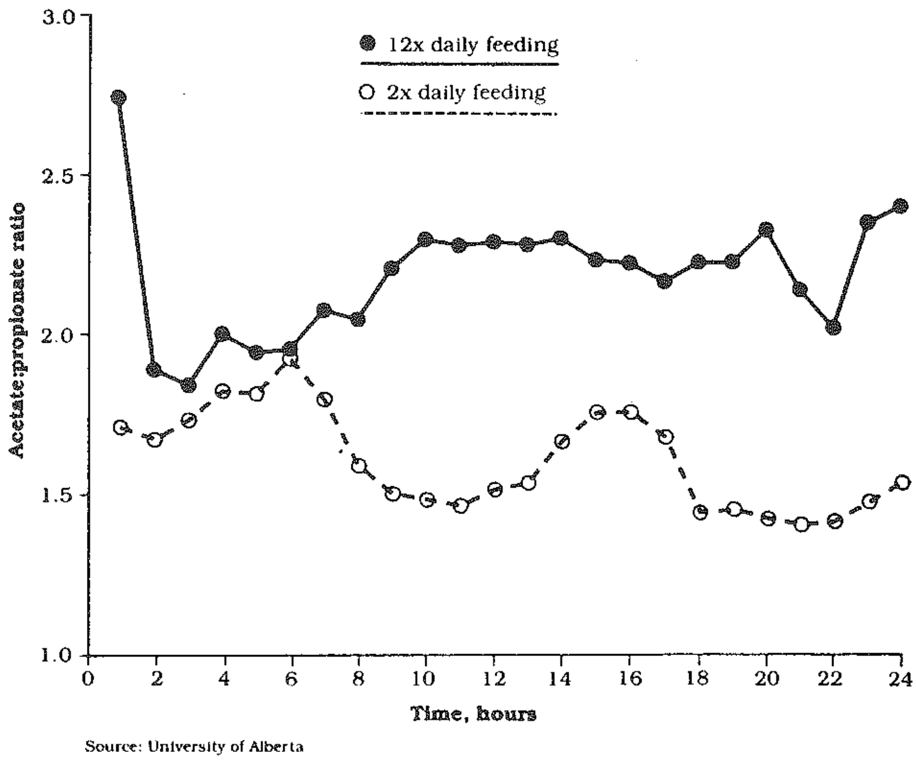


Figure 4. Effect of frequency of feeding on rumen acetate:propionate ratio (Source: "The Normalizer" 8:1, Arm & Hammer, Princeton, NJ).

48.Frequency of Feeding -- Feeding roughages and concentrates frequently during the course of the day can help fat test. Avoid feeding all grain in parlor if possible (too much grain dumped into the rumen at once). Feeding grain 3 or 4 times per day to high producers may help a depressed fat test. (See Figures 3 & 4.)

49.Feeding Routine -- This management point can change butterfat by several points. Feed hay to the cows before feeding them grain. This will get them salivating and send some of their natural buffer to the rumen before the grain gets there. Feed grain several times a day. Keep fresh feed in front of the cows.

50.Total Mixed Ration -- Feeding the cows grain mixed with forage is one method of preventing slugs of grain from hitting the rumen and the accompanying acid production. A TMR can be helpful in increasing butterfat if the grain is thoroughly mixed in and the forages are not too finely chopped. Cows should be fed ad lib (never to an empty bunk), and the bunk space should be adequate (12" per cow if feed is available all day, otherwise 24" per cow).

51.Computer Feeders -- These can help to increase butterfat by feeding the cow small amounts of grain throughout the day. No large amounts of grain will hit the rumen at any one time, so no drastic drops in rumen pH should be seen if ration fiber amount and length are adequate. Forage should be available ad lib for best results.

52.Water -- A cow requires 15 to 25 or more gallons of water per day.

A study at the Iowa Experiment Station showed that cows given free choice water produced 3.5% more milk and 10.7% more butterfat than cows watered twice a day at an outside tank.

CHECKLIST FOR FAT TEST PROBLEM SOLVING

Refer to Topic#:

Do you think the problem is nutritional in nature?

Is the ration balanced: Fiber........................28, 35, 44, 36

Protein (total and solubilities)..............45, 46, 44

Energy........................44

Minerals....................46, 44

Vitamins....................44

For the correct production and body weight?...........44

Are the forage analyses current for feeds being fed?..44

Are the cows eating what you think they are (pounds fed vs refusals; are coarser, high fiber forages refused)?..33, 28, 44

Is the forage : concentrate ratio 40:60 or greater?...29

Are the forages chopped too finely?..................31, 32, 15, 36

Does a great deal of the ration's fiber come from the grain?...31, 43

Are all ration components acidic (fermented)?.........22, 34, 39

Are large amounts of a fermented, high moisture grain being fed?.................................39, 22, 37, 38

Are forages fed before grain?.........................48

Is a pelleted grain or a grist being fed?.............40, 15

If a buffer or additive is fed, is the amount adequate according to recommendations to show results?...16 - 19, 21, 22, 25

Is the correct buffer or additive being used to acheive the desired results?.......................16 - 27

Is there feed in front of cows at all times?..........49, 50

Are cows fed grain only 2x a day?.....................48, 50, 51

Are the cows ruminating?.............................30, 14, 13

Had any sudden ration changes been made?..............47

Are ration changes made gradually?....................47

Is adequate water available?..........................52

Is the low test due to a factor other than nutrition?

Is the herd's somatic cell count high?................11

Is the majority of the herd in early lactation?.......2

Do the herd's low testing cows freshen at about the same time?..................................3, 2

Does the herd have a history of using bulls that were minus on fat test?............................3

Are the cows milked out completely? Is someone new milking the cows now?..........................7

Are 12 hour milking intervals or something near to that followed?....................................6

Are fat globules, or a heavy film seen in the bulk tank when it is drained?..........................8, 9

DAIRY FEEDING PROGRAMS AND REPRODUCTION

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Reproductive management continues to be a challenging area for dairy herd managers. Numerous studies have indicated that optimizing reproductive efficiency can help to maximize profit in a dairy herd. The data in Table 1 from Washington State University quantifies the relationship between calving interval and potential profit. The costs in Table 1 do not include any increased costs which may be required to alter reproductive performance.

Table 1. Economics of Selected Calving Intervals[a]

Calving Interval Days	Months	Return per cow to operator labor and management	Loss per Cow relative to a 383 day calving interval
365	12.0	$224	$3
383	12.8	$227	0
395	13.0	$226	$1
425	14.0	$169	$58
435	14.3	$137	$90

[a]Wilett and Ehlers, Washington State University, 1980.

By improving the reproductive efficiency of the dairy herd you can improve the efficiency of milk production and reduce costs. Longer calving intervals result in fewer calves, increased breeding fees and increased veterinary costs. Longer dry periods and an increased number of days at lower levels of milk production also tend to lower income.

There are a large number of factors which influence the overall efficiency of the reproductive management program. The major factors include:

A. Herd Management

1. Calving management
2. Heat detection
3. Nutrition

B. Health Management

1. General health
2. Reproductive health

C. AI Management

1. Bull fertility
2. Semen quality
3. Semen handling
4. Insemination timing and technique

With the large number of factors involved in reproductive management, the development of a team approach can pay valuable dividends. This team could include the herd manager, the herdsperson, AI technician, veterinarian, feed dealer and Extension agent. You will have to determine who the appropriate team members are in your particular situation.

Reproductive Management Goals

A key factor in any program is to have a set of goals to work towards. The following goals are suggested for your overall reproductive management program.

Measure	Goal
Calving interval	12-13 months
Actual days-calving to 1st service	75 or less
Days open-cows not bred	< 75
Days open-all cows	< 115
Conception rate	55% or higher
Breedings per conception	< 2
Heat detection efficiency	70% or higher

The Importance of Nutrition

Nutrition is one of many factors which can influence reproductive efficiency. There are 2 key points to keep in mind when attempting to relate nutrition and reproductive performance. These are:

1. Nutrition is only one possible cause of poor reproduction. The other factors which influence reproduction cannot be neglected. Problems such as poor heat detection, poor sanitation and hygiene at calving time should be ruled out before evaluating nutritional causes for breeding problems.

2. There is relatively little known with certainty about the interactions between nutrition and reproduction. Nutrient deficiencies, excesses or imbalances have all been demonstrated to alter reproductive performance. However, the actual degree of excess, deficiency or imbalance which is required to alter reproduction is not clear.

Specific Nutritional Considerations

All nutrients have at some time or another been linked with some aspect of reproductive performance. However, there are some nutrients which require specific attention in this relationship.

A. Energy - This may well be the most important nutritional factor related to reproductive performance. Animals which have inadequate energy intake or are in negative energy balance have been shown to have decreased reproductive performance. At the same time, excessive energy intake during late lactation or the dry period may result in "fat cow" problems which also lower reproductive performance.

   A critical factor in many herds is the relationship between energy intake in early lactation and the initiation of normal estrous activity. The larger the negative energy balance during this period, the longer the interval to first ovulation. Cows with low energy intake may also have an increased incidence of silent heats, lower conception rates and longer calving intervals. In a recent Cornell study, cows which a body condition loss of more than 1 point had longer intervals to first ovulation and estrus, lower first service conception rates and more days open.

B. Protein - Adequate quantities of protein must be provided. Inadequate protein intake has been reported to decrease reproductive performance. However, recent work has also indicated that excessive protein intakes may result in an increased number of services per conception and longer calving intervals. It appears that protein intakes in the range of 10-15% in excess of requirements may impair reproductive performance. Not all research has been consistent on this point. In addition, high levels of soluble or degradable protein may also impair performance.

C. Minerals - It is quite common to link mineral deficiencies and imbalances to reproductive performance. There is no question that adequate quantities of minerals must be provided. The actual effects of mineral deficiencies, imbalances or excesses on reproductive performance are not well documented.

Phosphorous is one mineral which is most often linked with reproduction. Low phosphorous intakes have been associated with anestrus, decreased ovarian activity and low conception rates. Current NRC requirements appear to be adequate to maintain normal reproductive performance.

Selenium is another mineral which has received much research attention. Selenium deficiencies in dry cows have been reported to be associated with an increased incidence of retained placentas. Dairy cattle rations in New York should be supplemented with 0.1 ppm of selenium which is the current FDA limit. However, there are cases, where this level of supplementation may still not elevate tissue levels to the desired levels. You should work closely with your herd veterinarian relative to other potential methods of selenium supplementation.

Most other minerals have in some studies been shown to have an impact on reproductive performance. Calcium, manganese, copper, zinc and iodine appear to be the ones with the most potential for influencing reproduction.

D. Vitamins - Vitamins A and E appear to be most related to reproduction. Deficiencies of Vitamin A have been shown to depress reproductive performance. Signs may include abortion, birth of weak calves, retained placentas and metritis. Beta-carotene is a precursor of vitamin A. There is still debate as to whether there is a specific beta-carotene requirement in addition to vitamin A.

Vitamin E is important because of its association with selenium. Again, evidence to link vitamin E directly with reproduction is limited. Vitamin D is important due to its function in calcium and phosphorous metabolism.

Summary and Recommendations:

It is clear from the above information that nutrition is an integral component of a total reproductive management program. Unfortunately, the exact relationships between nutrition and reproduction are not as clear as would be desirable. At this time, it appears that the following considerations should be kept in mind to provide a nutritional program to assist in providing the basis for an overall reproductive management program. Key points to consider are:

1. Feed balanced rations that are based on high quality palatable forages. Use forage testing and feed programming to develop rations based upon the forages which you have available.

2. Provide a balanced feeding program that meets nutrient needs at <u>all</u> stages of the lactation cycle.

3. Use feeding management practices that will maximize feed intake during early lactation. Proper use of these techniques will minimize "off feed" cows and metabolic disorders which impair reproductive performance.

4. Make sure that early lactation cows receive and consume adequate quantities of both energy and protein. Monitor dry matter intake. Look at the energy/protein balance.

5. Avoid feeding excessive amounts of total protein. The extra protein is costly and will not result in additional milk production. Excessive protein <u>may</u> impair reproductive performance. A consideration of protein types is also important. About 60% of the total protein should be degradable and about 50% of the degradable protein should be in the soluble form. Avoid high levels of soluble and degradable protein intakes.

6. Attempt to minimize early lactation weight loss and negative energy balance. The best approach to this is the stimulation of dry matter intake.

7. Provide adequate quantities of <u>all</u> minerals especially phosphorous. Try to maintain a Ca:P ratio of 1.5:1 to 2.5:1. Avoid feeding excessive quantities of minerals.

8. Supplemental selenium should be added to all rations at recommended levels.

9. Supplement rations with adequate amounts of vitamins A, D and E.

10. Provide balanced dry cow rations including minerals and vitamins. Milk fever has been shown to impair reproductive performance.

11. Avoid overconditioned dry cows. Fat cows have increased calving difficulty and more postcalving metabolic and reproductive disorders. Use body condition scoring to assess the dry cows. A condition score of 3+ to 4- is suggested at calving time.

12. The approach to nutrition must be a continuing, long-term approach. Reproductive problems related to nutrition may develop over a period of time. Corrections or adjustments will also take time.

13. Work closely with your feed dealer, veterinarian and Extension agent to assure that your nutrition program is on target and meeting the nutritional requirements of the cow.

Pearson Square - A Useful Tool in Dairy Ration Formulation

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The Pearson square is a method which can be used to formulate total mixes, grain mixes or mineral mixes. Even though this procedure can handle only a limited number of ingredients, it can be useful in many situations. This procedure is simple, rapid and easy to use. This paper will provide an overview of the steps involved in utilizing this procedure.

<u>Points to Remember</u>:

1. Always subtract diagonally across the square.
2. The results of the subtraction must always be positive.
3. One ingredient must be lower than the desired value while the other value must be higher than the desired value.

<u>Example 1</u>:

Assume that it is desired to formulate an 18% crude protein grain mix. Ingredients available are soybean meal (48% CP) and shelled corn (10% CP).

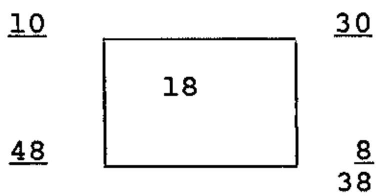
<u>Steps</u>:

1. Draw a square and write the desired CP% in the center.
2. Enter the % CP from shelled corn in the upper left hand corner.
3. Enter the % CP from soybean meal in the lower left hand corner.
4. Subtract diagonally across the square always subtracting the smaller number from the larger number. List your answers on the right corners of the square.
5. The value on the upper right corner represents parts of the total mix from corn.
6. The value on the lower right corner represents parts of the total mix from soybean meal.

7. Add the numbers in the right corners to obtain the total parts in the mix.

8. Determine the proportion of corn in the mix by dividing the parts of corn by the total parts in the mix.

9. Determine the proportion of soybean meal in the mix by dividing the parts of soybean meal by the total parts in the mix. Alternatively, the proportion of soybean meal can be determined by subtracting the proportion of corn in the mix from either 1.0 or 100%.



30/38 = .789 (or 78.9%) corn

8/38 = .211 (or 21.1%) soybean meal

If batch size is 3,000 lbs then:

3000 x .789 = 2367 lbs corn
3000 x .211 = 633 lbs soybean meal

Example 2:

Assume that you want to formulate a 23% CP grain mix using concentrates (2/3 corn and 1/3 oats) and protein supplements (equal parts of 44% soybean meal and 60% corn gluten meal). In this case, the average protein contents of the concentrate and protein supplements needs to be determined before using the Pearson square.

2 parts corn x 10	=	20
1 part oats x 12.5	=	12.5
Total		32.5

Average protein in grain = 32.5/3 = 10.8%

1 part soybean meal x 44	=	44
1 part corn gluten feed x 60	=	60
Total		104

Average protein in supplement = 52%

10.8		29
	23	
52		12.2
		41.2

29/41.2 = .704 (70.4%) concentrates
12.2/41.2 = .296 (29.5%) protein supplement

If batch size = 5,000 lbs then:

5000 x .704 = 3520 lbs concentrates
5000 x .296 = 1480 lbs protein supplement

To determine the amounts of the individual ingredients:

3520 x .667 = 2348 lbs corn
3520 x .333 = 1172 lbs oats

1480 x .5 = 740 lbs soybean meal
1480 x .5 = 740 lbs corn gluten meal

Example 3:

You want to determine the forage concentrate ratio for a total mixed ration. The required nutrient density is 0.74 Mcal NE_1/lb of dry matter. The forage available is a 50:50 mix (DM basis) of corn silage and alfalfa haylage with an average NE_1 content of .635. The concentrate to be used contains .84 Mcal NE_1. These NE_1 values are on a dry matter basis.

.635		.10
	.74	
.84		.105
		.205

.10/.205 = .488 (48.8%) forage
.105/.205 = .512 (51.2%) concentrate

Thus, the F:C ratio on a dry matter basis would be 49:51.

WHAT'S NEW IN THE 1988 NRC?

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The 1988 revision of the National Research Council (NRC) publication titled "Nutrient Requirements of Dairy Cattle" finally became available in August. Periodically, the NRC appoints a committee of scientists to review research data relating to dairy cattle nutrition. The responsibility of the committee is to determine if adequate research data exists to justify revising the nutrient requirement tables. The previous dairy cattle requirement tables were published in 1978. The purpose of this paper is to present an overview of the major changes.

A. DRY MATTER INTAKE

There have been some major adjustments in this area. These include:

1. Prediction tables are labelled for mid and late-lactation cows which have attained peak dry mater intake.

2. Tables include enough dry matter intake to support maintenance, milk production and a daily gain equal to .055% of body weight (i.e. 0.7 pounds for a 1300 lb cow).

3. It is noted that expected intake of early lactation cows may be about 18% less than table values.

4. A decrease in intake equal to 0.02% of body weight for each 1% increase in ration moisture above 50% is indicated.

5. The table has been expanded and now goes up to 130 pounds of milk per day.

6. The 1988 predicted intakes are consistently higher (Table 1) by 0 to 25%.

7. Predicted intakes in the 1988 NRC are determined by dividing the required daily energy requirement by the ration energy concentration.

The dry matter intake predicted from any table should be used as only a starting point for ration formulation. A monitoring system should be developed in your herd to fine-tune these estimates for your herd.

B. ENERGY

1. No changes in requirements for either lactating or dry cows.

2. There have been a few minor changes in the energy values of individual feeds listed in the feed composition table.

3. Feed composition table values in both 1978 and 1988 for TDN are at a maintenance level of intake.

4. Feed composition table values in both 1978 and 1988 for NE_1 are at an intake 3 times maintenance.

5. Both 1978 and 1988 NRC table NE_1 values assume a constant depression of 4% per multiple increase in intake over maintenance.

C. FIBER

1. ADF minimum values for lactating dairy cows were 21% for all levels of milk production in 1978. The 1988 NRC lowers this to 19% for high-producing cows and maintains the 21% for other milking cows.

2. The 1988 NRC incorporates a NDF requirement for milking cows. The minimum ration NDF ranges from 25 to 28%.

3. Feed composition table NDF values are analytical values and are not adjusted to reflect "effective" NDF values. Table values for high NDF concentrate sources need to be adjusted downward if rations are formulated using table NDF requirements.

D. PROTEIN

The major change in the new NRC is in the protein area. Two methods of expressing protein requirements are provided. One is the traditional method using total crude protein requirements. A second system utilizes degraded intake protein (DIP) and undegraded intake protein (UIP). This system is a refined system which permits more efficient utilization of dietary protein.

1. Total Crude Protein

There are only slight adjustments in the 1988 NRC when compared with 1978. Maintenance requirements have been increased by about 5 to 15%. Requirements for milk production are similar to 1978. The overall effect is that the total daily crude protein requirements will be 100-102% of the 1978 value.

2. **Absorbable Protein**

The absorbable protein requirements are based on the 1985 NRC publication titled "Ruminant Nitrogen Usage." This 1985 publication provides an in-depth description of the rationale and methodology for developing these requirements. The application of this system requires formulating rations for two specific protein fractions. These are:

Degraded intake protein (DIP - This fraction represents the proportion of the total protein intake that is degraded in the rumen. Soluble intake protein (SIP) is included within this fraction.

Undegraded intake protein (UIP) - This fraction represents the proportion of the total protein intake that is not degraded in the rumen. Bypass or escape protein are terms which have previously been used to describe this fraction. ADF-N is a component of the UIP fraction.

The 1988 NRC publication incorporates a table which provides UIP values for common feedstuffs. Table 2 contains sample DIP and UIP requirements for dairy cattle.

E. Minerals

There have been a few changes in the 1988 NRC. These include:

a. Calcium - The 1988 NRC assumes an average feed calcium availability of 38% versus the 45% in the 1978 NRC. This will effectively increase total daily calcium requirements by about 20%.

b. Phosphorous - An average feed phosphorous availability of 45-50% is assumed in the 1988 publication. The 1978 NRC used a value of 55%. This will increase total daily phosphorous requirements by 10-20%.

c. Magnesium - No changes for mid or late lactation cows. However, the requirement for early lactation and high producing cows is increased from 0.2 to 0.25% of the total ration dry matter.

d. Potassium - The requirement for lactating cows is increased to 0.9-1.0% of total ration dry mater from 0.8%.

e. Sodium - No changes.

f. Sodium chloride - This requirement has been deleted.

g. Chloride - This is a new requirement which has been added to the 1988 NRC. The requirement for lactating dairy cows is set at 0.25% of the total ration dry matter. This requirement is based upon research work done at Cornell.

h. Sulfur - The only change is for early lactation cows (weeks 1-3 of lactation) with a requirement of 0.25% of the total ration dry matter.

i. Iron, cobalt, copper, zinc and manganese - No changes.

j. Iodine - Requirement for lactating dairy cows have been increased to 0.6 ppm from 0.5 ppm.

k. Selenium - Requirements for all cows and heifers have been increased from 0.1 to 0.3 ppm. The 0.3 ppm level corresponds to the current FDA maximum addition level.

l. Maximum tolerable levels - This listing has been expanded. The values listed are:

	% of DM		ppm
Calcium	2	Iron	1000
Phosphorous	1	Cobalt	10
Magnesium	0.5	Copper	100
Potassium	3	Manganese	1000
Sulfur	0.4	Zinc	500
		Iodine	50
		Selenium	2

F. VITAMINS

1. Vitamin A - Increased from 1450 to 1800 IU/lb for early lactation cows. A maximum value of 30,000 IU/lb of dry matter is indicated.

2. Vitamin D - Increased from 140 to 450 IU/lb for all milking cows. A maximum of 4500 IU/lb is listed.

3. Vitamin E - A new requirement of 7 IU/lb of dry matter was listed. The maximum is listed as 900 IU/lb.

G. OTHER NOTES

1. Lactating cow requirements are provided for 5 rather than 4 levels of milk production.

2. A new column of requirements has been provided for cows in the first 3 weeks of lactation.

H. DRY COWS

1. Ration ADF is increased from 21 to 27% of the total ration dry matter. A new requirement of 35% NDF has been added.

2. Ration potassium content has been decreased to 0.65% from 0.8% of the total ration dry matter.

3. A chloride requirement of 0.20% has been added.

4. Ration iodine content has been lowered from 0.5 to 0.25 ppm.

5. Selenium is increased to 0.3 ppm.

6. Vitamin requirements are 1800, 540 and 7 IU/lb for A, D and E.

I. CALVES AND HEIFERS

1. Protein content of calf starter mix is increased from 16 to 18% on a dry matter basis.

2. Nutrient requirements are provided for heifers between 0-6, 6-12 and > 12 months of age. In 1978, there was only 1 set of requirements for these animals.

3. Protein requirements for both UIP and DIP are provided. However, there is an error in the equation used to generate these requirements. Thus, the printed requirements are incorrect. This should be corrected in the near future.

4. A chloride requirement of 0.20% of the total ration dry matter has been added.

5. The ration selenium content has been increased to 0.3 ppm.

6. A vitamin E requirement of 11 IU/lb of ration dry matter has been added.

J. COMPUTER DISKETTE

A computer diskette is also included as part of the nutrient requirements for specific animals. There appear to be a few differences in the protein area between the diskette and the printed tables. Thus, some caution must be used until these differences are sorted out.

SUMMARY

The 1988 NRC publication on the nutrient requirements of dairy cattle provides some updated information for ration formulation purposes. The major changes are the addition of NDF, a vitamin E requirement and an absorbable protein system. Most companies are currently updating their computer programs to reflect these changes.

Table 1. Comparative Dry Matter Intakes -- 1988 vs 1978 NRC

4% FCM (lbs)	Body Weight (lbs, % of BW) 880	1100	1320	1540
33	3.2 (2.8)*	2.8 (2.5)	2.6 (2.4)	2.3 (2.3)
55	4.0 (3.4)	3.5 (3.1)	3.2 (3.0)	2.9 (2.8)
77	5.0 (4.0)	4.2 (3.6)	3.7 (3.4)	3.4 (3.2)
99	--	5.0 (4.0)	4.3 (3.8)	3.8 (3.6)
121	--	--	5.0	4.4 --

*1978 NRC

Table 2. UIP and DIP Requirements[a]

Body Weight, lbs	Milk, lbs	Milk Fat, %	DIP lbs	UP, lbs
900	29	5.0	2.34	1.55
900	58	5.0	3.90	2.34
1100	36	4.0	2.70	1.71
1100	73	4.0	4.46	2.65
1300	47	4.0	3.42	2.07
1300	93	4.0	5.61	3.24
1500	52	3.5	3.69	2.18
1500	104	3.5	6.01	3.40

[a]Adapted from Appendix Table 4, 1988 NRC.

VITAMIN NUTRITION IN GROWING AND LACTATING ANIMALS

C. J. Sniffen and L. E. Chase

Introduction

Much time is spent on balancing rations for protein, energy and minerals. We always assume that the dairy concentrate being fed or the mineral supplement being mixed has adequate vitamins and that the vitamins will be balanced. Few of us calculate the vitamin requirements and balance for them. We frequently see vitamins overfed and, on some occasions, have seen rations where the vitamins have been absent or below recommendations.

Vitamin supplementation in dairy rations has been shown to be consistantly efficacious only for A, D and, for the young calf, E. Recently, strong evidence would suggest that E should be supplemented in the growing, dry and lactating animal's diet. Generally C, K and the B vitamins have been found to either be produced by the animal in sufficient quantities, are in more than adequate amounts in feeds that are commonly consumed by dairy cattle and/or are produced in sufficient quantities by the microflora in the rumen and in the small intestine. These assumptions have recently been challenged with research showing that niacin may be required under certain conditions and, more recently, research from Maryland would suggest that the addition of choline may be required. All the vitamins are required by the dairy animal. The question that continually needs to be answered is, are there enough vitamins being provided either endogenously, from the gut microflora, or from the feed to meet the needs of the high levels of productivity in dairy animals today? The recent research with vitamins E, niacin and choline suggest that we need to re-examine our assumptions concerning dietary requirements as animal productivity increases.

Sources and Biochemistry

Vitamin A has been supplemented in dairy rations for a long time. It has been classically shown to be important in vision and the most widely accepted hypothesis is that it is necessary for the synthesis of glycoproteins which control cell differentiation and involvement in the control of gene expression. There are many forms of Vitamin A with varying levels of activity.

Vitamin A compounds are absorbed mainly with the lipids and are converted to retinol in the intestinal mucosal lining or other organs.

B carotene is a precurser to Vitamin A and there is preliminary evidence that suggests that it acts as an antioxidant and a potent quencher of singlet oxygen thus reducing free radicals and is indirectly responsible for immunoenhancements.

Vitamin D is required in the ration by dairy animals that are excluded from exposure to sunlight. The normal forms of Vitamin D are D_3 which come from photoproduction from 7-dehydrocholesterol and D_2 which is commonly found in plants. The dietary D, like A, is taken up via the fat absorption, goes to the liver and is converted to 25-hydroxy-vitamin D (25-OH-D). This form is converted to 1,25-dehydroxy-vitamin D (1,25-$(OH)_2$-D) almost exclusively in the liver and is the active metabolite. This metabolite, along with parathyroid hormone, maintains calcium and phosphorus homeostasis. Research is now suggesting that the metabolites may have a more metabolic activity such as bone formation.

Vitamin E has been recognized as an essential nutrient for many years. The name Vitamin E, like the other vitamins, is a general description for a number of derivatives of 5,6,7-trimethyltocol. There are eight or more compounds distributed in nature. The most common are d -Tocopherol and the acetate of that compound (an esterification compound). The Vitamin E compounds are metabolized at the mucosal surface of the small intestine to tocopherol alcohols and absorbed with the fat. The vitamin is present in tissues as free tocopherols. Tocopherols act in the transfer of hydrogen for the reduction of free radicals within the cell. It is a powerful biological antioxidant. As a result of this, it acts as an enhancer for the immune system. This can positvely impact cell integrity and potentially help reduce mastitis. The interaction with selenium is now understood. Selenium is an essential part of the enzyme glutathione peroxidase which is involved in the metabolism of hydroperoxides. Vitamin E and selenium act together as parts of a multicomponent antioxidant defense system. The system protects against the oxidation of membrane phospholipids and critical proteins.

Niacin for ruminants is in adequate supply being synthesized in the rumen via the quinolic acid pathway and also from the amino acid tryptophan. However, recent evidence has suggested that there may be times when niacin needs to be supplemented. Niacin is a generic term for a number of derivatives. It is found in cereals which is in a bound form. The amino acid leucine acts as an antagonist in the conversion of tryptophan and is usually in excess quantities in ruminant feeds.

The most biologically active forms are nicotinic acid and nicotinamide. Nicotinamide is essential in some 35 oxidation-reduction reactions in the body playing physiologically critical roles in mitochondrial respiration and in the metabolism of lipids, carbohydrates and amino acids. Both forms of niacin are absorbed by simple diffusion across the intestinal mucosa. Nicotinamide diffuses at about twice the rate of nicotinic acid. The acid form is converted in the mucosa to the amide form. Nicotinamide is taken up by tissue and converted to its coenzyme forms of NADH and NADPH which are involved in the mitochondrial electron transport chain.

Choline is not a true vitamin, in the classical sense, but is important, as is methionine and cysteine/cystine, as a source of labile methyl groups. Choline appears in the free form as a component of lecithin, acetylcholine and other phospholipids. It is most commonly supplemented as choline hydrochloride which can be in either liquid or solid form. Other forms used are choline dihydrogen citrate or cytidine diphosphate choline (CDP-choline). Choline is abundant in soybeans but may be in an unavailable form. Absorption presumably takes place in the small intestine. Choline serves as a neurotransmitter (acetyl choline), serves a structural function as phoshatidyl choline (lecithin) in biological membranes and in lipid utilization. Choline has also been shown to be important in the transformation of the immunoreactive cells, thus playing a role in the immune system.

The other vitamins, K, ascorbic, thiamin, riboflavin (B_2), Vitamin B_6 (Pyridoxine), folic acid, pantothenic acid, vitamin B_{12} and biotin have, to this point, been shown to be provided in adequate quantities by either the gut microflora or diet and will not be discussed here. It should be added, however, that veterinarians have used injections of B complex in herds with high stress levels and have felt that it has helped. Much research needs to be done in this area as we move to higher levels of productivity.

Supplementation

The requirements from 1978 dairy NRC are listed in Table 1. Recent research would suggest that the vitamin D requirement is about 3 times current recommendations and that there should be a requirement for vitamin E for all classes of dairy animals. It is important to note the maximums for A, D and E. These come from the recently published NRC publication on vitamin tolerance in animals.

Overfeeding vitamin A is apparently not a problem but recent research provides evidence that vitamin D should not be overfed especially when calcium and phosphorus are adequate or in excess, as is the case in many of our rations. It can lead to calcification of soft tissue and an increased oppurtunity for disease. If one calculates the amount of vitamin D being supplemented in a typical lactating cow ration from all sources, it can at times be quite excessive. For example, if we make a generous assumption of 3x the current NRC system as required by the early lactating cow consuming 48 lbs of dry matter, there is a requirement of 20,000 IU/day. The suggested maximum allowed for continuous feeding is 48,000 IU/day. A typical mineral source will range from 50,000 to 200,000 IU/lb. Most typical would be 150,000 IU/lb. To meet requirements one should not feed more than .13 lb or 2 oz of a mineral supplement/day. To not exceed safety limits they should not feed more than .3 lbs/day or 5 oz. The bottom line is that we should be careful about our long-term vitamin D supplementation in ALL phases of the dairy operation. It would appear, at this time, that there is not concern for overfeeding vitamin A or E. However, it would seem prudent to carefully meet the animal requirement and not exceed them.

Vitamin E has received much attention lately. It has been known that vitamin E is important in white muscle disease in calves and relatively recent Ohio work has shown that vitamin E interacts with selenium in preventing reproductive disorders such as retained placenta and reducing mastitis. Recommendations for inclusion in lactating animal diets must wait for the publication of the new recommendations for dairy cattle to be published later this year.

Extensive research with niacin has shown that feeding 7-10 g/day may be beneficial for cattle in excellent condition going into the lactation. There has been recent work which would suggest that niacin would also be beneficial for cows on high fat diets to overcome depressed milk protein. It is suggested that the addition of niacin might be viable for the high producing herd with good condition and that it be supplemented in the two week prepartum ration out through peak of lactation. It would appear that as we move into higher levels of productivity we may find more instances where there are inadequate amounts of B complex vitamins being provided by the GI tract microbial mass and supplementation will be required.

Preliminary studies at Maryland by Erdman have been done feeding choline to lactating cows. The first study, feeding either 18.6 or 33.5 g/cow/day in a low forage diet (30% corn silage, 70% concentrate), resulted in a 9% increase in fat test (from 3.43 to 3.77) at the 33.5 g level. A subsequent study showed no response. The effects of diet on the stimulation of rumen supply are complex. The data would suggest that there are times when supplies might be limiting. More work needs to be done defining dietary conditions under which choline is needed in the diet.

Table 2 lists some suggested DELIVERED vitamin concentrations in various types of supplements. These recommendations are lower than what is currently being practiced. Much of this is based on the early lactation cow. It is equally important to calculate the requirements for all classes of animals on the farm not covered in the table.

A question may arise as to the IU actually delivered. It is known that vitamins placed in mineral packages are oxidized rapidly; therefore vitamin premixes have been developed which inhibit oxidation with the use of antioxidents. It has also been shown that the pelleting process can reduce the vitamin A potency in a feed by as much as 30-40 %. When vitamins are added care must be taken to account for vitamin sources and losses and to guarantee the producer a potency level on the farm for the average time the product will be on the farm. This becomes especially critical in large freestall operations using mainly fermented feeds with little exposure to sunlight and higher degrees of stress due to high productivity and being on concrete. One must also be careful in recognizing the form of vitamin and the conversion factors for ration inclusion. Some of these conversions are given in Table 3. Be sure to check labels carefully.

The vitamin program on the farm needs to be tightened up. This means that we need to pay more attention to the DELIVERED level of vitamins in our dairy concentrates, supplements and premixes. Vitamin recommendations are changing and will probably be reflected in the new dairy NRC publication. It is definitely an area that we need to stay on top of.

References

Erdman, R. A., R. D. Shaver and J. H. Vandersall. 1984. Dietary choline for the lactating cow: Possible effects on milk fat synthesis.

National Research Council. 1987. Vitamin Tolerance of Animals. National Academy of Sciences, Washington, DC.

Technical Symposium. 1987. The role of vitamins on animal performance and immune response. Hoffmann-La Roche, Nutley, NJ.

Table 1. Vitamin Requirements of Dairy Animals

Vitamin	Calf Milk Replacer	Calf Starter	Growing			Dry	Lactating		
			3-5	5-12	>12		Early	Mid	Late
A, IU/lb[a]	1720	1000	1000	1000	1000	1450	1450	1450	1450
D, IU/lb[b]	270	140	140	140	140	140	140	140	140
E, IU/lb[c]	136	---	---	---	---	---	---	---	---

[a]Maximum level 29,945 IU/lb
[b]Maximum level 1000 IU/lb
[c]Maximum level 34 IU/lb BW

Table 2. Vitamin Incorporation in Different Supplements[a]

Vitamin	Milk Replacer	Calf Starter	16% Dairy	20% Dairy	32% Dairy	Mineral Suppl.
Assumed intake	Total	6 lbs	-50% of	ration-	25% of ration	.5 lb/day
A	1920	1000	3000	3000	4440	139,200
D	270	140	286	286	428	13,440
E	136	--	--	--	--	--

[a]IU/lb dry matter.

Table 3. Conversion Factors and Equivalencies

Vitamin A

1 IU = 1 USP Unit
= Vitamin A activity of 0.300 microgram crystalline Vitamin A alcohol
= Vitamin activity of 0.344 microgram vitamin acetate
= Vitamin A activity of .550 microgram vitamin A palmitate

1 IU Vitamin A = 0.6 microgram beta-carotene
1 mg beta-carotene = 1,667 IU Vitamin A

Vitamin D

1 IU = 0.025 ug vitamin D_3

Vitamin E

1 IU - 1 mg dl - a - tocopherol acetate

United States-Canadian Tables of Feed Composition

Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by
lb	g	453.6
lb	kg	0.4536
oz	g	28.35
kg	lb	2.2046
kg	mg	1,000,000.0
kg	g	1,000.0
g	mg	1,000.0
g	μg	1,000,000.0
mg	μg	1,000.0
mg/g	mg/lb	453.6
mg/kg	mg/lb	0.4536
μg/kg	μg/lb	0.4536
Mcal	kcal	1,000.0
kcal/kg	kcal/lb	0.4536
kcal/lb	kcal/kg	2.2046
ppm	μg/g	1.0
ppm	mg/kg	1.0
ppm	mg/lb	0.4536
mg/kg	%	0.0001
ppm	%	0.0001
mg/g	%	0.1
g/kg	%	0.1

Minerals in Dairy Cattle Nutrition

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Introduction

Dairy cattle require at least 16 minerals in the ration for efficient milk production and the maintenance of normal herd health and reproduction. Minerals are required for the maintenance, growth and replenishment of the skeletal tissues in the animal body. In addition, minerals are needed for many enzyme systems, maintenance of osmotic balance in the body, development and function of soft tissues and blood cells, muscular contractions and normal function of the nervous system. Minerals are generally classified as either macrominerals or microminerals depending upon the daily amounts required by the animal. Microminerals may also be termed trace minerals.

Macrominerals	Microminerals
Calcium	Iodine
Phosphorous	Iron
Magnesium	Copper
Potassium	Cobalt
Sodium	Manganese
Chloride	Zinc
Sulfur	Selenium
	Molybdenum

As the level of milk production in dairy cows has increased, the mineral feeding program becomes more critical. Small imbalances may, over a long period of time, develop into health, production or reproduction problems. In the field, it is uncommon to observe a true mineral deficiency problem. However, there are many situations in which variable degrees of underfeeding, overfeeding or imbalances of mineral intake do occur. This paper will not review the specific functions and deficiency symptoms for each of the above minerals. The approach will be on information which may be useful in problem solving situations.

Mineral Requirements, Allowances and Maximum Levels

The best current base for determining mineral requirements for dairy cattle is the 1978 NRC publication. However, many nutritionists make some adjustments to these requirements in practical ration formulation. This is probably the area of dairy cattle nutrition in which there is the largest variation in the actual levels used in ration formulation.

Overfeeding minerals is both expensive and at times may also result in health or production problems. Table 1 contains the NRC requirements for minerals and also the maximum safe level. The maximum safe level is not the level that causes a toxicity. The maximum safe level is rather a level at which animal performance may be impaired if these levels are fed for extended periods of time.

What Factors Influence Mineral Absorption and Utilization?

As with other nutrients, a large number of factors influence overall nutrient utilization. The most important ones which influence mineral utilization include:

1. Age of the animal - In many cases, as animals grow older, mineral absorption and utilization decreases. The best example of this is calcium. Young calves may absorb 90% of the calcium ingested in milk. However, mature, lactating cows may absorb only 22-25% of the ingested calcium.

2. Mineral element - It is thought that essentially all of the sodium, potassium and chloride ingested is absorbed in dairy cattle. However, only about 3-5% of the ingested manganese appears to be absorbed.

3. Availability of minerals in different feedstuffs - The type of feed may have an impact upon the amount of a given mineral absorbed. The best example is apparent absorption of magnesium from forage crops. Magnesium availability of hay is from forage crops. Magnesium availability of hay is approximately 25% while in lush, early spring grass it may be 10% or less. This is a prime factor in many grass tetany situations.

4. Interactions with other nutrients - High levels of potassium and nitrogen have been shown to depress magnesium utilization. The copper-molybdenum-sulfur interaction is another common example.

5. Amount of mineral consumed - In many cases, absorption as a percent of intake decreases as the amount of mineral ingested increases. Calcium, zinc and iron seem to be the minerals for which this has been most commonly demonstrated. Thus, feeding more mineral does not always result in more mineral being utilized by the animal.

6. Organic versus inorganic sources - Limited studies indicate that the organic form of many minerals are more available than the organic form.

What is Mineral Availability?

Mineral availability is commonly thought of in terms of biological availability. This basically refers to the ability of a specific mineral source to support physiological processes in the animal. The true measure of a mineral source is a combination of the mineral content and availability. A source with a high level of a mineral with a low availability may not be a good source for inclusion in rations.

What Are Some of the Differences in Mineral Availability?

True mineral availability is a very difficult and expensive quantification to obtain for lactating dairy cows. However, a limited data base does exist. Biological availability is usually expressed on relative rather than absolute terms. One source is selected as the standard and its availability according to the standard source. The results of a trial using this concept are in Table 2.

Tables 3, 4 and 5 contain data on relative availabilities for calcium, phosphorous, magnesium and sulfur sources. Limited work has indicated that the chloride, sulfate, acetate, citrate and biophosphate forms of potassium are similar in availability.

Research on the availability of the trace mineral sources is quite limited and often conducted with rats or chicks. However, a ranking of relative availabilities for the trace mineral sources would be as follows:

Availability	Form
Highest	Sulfate
	Carbonate
	Chloride
	Citrate
	Nitrate
Lowest	Oxide

<u>What About Mineral Interactions?</u>

The mineral metabolism picture is further complicated by the fact that a number of interactions occur between elements. Unfortunately, most of these interactions are not well defined or quantified. Figure 1 contains an overview of the complexity of this situation. Figure 2 is one specific example of the effect of levels of one mineral on the absorption of another.

A brief listing of some of the interactions which are known to exist include:

a. Copper-molybdenum-sulfur
b. Sulfur-selenium
c. Calcium-phosphorous
d. Calcium-zinc
e. Calcium-manganese
f. Potassium-magnesium

<u>Mineral Calculations</u>

A point of continual confusion is the calculations and conversions which are required in either formulating or evaluating the mineral content of the ration. This is because mineral content is usually expressed as either % or ppm. Practically, this means that conversions must be made between different systems of measurement. Some of the more common conversion factors are:

1 pound = 453.6 grams	1 kilogram = 2.2 pounds
1 pound = 16 ounces	1 kilogram = 1000 grams
1 ounce = 28.4 grams	1 gram = 1000 milligrams
1 ppm = mg\lb x 2.2	1 ppm = 1 mg/kg

Evaluating Mineral Feeding Programs

The process of evaluating the adequacy of a mineral feeding program is a similar process to any other nutrient. The general process would include:

1. Define what feeds and what quantities are fed per day
2. Define feed refusal and determine feed consumed
3. Obtain dry matter values on the feed(s)
4. Calculate daily ;mineral intake by multiplying feed consumed by mineral content
5. Compare with requirements

What About Tissue Samples?

In most cases, the best way to determine mineral adequacy is by calculating intake. However, in some cases, a tissue sample may also be a useful diagnostic tool. Unfortunately, blood samples are not very good for most minerals due to the homeostatic mechanisms in the body. The following is a list of the types of samples which may be most useful for some minerals:

Mineral	Samples
Magnesium	Plasma, urine
Selenium	Plasma
Sodium	Saliva, urine
Chloride	Saliva, urine
Copper	Liver, plasma
Zinc	Plasma
Iodine	Milk
Phosphorous	Plasma
Potassium	Plasma

Summary

Mineral nutrition is an important but complex area of dairy cattle nutrition. Many problem situations may represent borderline deficiencies or excess intake and are thus difficult to define. In addition, a mineral problem may develop over a long period of time and may require a considerable length of time to correct.

Table 1. Mineral tolerance and toxicity levels for lactating dairy cattle

Mineral	Minimum Requirement	Maximum Safe Level	Factor (Max Min)
Calcium, %	.4 - .6	2*	4
Phosphorous, %	.3 - .4	1*	3
Magnesium, %	.2	.5*	2.5
Potassium, %	.8	3*	3.7
Sodium, %	.18	1.6*	9
Chloride, %	.3	2.4*	8
Sulfur, %	.2	.4	2
Iron, ppm	50	1000	20
Cobalt, ppm	.1	20	200
Copper, ppm	10	80	8
Manganese, ppm	40	1000	25
Zinc, ppm	40	1000	25
Iodine, ppm	.5	50	100
Selenium, ppm	.1	5	50
Fluorine, ppm	?	30	?
Molybdenum, ppm	1*	6	6

*Estimate

Table 2. Bioavailability of phosphorous from different sources using chicks

Mineral Source	Bone Ash	Weight Gains	Average Biological Value
	(Relative Value)		
Monocalcium phosphate[a]	100	100	100
Supplement 1	87.5	106.2	96.8
Supplement 2	82.3	104.6	93.5
Supplement 3	90.2	100.3	95.2
Supplement 4	79.8	88.6	94.2

[a]Monocalcium phosphate is used as a standard test source and is assigned a value of 100. Other sources are ranked by comparing their performance with chicks receiving monocalcium phosphate.

Table 3. Relative availabilities of calcium and phosphorous from supplemental mineral sources used in ruminant diets[a]

Relative Availability	Calcium Source	Phosphorous Source
High (125-135)	Steamed bone meal (135)[b]	Monocalcium phosphate (125-135)
	Monocalcium phosphate (125-135)	Mono-disodium phosphate (115-125)
	Dicalcium phosphate (95-125)	Phosphoric acid (115-125)
		Ammonium phosphate (115-125)
		Dicalcium phosphate (105-115)
Medium	Calcium carbonate (100)	Steamed bone meal (90-100)
	Limestone (85-90)	Defluorinated phosphate (95-100)
		Sodium tripolyphosphate (95-105)
Low		Low fluorine rock phosphate (55-75)
		Soft rock phosphate (25-35)

[a]Adapted from Peeler, J. Anim. Sci., 35:695, 1972 and McGillivray, Proc. 1st International Minerals Conference, 1978.

[b]Approximate relative availabilities compared with a standard source.

Table 4. Approximate availabilities of magnesium from various sources

Source	Approximate Availability
Magnesium oxide	50 - 60%
Magnesium chloride	40 - 60%
Magnesium sulfate	40 - 70%
Magnesium carbonate	45 - 75%
Dolomitic limestone	10 - 30%
Forages	30 - 40%

Table 5. Relative availabilities of sulfur sources

Source	In Vivo Availability
Calcium sulfate	50 - 90%
Sodium sulfate	50 - 90%
Potassium & magnesium sulfate	50 - 90%
Elemental sulfur	30 - 50%
Methionine analog	65 - 80%

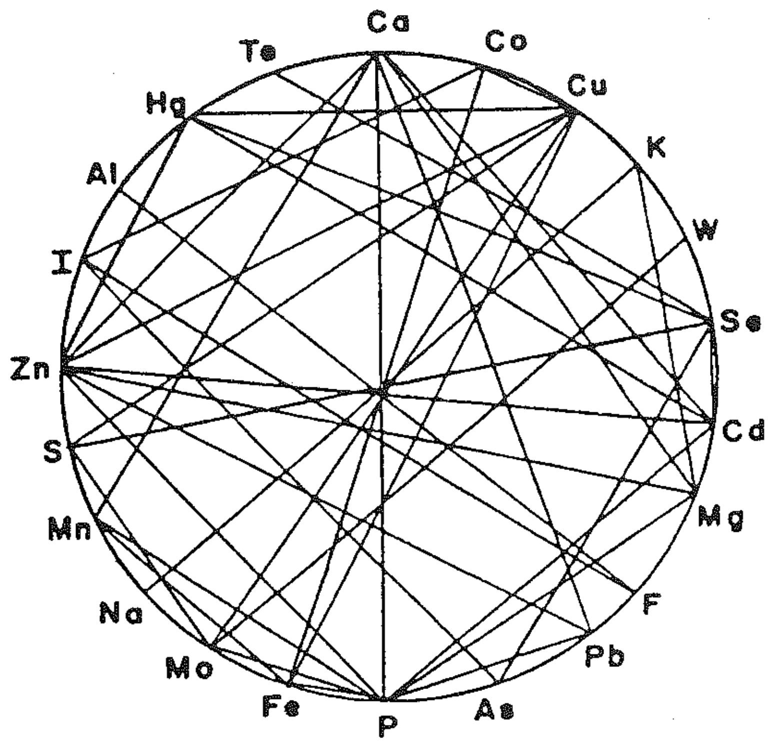

Figure 1. Mineral interrelationships (Miller, 1979)

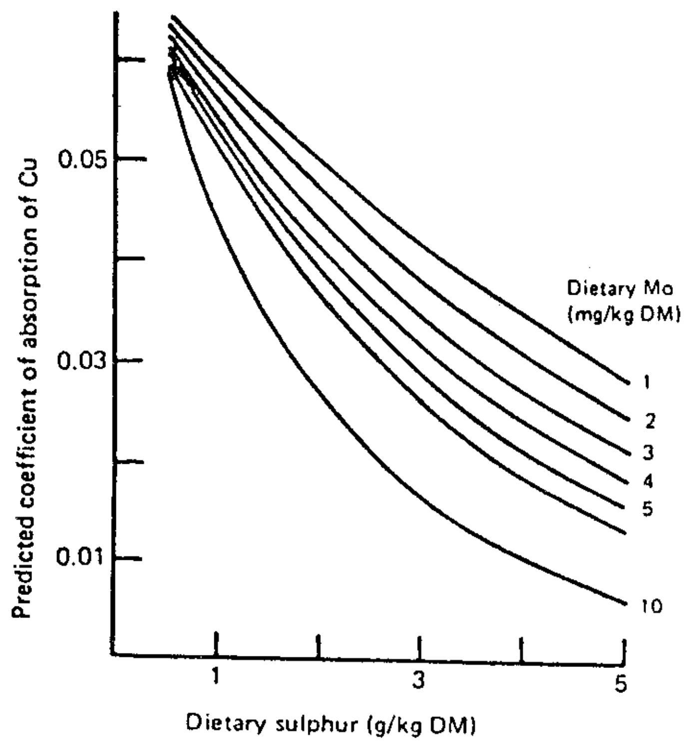

Figure 2. Influence of total dietary sulfur and molybdenum on absorption of copper in sheep

(Suttle and McLauchlan, 1976 as shown in ARC, 1980)

Selenium Supplementation of Dairy Cattle Rations

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Selenium is a trace mineral required by all animals. Even though only small quantities of selenium are required on a daily basis, deficiencies are frequently reported in the Northeast. The soils in the Northeast are quite low in selenium and as a result most of our forages contain < .05 ppm of selenium.

The current requirement of dairy cattle for selenium is given as 0.1 ppm in the total ration dry matter (NRC, 1978). It is anticipated that this will be increased to at least 0.2 ppm in the future when the revised NRC requirements for dairy cattle are published. The milligrams of selenium needed daily to meet these requirements is in Table 1.

Selenium supplementation of dairy rations with selenium is common in the Northeast. Selenium may be added through minerals, salt or concentrate mixes. However, the real question is how much selenium can be legally added?

The Food and Drug Administration (FDA) sets the guidelines for selenium addition. In the past, the limit has been an addition of 0.1 ppm of selenium to the total ration dry matter. However, this level was increased to 0.3 ppm on April 6, 1987. The following guidelines are currently provided for selenium addition by the FDA:

1. The supplementation level in the total ration is increased from 0.1 to 0.3 ppm.
2. This regulation includes chickens, turkeys, ducks, swine, cattle and sheep.
3. The additive is to be used in animal feed as a nutrient in the form of sodium selenate or sodium selenite.
4. The guidelines when selenium is incorporated into limit fed supplements are:
    a. Sheep - at a level not to exceed an intake of 0.7 Mg per head per day.
    b. Beef cattle - at a level not to exceed an intake of 3 Mg per head per day.

Note: It is assumed that dairy animals follow the beef guidelines.

5. The guidelines when selenium is incorporated into salt-mineral mixtures for free-choice feeding are:

   a. Sheep - up to 90 ppm in a mixture for free-choice feeding at a rate not to exceed an intake of 0.7 Mg per head per day.

   b. Beef cattle - up to 120 ppm in a mixture for free-choice feeding at a rate not to exceed an intake of 3 Mg per head per day.

Note: There is no provision for free choice salt-mineral feeds for dairy cattle.

6. Guidelines for methods by which selenium can be incorporated into feeds:

   a. No less than 1 pound of premix containing no more than 90.8 mg of added selenium shall be incorporated into 1 ton of complete feed. This is equivalent to a premix with 200 ppm (0.02%) selenium.

   b. A premix containing no more than 4.5 g of added selenium per pound shall be incorporated into each ton of salt-mineral mixture for beef cattle or sheep. This is equivalent to a premix with 9900 ppm (.99%) selenium.

7. The premix manufacturer should follow good manufacturing practices in the production of selenium premixes. Inventory, production and distribution records must provide a complete and accurate history of product production. Production controls must assure products to be what they are labeled. Production controls shall include analysis sufficient to adequately monitor quality.

8. The label or labeling of any selenium premix shall include adequate directions and cautions for use including the statement "Caution: Follow label directions. The addition of feed of higher levels of this premix containing selenium are not permitted."

It should be pointed out that the 90.8 mg per pound limit on potency is not in line with the new 0.3 ppm regulation. The 90.8 level is the same as with the old 0.1 ppm requirement. A petition has been filed by AFIA to have the 90.8 limit increased to 272.4 Mg. This change was approved by FDA on June 4, 1987.

The selenium content of mineral mixes and premixes may be listed on the feed tag in a number of ways. The most common are ppm and %. Table 2 provides a reference for converting values between these ways of reporting. This table also contains values for selenium content in terms of Mg/kg, Mg/lb and Mg/ton.

The FDA regulation is for the quantity of selenium which can be added to the total ration. However, the selenium is normally added via a grain or mineral mix. Thus, these feeds can contain selenium levels higher than the 0.1 or 0.3 ppm levels set by FDA. The actual level which they can contain will depend upon your estimate what % of the total ration this particular feed will represent.

Examples:

a. A 16% concentrate feed which is expected to comprise 50% of the ration. This feed could contain either 0.2 (0.1*2) or 0.6 (0.3*2) ppm of selenium.

b. A 40% protein supplement which is expected to comprise 20% of the total ration. This feed could contain either 0.5 (0.1*5) or 1.5 (0.3*5) ppm of selenium.

c. A mineral mix which is expected to comprise 1% of the total ration. This mineral could contain 10 (0.1*100) or 30 (100*.3) ppm of selenium.

Note: These examples assume that only source of supplemental selenium is added to the ration.

Table 3 contains information on the amount of various supplements which need to be consumed per day to meet selenium requirements. Note that with the 0.2 and 0.4 ppm supplements that it is difficult to supply much selenium with normal levels of intake.

Formulating Feeds and Minerals Containing Selenium

The actual formulation of a feed containing selenium is quite simple. The basic steps are:

a. Determine the total Mg's of selenium which need to be in the mix.

b. Determine the Mg/lb of the selenium premix being used.

c. Divide a by b. Result is the pounds of the selenium premix to be added per ton of feed.

Examples:

1. You want to manufacture a 18% CP grain mix which will contain 0.4 ppm of selenium. The premix you are using contains 200 ppm (.02%) of selenium.

   a. (2000 *.4536) * .4 = 363 Mg's

   b. 200 * .4536 = 90.7 Mg Se/lb

c. 363/90.7 = 4 lbs of the premix would be added per ton of feed

2. You want to manufacture a 38% CP supplement which will contain 1.0 ppm of selenium. The premix you are using contains 600 ppm (.06%) selenium.

   a. (2000 * .4536) * 1.0 = 907 Mg's

   b. 600 * .4536 = 272.2 Mg Se/lb.

   c. 907/272.2 = 3.3 lbs of the premix would be added per ton of feed

3. You want to manufacture a mineral mix which will contain 10 ppm of selenium. The premix which you are using contains 660 ppm (.06%) selenium.

   a. (2000 * .4536) * 10 = 9072 Mg's

   b. 600 * .4536 = 272.2 Mg Se/lb

   c. 9072/272.2 = 33.3 lbs of the premix would be added per ton of feed

4. You want to manufacture a salt mix for free-choice feeding that contains 80 ppm of selenium. The premix you are using contains 9900 ppm (.99%) selenium.

   a. (2000 * .4536) * 80 = 72576 Mg's

   b. 9900 * .4536 = 4490 Mg Se/lb

   c. 72576/4490 = 16.2 lbs of the premix would be added per ton

Table 1. Daily selenium intake

Dry Matter Intake		Total Ration Selenium Content		
lbs	kg	0.1 ppm	0.2 ppm	0.3 ppm
		(Mg)		
10	4.5	.45	.90	1.35
20	9.1	.91	1.82	2.73
30	13.6	1.36	2.72	4.08
40	18.1	1.81	3.62	5.43
50	22.7	2.27	4.54	6.81
60	27.2	2.72	5.44	8.16

Note: 0.1 ppm = 0.1 Mg/kg

Table 2. Selenium Concentration Equivalency Table

Selenium Concentration		Selenium Content		
%	ppm	Mg/kg	Mg/lb	Mg/ton
.00001	.1	.1	.045	90
.00025	2.5	2.5	1.13	2260
.00035	3.5	3.5	1.59	3180
.0004	4.0	4.0	1.81	3620
.0005	5.0	5.0	2.27	4540
.001	10.0	10.0	4.54	9080
.002	20.0	20.0	9.07	18,140
.007	70.0	70.0	31.75	63,500
.01	100.0	100.0	45.36	96,720
.02	200.0	200.0	90.7	181,400
.04	400.0	400.0	181.4	362,800
.06	600.0	600.0	272.2	544,400

Table 3. Amount of Supplement Requird to Meet the Daily Selenium Requirement

Daily Selenium Requirement	Supplemental Selenium Content (ppm)					
	.2	.4	1	5	10	20
(Mg/cow/day)	(lbs/cow/day)					
.9	9.9	5.0	2.0	.4	.2	.1
1.81	19.9	8.3	4.0	.8	.4	.2
2.73	30.0	15.0	6.0	1.2	.6	.3
4.08	45.0	22.5	9.0	1.8	.9	.45
5.43	60.0	29.9	12.0	2.4	1.2	.6
6.81	75.0	37.5	15.0	3.0	1.5	.75

CATIONS AND ANIONS IN DAIRY CATTLE NUTRITION

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In recent years, there has been some interest in the potential of adjusting dairy cattle rations for cation-anion content and balance. The primary impetus for this has been an attempt to lower the incidence of milk fever by altering the cation-anion content of dry cow rations. The purpose of this paper is to provide a basis of understanding for this concept. In addition, examples of the calculations required to utilize this concept are presented.

What are Cations and Anions?

Cations and anions are simply a description of the mineral elements in the ration. The determination of whether a specific mineral element is a cation or anion is related to the electrical charge carried by the element. Cations have a positive electrical charge while anions have a negative charge. The common mineral elements are classified as follows:

Cations	Anions
Sodium	Chloride
Potassium	Phosphorous (phosphates)
Calcium	Sulfur (sulfate)
Magnesium	

What Factors are Involved in Calculating Cation-Anion Balances?

The actual calculations are based upon the equivalent weights of each element. The equivalent weight of an element is equal to the molecular weight divided by the valence. Commonly, the term milliequivalent is used. A milliequivalent (mEq) is 1/1000 of an equivalent. The following information can be used as a reference for these calculations:

Mineral	Molecular weight	Valence	Equivalent Weight	Milliequivalent Weight	
	(g)		(g)	(g)	(mg)
Sodium	23	1	23	.023	23
Potassium	39	1	39	.039	39
Calcium	40	2	20	.020	20
Magnesium	24	2	12	.012	12
Phosphorous	31	1.8*	17.2	.0172	17.2
Chloride	35.5	1	35.5	.0355	35.5
Sulfur	32	2	16	.016	16

*The inorganic phosphorous in serum exists as a buffer in which about 80% is present as HPO_4 and 20% as H_2PO_4. In this case, the atomic weight is divided by 1.8 to determine the equivalent weight.

How is a Cation-Anion Balance Calculated?

In reviewing the literature, there does not appear to be any consensus on which minerals are included in the balance calculations. Much of the early work was done in the poultry area. The following are some of the equations which have been proposed:

A. Cation-anion balance = mEq(Na + K + Ca + Mg) = mEq(Cl = SO_4 + H_2PO_4 + HPO_4)

B. Cation-anion balance = mEa(Na + K) - mEq(Cl)

C. Cation-anion balance = mEq(Na + K) - mEq(Cl + S)

D. Cation-anion balance = mEq(Ca + Mg + K + Na) - mEq(P + S + Cl)

In addition, a number of other equations can be found in the literature. Equations B and C appear to be the most common ones used.

What About Ration Acidity and Alkalinity?

A number of papers have looked at the relative acidity and alkalinity of rations rather than the actual cation-anion balance. The cations are generally assumed to be alkalogenic in nature while the anions are acidic.

Research examining the relationship between diet acidity and calcium absorption has been conducted at Rutgers University (Verdaris and Evans, J. Dairy Sci., 59:1271, 1976). Dry Holstein cows were assigned to diets with varying levels of calcium and pH. Results were:

Diet Calcium Level, % of DM	Diet pH	Calcium Intake, (g/day)	Calcium retained, % of intake
0.2	6.1	20.5	10
0.2	4.5	26.8	30
2.1	6.1	142.1	18
2.1	4.5	161.7	27

Note that calcium absorption was improved on the more acidic diets.

How Can the Cation-Anion Balance of a Ration be Calculated?

The actual calculations are quite simple once the above principles and guidelines are understood. The following example illustrates the method of calculation for a ration:

Mineral	% of Ration DM	g/kg of Ration DM	mEq/kg
Calcium	.85	8.5	425
Potassium	1.00	10.0	256
Magnesium	.28	2.8	233
Sodium	.24	2.4	104
Chloride	.30	3.0	85
Phosphorous	.45	4.5	262
Sulfur	.26	2.6	163

Using the above equations, the following balances would be calculated for this ration:

Equation B = (104 + 256) - (85) = + 275 mEq/kg

Equation C = (104 + 256) - (85+ 163) = + 112 mEq/kg

Equation D = (425 + 256 + 233 + 104) - (85 + 262 + 163) = +508 mEq/kg

What Research Information is Available?

At this time, the research data in this area for lactating dairy cows is quite sparse. The information available can be summarized as follows:

A. Lomba et al, Brit. J. Nutr. 39:425, 1978

These workers carried out an analysis of a large number of different rations fed to dairy cows. They calculated the sum of the alkaline ions (Na,K) minus the acidogenic ions (Cl, S, P) for all rations. Results were:

1. For rations with a positive calcium balance, an excess of anions (Cl, S, P) resulted in an increased absorption of calcium from the intestine.
2. The effect on calcium absorption was not as apparent for rations with a negative calcium balance.

B. Block, J. Dairy Sci., 67:2939, 1984 -

This was a trial with dry cows to examine the relationship between dietary ions and milk fever. Diets were formulated using alfalfa hay, corn silage, high moisture ear corn and minerals. Mineral composition of the diets was:

Mineral	Diet: Cation	Diet: Anion
Calcium, %	.63	.69
Phosphorous, %	.25	.24
Sodium, %	.53	.16
Potassium, %	1.22	1.22
Chloride, %	.42	.57
Sulfur, %	.15	.56

The cation-anion balance was calculated as (Na+K)-(Cl+S). The cation diet had a balance of +330.5 mEq/kg while the anion diet was -128.5 mEq/kg. This trial was conducted for a 2 year period.

The incidence of milk fever was 47.4% for cows on the cation diet. There was no incidence of milk fever in cows fed the anion diet. The author suggests that the first step in designing dry cow diets should be an attempt to keep calcium intakes low. The second step is to try to keep the diets acidogenic.

C. Gaynor et al., J. Dairy Sci., 70(Suppl 1): 202, abstract P294, 1987

This trial was conducted using Jersey cows at the Lewisburg station in Tennessee. All cows used were in the third or later lactation. The cows were assigned to alfalfa haylage diets at 6 weeks prior to projected calving date. Diet dry matter intakes were 1.8% of body weight. The cation-anion balance of the diets was adjusted by varying the mineral composition of the grain mix. Average diet calcium levels ranged between 1.12 and 1.21% of dry matter. Cation-anion balances (Na+k-Cl) of the diets were + 26.7, +65.9 and +122.3 mEg. The incidence of clinical and subclinical milk fever on the 3 diets was 0, 50 and 33%.

D. Oetzel et al., J. Dairy Sci., 70(Suppl 1): 229, abstract 376, 1987

Workers at Colorado State University conducted a trial with 48 Holsteins with a previous history of milk fever. These cows were randomly assigned to one of 4 complete rations for the last 21 days of the dry period. The diets contained either 75 or 150 grams of calcium per cow per day. Each level of calcium was fed with or without the addition of anionic salts. Calculated anion-cation balances (Na+k-Cl+S) of the diets were -48 and +190 mEg per kg of diet dry matter.

The incidence of milk fever for cows receiving the anionic diet (-48 nEg) was 4% while it was 17% on the other diet. Dietary calcium levels had no significant effect on the incidence of milk fever. These results may indicate that the dietary anion-cation balance during the dry period may be a more important factor related to milk fever than calcium intake.

Summary

The principles of evaluating the anion-cation balance of a ration are relatively simple. The limited research to date indicates that diets which are acidogenic (negative anion-cation balance) may be beneficial in terms of calcium absorption and the prevention of milk fever. However, there does not appear to be enough information to provide specific guidelines or recommendations at this time. The adjustment of diets for anion-cation balance appears to have potential as a fine-tuning tool in dairy rations. However, before using this tool, make sure that other factors contributing to milk fever have been controlled. The key factor to concentrate on is to try and limit daily calcium intakes for Holsteins to about 70-80 grams per day.

WATER IN DAIRY CATTLE NUTRITION

L. E. Chase and C. J. Sniffen
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Introduction

Water is the nutrient required in the largest amount daily by dairy cattle. It is also probably the cheapest of the nutrients provided to dairy cattle. However, too often, water quantity and quality are overlooked in terms of evaluating farm situations. A lack of water will have a rapid and dramatic effect on milk production.

There are many key physiological functions in the animal which are dependent upon water. Water is a universal solvent and is involved in numerous metabolic and transport functions within the body. Many joints utilize water as a lubricant and it is involved in the senses of sight and hearing.

A key consideration in the lactating cow is the synthesis of milk. Milk contains about 87% water. The body of the mature dairy cow will contain from 42 to 75% water. Normal rumen fermentation, digestion and absorption of nutrients requires a plentiful supply of water.

How Much Water Does a Cow Need?

There have been a number of reports providing estimates of the amount of water required by dairy cattle. One of the most extensive papers was by C. F. Winchester and M. J. Morris (J. Anim. Sci., 15:722, 1956). The following equations (Sniffen, 1982) were derived from this data set to estimate daily water needs.

Water (gallons/day) = (.0063 x BW, lbs)

+ (.3 x Milk,lbs)

Water (lbs/day) = (.053 x BW, lbs) + (2.5 x Milk, lbs)

Example:

Body Weight, lbs	Milk Prod., lbs.	Water Gallons/day	Water lbs/day
1000	30	15.3	128
	50	21.3	178
1200	40	19.6	164
	60	25.6	214
1400	60	26.8	224
	80	32.8	274

Table 1 contains estimates of the quantity of water required daily by dairy heifers and dry cows. Both of these estimates are for total water intake. Adjustments should be made for water consumed in the feed.

Effect of Water Intake Restriction

Only limited quantitative studies have been done examining the effects of water deprivation on performance in dairy cattle. Table 2 contains information from England in which various levels of water restriction were imposed for 6 day periods. Table 3 contains data for a similar trial using a 3 week restriction period.

Even though these were relatively low producing cows, there were significant reductions in both dry matter intake and milk production due to a restriction of water intake. More dramatic changes would be anticipated in higher producing cows.

Indications of Restricted Water Intake

There are a number of signs which may indicate inadequate water intake. These include:

1. Firm, constipated manure
2. Decreased urine output
3. Infrequent drinking activity
4. Decreased feed intake
5. Decreased milk production
6. Drinking of urine, puddles, etc.
7. Dehydration
8. Body weight loss
9. Increased blood packed cell volume
10. Increased blood hematocrit and osmolality

Even though the above items may be associated with depressed water intakes, other problems may also cause similar metabolic changes.

Excessive Water Intake

In some situations, cows may actually consume abnormally high quantities of water per day. Signs associated with this could include excessive urine output and abnormally loose manure. There may also be an increase in drinking activities. One potential cause of excessive water intakes may be a high level of minerals in the ration.

Evaluating Water Intake

The actual quantity of water consumed will require some observations and measurements on the farm. There are a number of approaches to evaluating this situation.

1. Are an adequate number of watering devices available?

2. Are they clean and do they work?

3. Is there adequate water pressure available? (Make sure to check this during milking when overall water pressure may be reduced)

4. Install a water meter on the supply line for the waterers.

   a. Avoid providing any other source of water.
   b. Monitor for at least 5-10 days.
   c. Keep track of the number and types of animals (milking cows, dry cows, heifers, etc.)
   d. Subtract expected intakes from animals other than milking cows from the total drinking water.
   e. Determine feed intake.
   f. Calculate water intake from the ration.
   g. Determine total water intake (feed + waterers).
   h. Compare with the guidelines given above.

5. Check for possible stray voltage in the watering system.

Water Quality

In addition to an adequate quantity of water, the quality of the water is also quite important. Unfortunately, the actual water quality guidelines for livestock are not as definitive as would be desirable. The following guidelines can be used to evaluate the suitability of a water source for dairy cattle:

1. pH - Values lower than 6 or higher than 8.5-9 may present problems.

2. Bacterial - Check for both total bacteria and coliforms.

3. Elements - see Table 4.

   a. Hardness - This is normally considered to be the sum of calcium and magnesium expressed as the equivalent of calcium carbonate. It may also be expressed as grains. It does not appear that hardness is a problem for dairy cattle.

   b. Total dissolved solids - This is the sum of all constituents dissolved in the water. Included would be inorganic salts, organic matter and other dissolved materials. The primary salts would be calcium, magnesium, bicarbonates, chlorides, sodium, sulfates and trace minerals. The NRC publication on water quality indicates that levels lower than 3,000 mg/liter should be satisfactory for all classes of livestock. An upper level of 500 ppm (mg/liter) of total dissolved solids is suggested for humans.

Water Quality Considerations

There are a number of considerations if you suspect water quality to be a problem. The following questions may be of value in sorting through the question of water quality.

A. Gross characteristics:

1. Do any of the following characteristics of your water supply appear to be abnormal?

   a. Odor?
   b. Color?
   c. Taste?
   d. Sediment, Scum, particles, cloudiness?

B. Health Effects:

1. Do your animals drink this water?
2. Do they exhibit any apparent effects such as diarrhea, cramps, etc.?
3. Is this their sole source of water?
4. Do you or other people drink this water?
5. If yes, are there any apparent effects from it?

C. Water source

1. Is the water from:

   a. Deep or artesian well?
   b. Shallow or dug well?
   c. Spring?
   d. Pond?

2. How long has this source been used?

3. Have any changes been made recently to the water supply system?

4. Is your water source and system protected from pollution?

5. Does the water change during the seasons; or during wet and dry periods?

6. Are there nearby dumps, landfills, manure storages or chemical disposal sites?

Comparative Performance of Different Water Sources

One way to make an evaluation of a potential water quality problem is to make available an alternate water source of known or acceptable quality. There are a number of ways to obtain an alternate water source. Tanker trucks or wagons may be used to bring in an alternative water source. The local fire department may also be a possibility. One potential source of water could be from a nearby town or village with a water treatment plant.

This approach may be an inconvenience and will also be an added expense. However, this option should receive serious consideration if there is a reasonable suspicion of a water quality problem. If cows drink large quantities when given access to the alternate source or if they show a preference for it, this is evidence that the permanent source has some palatability problems. Some contaminants and other compounds may not affect palatability. If performance improves when cows are given access to the alternate source, this may indicate a problem worthy of additional investigation.

Water Testing Procedures

When the preliminary investigation indicates a water quality problem, it would be best to consult with someone who specializes in water quality. Even though water testing can be a useful tool, it must be approached with some caution. It is not feasible (or affordable) to test a sample for all possible compounds which may influence quality or animal performance. There are literally thousands of individual compounds contained in water. The following approach to water testing may be useful:

1. Bacteriology

   a. Coliforms - indicator of mammalian fecal contamination, not necessarily disease causing

   b. Pathogens - e.g. Salmonella - finding a pathogen in water that matches isolates from affected animals may indicate a causal relationship.

2. Basic chemical analyses

   a. pH
   b. Nitrates
   c. Hardness
   d. Minerals (such as calcium, magnesium, sulfates, sodium, trace minerals).

3. Toxic metal and pesticides analysis

   May be useful in some situations but can be expensive. In addition, you must have some idea of what compound or type of compound to test for since this type of testing can be expensive.

Where to Have Water Tested

There are a number of commercial labs which provide water testing. In addition, some county health labs can test for bacterial qualities. It is important to obtain sampling containers and instructions from the lab which you will be working with. This list is only a few of the labs which have water testing capability. Other labs may also provide these services.

Laboratory	Tests	Costs
Diagnostic Lab College of Veterinary Medicine Cornell 607-253-3900	Bacteriology	$13.00
New York DHI Forage Analysis Lab 730 Warren Road Ithaca, NY 14850 607-257-1272	Calcium, Magnesium Iron, Sodium, Nitrates, pH and Hardness	$10.00
Spectrograph Lab Pomology Dept. Cornell 607-255-1785	Heavy metals	$ 8.00
Toxicology Lab 925 Warren Road Ithaca, NY 14850 607-255-2108	Targeted Pesticides/ Herbicides	Variable, $50-$500
O'Brien & Gere Engineers Inc. 1304 Buckley Road Syracuse, NY 13221 315-451-4750	US EPA Priority Pollutants	Variable $50-$500
Eastern Laboratory Service Associates 517 N. George Street York, PA 17404 717-846-4953	Microbiological, Minerals, Trace Metals	Contact for prices
Water Test Box 186 New London, NH 03257 1-800-343-2041	Minerals, Heavy Metals, Bacteriological	Contact for prices
A & L Labs 7621 Whitepine Road Richmond, VA 23237 804-743-9401	Minerals, pH Nitrate	Contact for prices

Table 1. Estimated total water intakes of heifers and dry cows[a]

Body Weight lbs	Temperatures 40F	80F
	-(gallons/day)-	
A. Heifers		
100	0.7	1.1
200	2.0	3.3
400	3.7	6.1
600	5.0	8.4
800	6.3	10.6
1000	7.3	12.3
1200	8.0	13.4
B. Dry cows (includes fetal allowance)		
800	7.4	12.3
1000	8.0	13.4
1200	8.7	14.5
1400	9.7	16.2
1600	10.4	17.3

[a]Adapted from Winchester and Morris (J. Anim. Sci. 15:722,1956) by W. G. Merrill

Table 2. Water intake, milk production and body weight change in dairy cattle[a]

Item	Water Intake (% of control)			
	100	87	73	60
Water intake, lbs/day	122	113	96	78
Dry matter intake, lbs/day	29.5	28.8	27.7	24.6
Milk, lbs/day	31.7	29.3	29.3	26.6
Body weight change, lbs	+17.4	-10.8	-24.0	-46.2

[a]Little et al., Anim. Prod. 22:329,1976

Table 3. Effect of a 40% reduction in water intake for dairy cows[a]

Item	Water Intake (% of control)	
	100	60
Water intake, lbs/day	121	77
Dry matter intake, lbs/day	29.6	22.6
Milk, lbs/day	44.4	37.2
Body weight change, lbs	0	-44

[a]Little et al., Anim. Prod., 27:79, 1978

Table 4. Water quality guidelines for dairy cattle

Item	Average[a]	Safe upper limit[b]
		(Mg/liter)
Arsenic		0.2
Cadmium		0.05
Calcium	60.4	NE[c]
Chloride	20.2	NE
Chromium		1.0
Cobalt		1.0
Copper	0.1	0.5
Fluoride	0.2	2.0
Iron	0.8	NE
Lead		0.1
Magnesium	13.9	NE
Manganese	0.3	NE
Mercury		0.01
Molybdenum		NE
Nickel		1.0
Nitrate-N	33.8	100
Nitrite-N	.3	10
Potassium	9.11	NE
Sodium	21.8	NE
Sulfate	35.5	100[d]
Total hardness	208	NE
Vanadium		0.1
Zinc		25.0

[a]Average of about 350 samples analyzed at Penn State University.

[b]Nutrients and toxic substances in water for livestock and poultry, National Academy of Science, 1974.

[c]Not established.

[d]Estimate.

Update on Water Quality

L. E. Chase and C. J. Sniffen

Water is the nutrient required in the largest quantity daily by dairy cattle. It is also probably the lowest cost of the nutrients provided to the dairy cow. However, too often, water quantity and quality are overlooked in evaluating farm situations. A lack of water will have a rapid and dramatic impact on milk production.

There are many key physiological functions in the animal which are dependent upon water. Water is a universal solvent and is involved in numerous metabolic and transport functions within the body. A key consideration in the lactating dairy cow is the synthesis of milk. Milk contains about 87% water while the body of a mature cow is 55-65% water. Normal rumen fermentation, digestion and absorption of nutrients requires a plentiful supply of water.

How Much Water Does A Cow Need?

There have been a number of reports which provide estimates of the quantity of water required by the dairy cow. One of the most extensive papers was by C. F. Winchester and M. J. Morris (J. Anim. Sci., 15:722, 1956). The following equations were derived by C. J. Sniffen from this dataset to estimate daily water needs.

Water (gallons/day) = (.0063 * BW, lbs) + (.3 * Milk, lbs)

Water (lbs/day) = (.053 * BW, lbs) + (2.5 * Milk, lbs)

Example;

Body Weight (lbs)	Milk (lbs)	Water Gallons/day	Water lbs/day
1000	30	15.3	128
	50	21.3	178
1200	40	19.6	164
	60	25.6	214
1400	60	26.8	224
	80	32.8	274

Note: This is total (feed + drinking) water

The 1988 NRC publication on nutrient requirements of dairy cattle contains the following equation to estimate water intake:

$$\text{Water intake (kg/day)} = 15.99 + (1.58 * \text{DMI, kg}) + (0.9 * \text{Milk, kg}) + (.05 * \text{sodium intake, g}) + (1.2 * \text{minimum daily temp. C})$$

Example:

Dry matter intake = 20 kg
Milk production = 35 kg
Sodium intake = 45 g
Min. temperature = 20 C

$$\text{Water intake (kg)} = 15.99 + 31.6 + 31.5 + 2.2 + 24 = 105$$

This equation was developed by workers at the University of Illinois from a dataset of cows in the first 16 weeks of lactation. The 1988 NRC indicates that another way to estimate daily water intake is 3.5-5.5 lbs of water per pound of dry matter intake. This guideline is for cows exposed to environmental temperatures between -17 and 27 C.

Water Quality

In addition to an adequate quantity of water, the quality of the water is also quite important. Unfortunately, the actual water quality quidelines for livestock are not as definitive as would be desired. The following quidelines can be used to provide an indication of the suitability of the water source for dairy cattle:

1. pH - Values <6 and >8.5-9 may present problems.

2. Bacterial - Check for both total and bacterial coliforms.

3. Hardness - This is normally considered to be the sum of calcium and magnesium expressed as the equivalent of calcium carbonate. It may also be expressed as grains. There is little information to indicate that hardness is a problem for dairy cattle.

4. Nitrates - The EPA public health standard for public water supplies is 10 ppm nitrates. It has been suggested that higher levels are acceptable for mature cows.

5. Total dissolved solids - The NRC publication on water quality for livestock indicates that levels below 3,000 mg/liter (ppm) should be satisfactory for all classes of livestock. An upper level of 500 mg/liter has been suggested for public water supplies.

6. Other mineral elements - The levels of calcium, sulfates, magnesium and iron which may cause problems in dairy cattle are not well defined. It may be that high levels of these elements may decrease palatability and lower water intake.

Are the Minerals in Water Available to the Cow?

There appears to be little definitive work in this area. However, it is our assumption that mineral elements soluble in water are probably available to the cow.

Should the Mineral Contributions of Water be Considered in Ration Formulation?

It would appear logical to consider the contribution from water when levels of a specific nutrient are quite high. The problem is defining the threshold level above which the contribution should be considered. Most research trials evaluating the nutrient requirements of dairy cattle do not specify either the quantity or quality of the water consumed by the cows. Thus, it is difficult to estimate the contribution from water in these studies.

However, we have observed field situations in which the mineral content of the water was important. This has been observed most frequently with high calcium water and dry cow programs. In one situation, the calcium content of the water was 489 ppm. If we assume an intake of 15 gallons of water per day, the cow would obtain 28 grams of calcium from the water. This could present a problem if a restricted calcium intake is desired.

The following method can be used to calculate the mineral contribution from water:

Assumptions:

Daily water intake = 25 gallons = 207 lbs = 94 kg

Nutrient in water = 350 ppm

Calculations:

a. Calculate mg nutrient intake (1 ppm = 1 mg/kg)

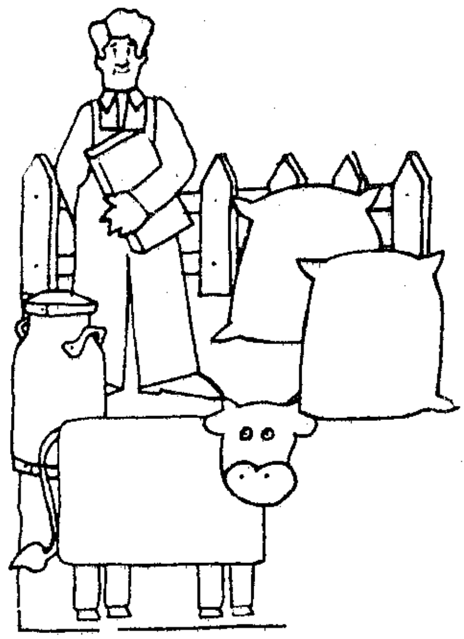
94 * 350 = 32,900 mg

b. Convert to grams

32,900/1000 = 32.9 grams

DAIRY CATTLE NUTRITION

Home Study Course



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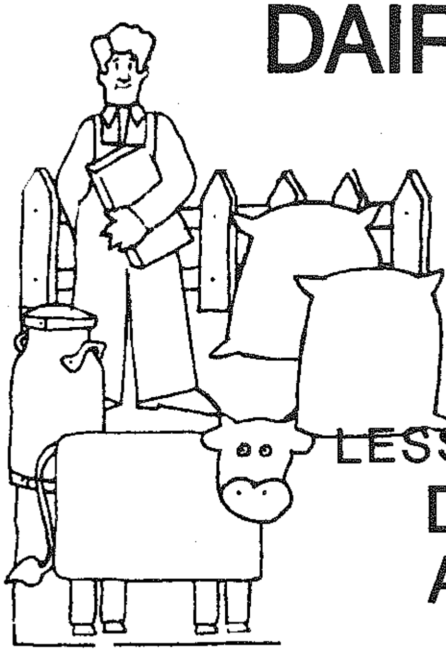
September, 1983

DAIRY CATTLE NUTRITION

Home Study Course

DAIRY CATTLE NUTRITION



LESSON 1: DIGESTIVE ANATOMY

Dairy cattle nutrition is a very complex and interesting field. The nutrition of the dairy cow has not yet been totally defined. Research on the cow is still being performed and new concepts are replacing traditional ideas. In order to begin the study of dairy cattle nutrition, an understanding of the digestive anatomy is essential.

The cow is a ruminant, one of the cud chewing animals with a compartmentalized stomach. This compartmentalized stomach permits the cow to breakdown and digest fibrous feeds through the fermentation process. Let's take a tour through the digestive system.

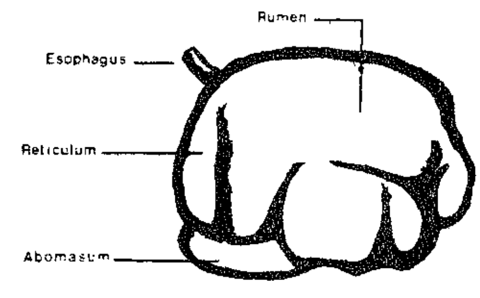
At the beginning of the tour, we visit the mouth and the esophagus. The mouth and the esophagus are important components of the anatomy of the digestive system. The mouth is involved with one of the physical processes of digestion, mastication.

Mastication or chewing takes place at two times during the digestive process. The first is during the ingestion of feed. The cow will form boluses of feed and will swallow about three of them per minute. However, this figure will vary with the type of ration and with the hunger of the cow. In the mouth, saliva wets and lubricates the feed for passage through the esophagus to the reticulo-rumen. The bolus upon swallowing has a dry matter of 12-13%. The esophagus is a muscular tube that connects the mouth to the reticulo-rumen. The opening of the esophagus into the reticulo-rumen is called the cardia. It opens in an area where there is no special division between the rumen and the reticulum.

Mastication also takes place during rumination. Rumination is the regurgitation and rechewing of the feed. Rumination reduces the particle size of the feed, via remastication, in order to increase the surface area of the feed for better digestion. A cow will ruminate (chew cud) for about 1/3 of the day with any individual rumination period lasting from 2 minutes to 2 hours. Two factors that deter rumination are low rumen pH and fine particle size. Let's move on to the rumen.

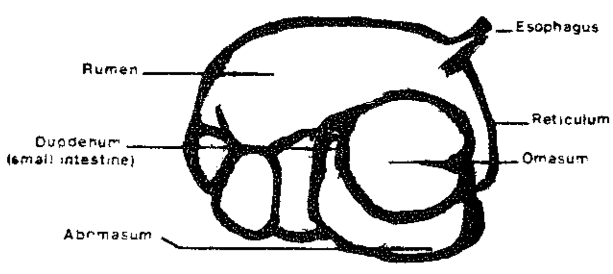
RUMEN

The rumen is the largest compartment of the cow's stomach. The capacity of the mature cow's rumen varies due to the method of estimate; however, it holds about 30-35 gallons of rumen contents. The rumen is a muscular organ with finger-like projections called papillae. The papillae, up to one half inch in length, are important for the absorption of nutrients from the rumen. The rumen muscles are important for the mixing of the rumen contents. The rumen contents are mixed by the primary contractions of the rumen muscles. The primary contractions will occur from approximately 60 times per hour up to about 105 times per hour when the cow is eating. There are also secondary contractions which are usually associated with eructation (belching).



RUMINANT STOMACH
left view

Anatomy of the ruminant stomach.

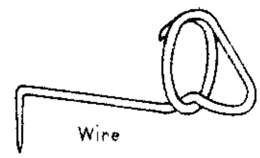


RUMINANT STOMACH
right view

A detailed description of the digestion that takes place in the rumen will be discussed in the next lesson. However, the rumen functions as a large fermentation vat. The rumen provides an excellent environment for anaerobic microorganisms. The pH range is 5.5 - 7.0, and the temperature is 39 to 40 degrees centigrade. Fermentation of the feed takes place in the environment by the action of 16-40 billion bacteria and 200,000 to 1 million protozoa per milliliter. During this fermentation the microorganisms digest fiber, utilize non-protein nitrogen to make protein and synthesize many vitamins. The next section of the stomach is the reticulum.

RETICULUM

The reticulum is closely associated with the rumen. In fact, the two compartments are often referred to as the reticulo-rumen. The inside of the reticulum has a honey-comb appearance due to folds, about a half inch high, which enclose 4, 5 or 6 sided cells. The honey-comb may trap metal objects such as wire, or nails. Contractions of the reticulum may cause penetration of the reticulum wall by the metal object. This may result in leakage of digesta into the body cavity and a local infection (peritonitis) occurs. The metal object may pierce both the reticulum and the diaphram and cause either an infection around the lungs (pleuritis) or an infection around the heart (pericarditis). These conditions are called hardware disease.



Wire trapped in the reticulum may result in hardware disease.

The reticulum, as was mentioned earlier, is closely associated with the rumen. Functionally the reticulum acts as an extension of the fermentation vat. Digesta from the reticulum mixes to and from the rumen. The separation between the two compartments is simply a fold in the tissue. This fold is called the rumino-reticular fold. This fold plays an important part in the process of eructation.

ERUCTATION

Eructation is another process that takes place in the digestive system. Eructation or belching removes the gases of fermentation (methane and carbon dioxide). The amount of gas produced is approximately 30-50 liters per hour. It is important that the gas be removed in order to keep the animal from being blown up like a balloon. During eructation the rumino-reticular fold contracts and acts as a dam to the rumen contents. Then, a rumen contraction forces the gas out of the fermentation vat. However, if the cardia is blocked with solids or liquid foam, the eructation is prevented and bloat will occur.

Another important structure is the esophageal groove. The esophageal groove is a groove that starts at the cardia and passes to the reticular-omasal orifice. The groove is approximately 7-8 inches long.

OMASUM

The third compartment of the cow's stomach is the omasum. The omasum is often called "many plies" due to its appearance. The interior folds, that number up to 100, apparently absorb considerable amounts of fluid from the digesta. The omasum is a separate compartment of the stomach connected to the reticulum via the reticular-omasal opening and the abomasum via the omasal-abomasal opening. The rumen, reticulum and omasum all are of the non-glandular structure. These three compartments are often referred to as the forestomach.

The omasal groove is a four inch groove that connects the reticular-omasal opening to the omasal abomasal opening. The esophageal and omasal groove form the gastric groove.

ABOMASUM

Unlike the first three compartments of the cow's stomach, the abomasum is glandular. Therefore, it is referred to as the true stomach. The abomasum has a section that has up to a dozen extensive spiral folds, that look like leaves. The abomasum provides an acid environment and enzymes which begin the enzymatic digestion process. The pyloric valve is at the exit for the stomach contents on its way through the digestive system.

The relative volumes of the cow's stomach are:

80% for the rumen
5% for the reticulum
7-8% for the omasum
7-8% for the abomasum

The relative weight of the contents is 12% in the omasum, 4% in the abomasum and the rest in the reticulo-rumen. Now let's move on to the small intestine.

SMALL INTESTINE

The small intestine is similar to that of simple stomach animals. The small intestine is about 130 feet long in the average size cow and has a diameter of approximately 2 inches. The small intestine is divided into three main sections: The duodenum, the jejunum, and the ileum. The small intestine has many villi, tiny finger-like projections, that provide a large surface area for the absorption of nutrients. The small intestine and large intestine move digesta through the tract by the process of peristalsis. Peristalsis is a rhythmic progressive wave of contractions. The purpose of the small intestines is to complete digestion of the feed and absorb the digested nutrients. The ileo-cecal valve leads to the large intestine.

LARGE INTESTINE

The cecum, a blind sack 30 inches long and 5 inches in diameter, joins the small intestine. This blind pouch provides an environment for another fermentation. This post gastric fermentation is very important to non-ruminant herbivores, such as the horse. The fermentation in the cecum makes it possible for the horse to digest the fibrous portion of the feed. The large intestine or colon, is about 35 feet long and diminishes in diameter from 5 inches to 2 inches until it joins the rectum. The main purpose of the large intestine is the absorption of water.

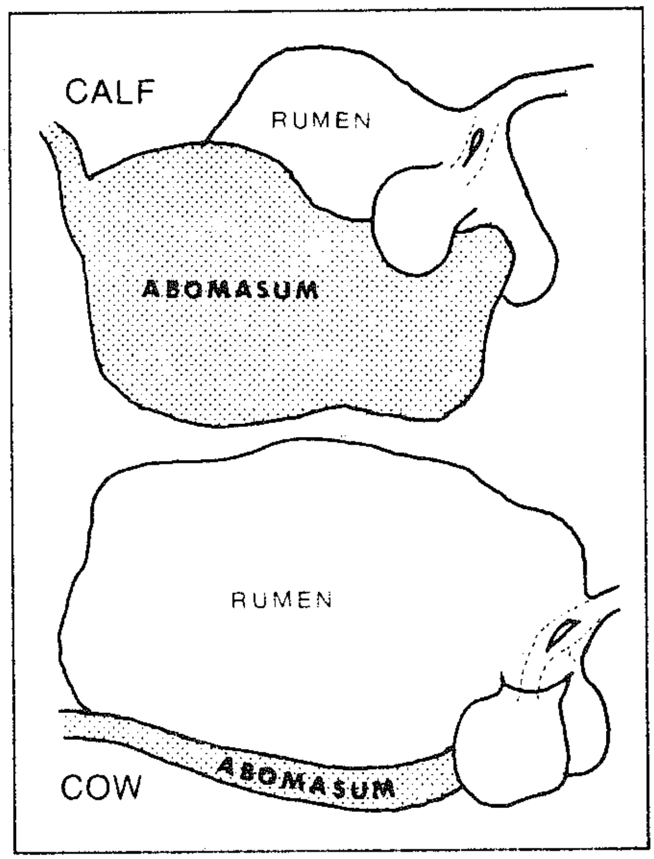
This completes our tour of the cow's digestive tract.

THE DEVELOPMENT OF THE FUNCTIONAL RUMINANT

When a calf is born, its digestive system does not appear as it does in later life. The abomasum, rather than the rumen is the major compartment. The abomasum contains about 49% of the stomach tissue at birth. When the calf drinks milk, the esophageal groove captures the liquid and shunts it directly to the abomasum, so that the proteins can be digested without fermentation. In addition, soon after birth, the antibodies in the colostrum can be absorbed directly, giving the calf some immunity. With the milk-drinking calf, little rumen development occurs. So how does the stomach change so that the calf becomes a functional ruminant? The development that needs to take place is muscular growth, papilla growth, and size and shape modifications.

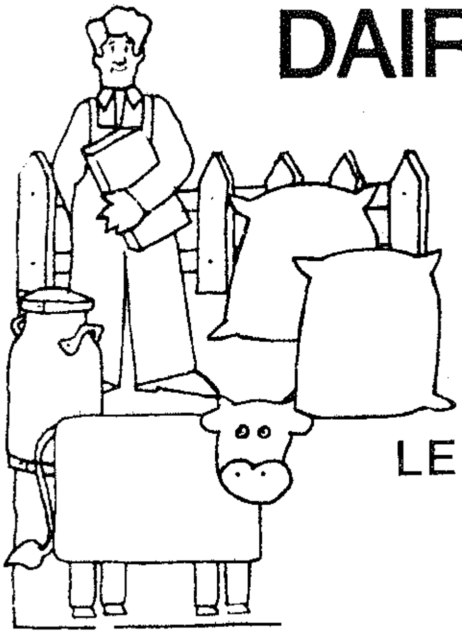
As mentioned, the milk-fed calf develops little as far as the fore-stomach is concerned; however, when hay or grain are fed, there is a rapid rumenal development. Muscular development of the rumen is due to exercise caused by the dry feed being fed. The papillary growth is the result of chemical stimuli. The volatile fatty acids (VFA's) produced in the fermentation process cause papillary growth. Therefore, milk provides little papillary growth since no VFA's are produced. Hay and grain cause considerable growth due to the production of VFA's during fermentation.

As a yardstick for ruminant development, one can expect that rumination will begin at 2-3 weeks of age with B-vitamins synthesis, fiber digestion and bacterial and protozoa function beginning at 3-7 weeks of age. The protozoal innoculation of the rumen requires animal to animal contact.



Physiology of a calf compared with that of a cow.

This concludes our first lesson on the anatomy of digestion. In the next lesson, the digestion process will be discussed in detail.



DAIRY CATTLE NUTRITION

LESSON 2: RUMINANT DIGESTION

DIGESTION

A discussion of ruminant digestion should begin with a few definitions. To begin with, let's define nutrition. Nutrition is "the sum processes by which an animal or plant takes in and utilizes food substances."[1] "Nutrients are the chemical substances found in feed materials that can be used, and are necessary, for the maintenance, production and health of animals."[2] Digestion is "the process of converting food to an absorbable form by breaking it down to simpler chemical compounds."[3] In this lesson the process of digestion, or breaking down feed substances so they can be absorbed by the cow, will be discussed.

"Animal production involves a series of chemical reactions and physiological processes in which feed is transformed and used by body tissues to meet the requirements for maintenance and production. In a broad sense, this 'chemistry of life' can be considered a cycle (Figure 1)."

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[1]Webster's New Collegiate Dictionary.

[2]Ensminger & Olentine, Feeds & Nutrition.

[3]McGraw-Hill Dictionary of the Life Sciences.

This statement is found in Dr. Dale Bauman's paper at the 1979 Cornell Nutrition Conference for Feed Manufacturers. Dr. Bauman is a professor of animal science at Cornell University.

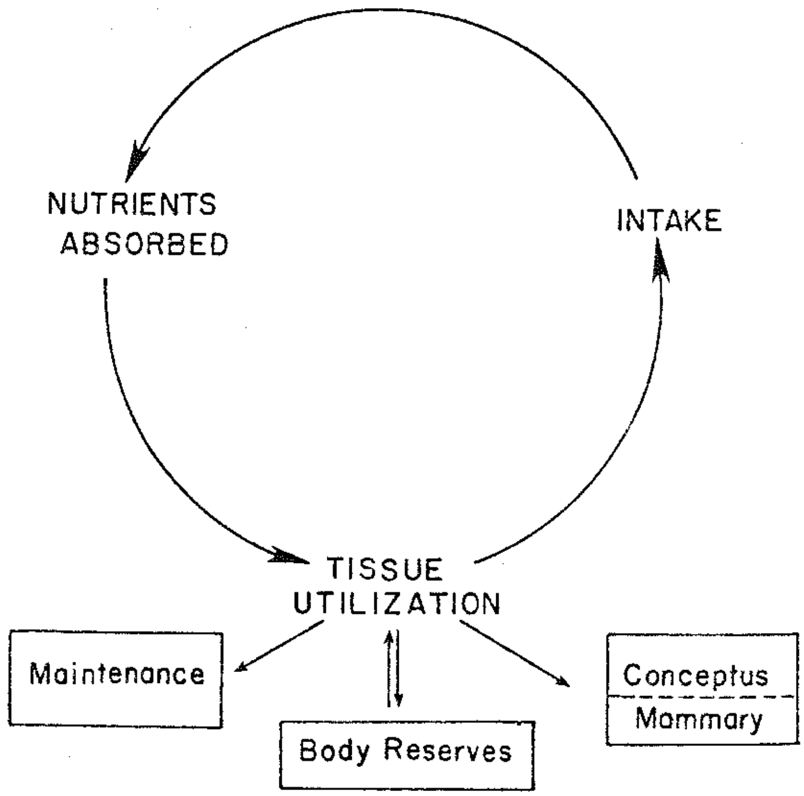


FIGURE 1: Cycle of Life (from Bauman and Currie).

Figure 1 puts the concept of nutrition into proper perspective. The animal ingests feeds, absorbs some of the nutrients released by the digestive process, and uses the nutrients for maintenance, body reserves, or production. The tissue utilization then has some feedback to the intake level of the animal. This very simple figure is the theme as addressed in this second lesson of the home study course.

THE NUTRIENTS

Now that we have defined some important items and have examined the concept of nutrition, a discussion of the nutrients is in order. The nutrients are: carbohydrates, proteins, fats, minerals, vitamins, and water.

Water plays a very important role in the animal body. Some of the functions of water are:

1. It is a solvent for the body.
2. It can absorb or release much heat, therefore much water is important to temperature regulation.
3. It is an important substance in many metabolic actions.
4. It acts as a transport mechanism.
5. It lubricates joints via the synovial fluid.
6. It acts as a water cushion for the nervous system.
7. It transports sound to the ear.
8. It aids in the sight of the eye.

If the animal loses 1/10th of its water, it will die. No other nutrient has that dramatic result for such a small loss.

Water can be supplied to the cow in three ways. The most obvious is by drinking water. Water that is in the feed is another source of meeting the water requirement of the cow. A less obvious source is the water that is released by chemical ractions in the body; this water is referred to as metabolic water. The loss of water occurs as sweat, respiratory water, feces, urine and milk.

WATER

The amount of water that is drunk by the cow is influenced by a number of things. Feed intake, protein concentration, salt concentration, feed, water and ambient temperature all affect the voluntary intake of water. Table 1 gives some water intakes at two temperatures. As one can see, a 1400 pound cow producing 60 pounds of 4% milk will drink 22 gallons of water for milk and maintenance at 40 F, whereas the same animal will drink nearly 32 gallons of water at 80 F. Since milk is 87% water and the daily intake of water is so high, water should be available to the cow 24 hours a day. If not, milk production will decrease.

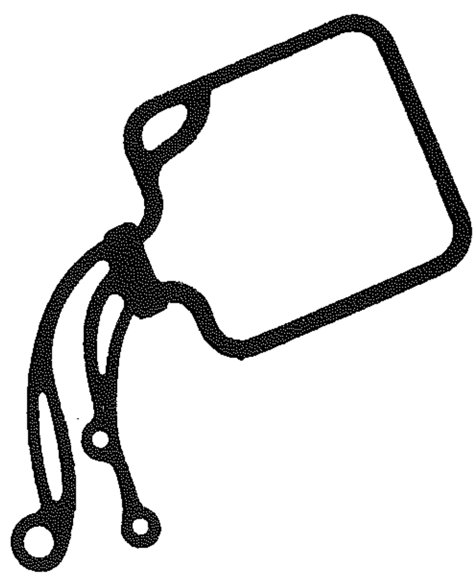


Table 1. Total daily water intake by dairy cattle[a]

	Gallons/day 40° F		Gallons/day 80° F	
1400 lb cow				
Maintenance	7.0		10.7	
Pregnant	2.7		4.5	
Dry-Pregnant	9.7		15.2	
Milk lbs (4%)	Milk	Milk + Maint.	Milk	Milk + Maint.
20	5.0	12.0	7.0	17.7
40	10.0	17.0	14.0	24.7
60	15.0	22.0	21.0	31.7
80	20.0	27.0	28.0	38.7
100	25.0	32.0	35.0	45.7

[a]Calculated from the data of Winchester and Morris, J. Animal. Sci., 15:722, 1956.

CARBOHYDRATES

Carbohydrates are substances that are made up of carbon, hydrogen and oxygen. These substances provide much of the energy that the cow uses. There are several types of carbohydrates including sugars, starches, celluloses and hemicellulose. Simple sugars, monosaccharides, can be either pentoses (5 carbon sugars $C_5H_{10}O_5$) or Hexoses (6 carbon sugars $C_6H_{12}O_6$). Glucose, a hexose, is probably the most familiar monosaccharide. It is the blood sugar. Disaccharides are carbohydrates that are combinations of two monosaccharides. Lactose, milk sugar, is a disaccharide made from the hexoses glucose and galactose.

Polysaccharides are combinations of many monosaccharides. Starch and cellulose are examples of this more complex combination of sugars. Some of the complex carbohydrates, such as cellulose are not as easily digested as starch (glucose polysaccharide). Cellulose has a different chemical bonding that makes it less digestible. Lignin, an indigestible compound, is also composed of carbon, hydrogen, and oxygen, but it is not considered a carbohydrate. Lignin is involved in the structure of the plant.

FATS

Fats or oils are also energy sources to the ruminant animal. Fats contain carbon, hydrogen and oxygen as do carbohydrates; however, due to the high proportion of carbon and hydrogen, fats furnish more energy than carbohydrates. Fats are made up of triglycerides. Triglycerides are three fatty acids that are bound together with glycerol, an alcohol. Fats are useful in feeding for palatability, aiding in the absorption of fat soluble vitamins and as a source of energy.

PROTEIN

Proteins are often called the building blocks of life. Proteins contain nitrogen in addition to carbon, hydrogen, and oxygen. Small amounts of sulfur and phosphorous may also be contained in some proteins. Structurally, proteins are made up of combinations of amino acids. There are at least 23 amino acids in nature. Amino acids can either be essential, needing to be supplied in the ration, or non-essential, can be synthesized if nitrogen is provided.

Ruminants, through the fermentation in the rumen, can use non-protein nitrogen to synthesize microbial proteins. The microbial proteins may then be digested by the cow in the abomasum and small intestine. Non-protein nitrogen is defined as a nitrogen-containing substance that is smaller than bovine insulin, the smallest protein.

VITAMINS

Vitamins are complex compounds that are important in the bio-chemical regulation of metabolic processes in the cow. They work through enzyme systems. There are fat soluble vitamins, A, D, E, and K, and water soluble vitamins, vitamins C and the B vitamins. A chart of the functions of the vitamins and deficiency symptoms are found later on in this lesson.

MINERALS

The inorganic portion of the feed is classified as mineral. There are several minerals needed for the proper function of the body. The macrominerals are those needed in the greatest concentration. Microminerals are needed only in small quantities. The minerals are needed for structure or enzyme activation.

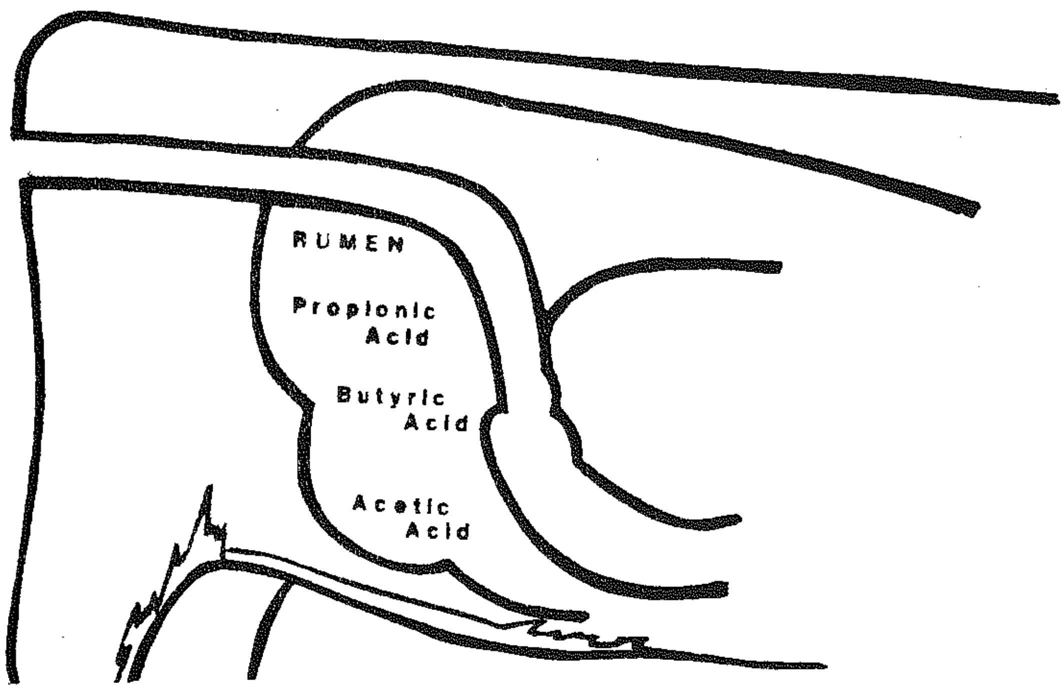
NUTRIENT DIGESTION

The digestion of these nutrients will be discussed in a moment; however, the digestive process needs a further explanation. The rumen provides a continuous fermentation. There is a nearly continuous flow of feed into the system and a continuous removal of the end products of digestion (such as volatile fatty acids) and a continuous passage from the rumen. Thus, there is a constant turnover in the rumen. This process is important, since a buildup of the end products could kill the fermentation.

One other thing that we need to reflect on is that the cow and microorganisms in her rumen exist in a symbiotic relationship. The cow provides an environment for microbial growth and the rumen organisms provide the cow with energy, protein, and B vitamins. This relationship becomes much clearer when carbohydrate fermentation is discussed.

CARBOHYDRATE FERMENTATION

The carbohydrates, when they undergo rumen fermentation are broken down into starches and sugars. The end products of carbohydrate fermentation are the volatile fatty acids (VFA's), acetic acid, propionic acid and butyric acid. These VFA's are actually the end products of the microbes metabolism of the carbohydrates. The VFA's are available to the cow as an energy source. Thus, a waste product for the bacteria is the major source of energy for the cow.



Cellulose, the most abundant carbohydrate in the world, is broken down in a similar manner. However, the enzyme cellulase, produced by the bacteria, initially breaks down the cellulose to starches and sugars. The end result, however, is the same; the production of volatile fatty acids. Therefore, the bacteria provide energy to the cow through the use of the relatively indigestible fibers. The VFA's are absorbed directly into the blood stream from the rumen, to provide the energy for the cow.

The relative amounts of the VFA's produced in the rumen vary with the type of ration fed. When forage fiber is being fermentd, acetate is produced in the greatest amount. When concentrates are fermented, the starch present shifts the VFA production to propionate. This becomes important in the balance needed for milk fat production or depression. This will be discussed later under milk fat depression in Lesson 5A.

If the cow is fed a high level of intake or with too fine a particle size, there may be some bypass of carbohydrates that would have to be digested in the lower tract. This digestion splits the carbohydrates into simple sugars via the enzymes which are absorbed directly from the small intestines into the blood.

PROTEINS

The digestion of protein is very interesting. It is an area that animal nutritionists are studying intensively. The concept of soluble and insoluble protein is the focus of many of these research studies. The concept will be examined in another lesson. The protein partition of feedstuffs is depicted in Figure 2. The pathways for protein digestion are many. Protein is broken down by the bacteria to amino acids then the ammonia is split off and the bacteria make bacterial protein. This bacterial protein then will eventually be passed down the tract and is digested in the abomasum and small intestine via proteases (enzymes that split proteins into amino acids). The amino acids are then absorbed through the small intestine. This would be the route soluble protein and insoluble protein that is degraded in the rumen travels. Insoluble protein, that escapes rumen degradation, would pass undigested to the abomasum and be broken down to amino acids and absorbed.

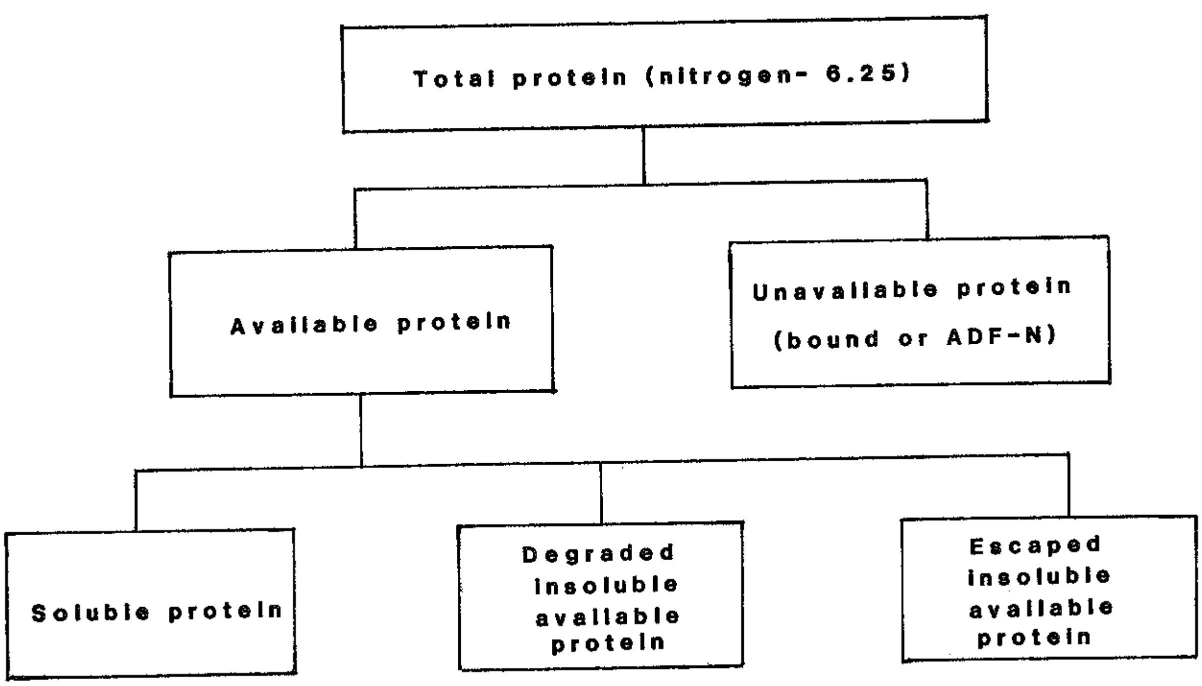


FIGURE 2: Protein partition of feedstuffs

Non-protein nitrogen (NPN) provides protein to the cow by the action of the rumen miroorganisms. The "bugs" deaminate (remove the ammonia) the NPN and use the ammonia for their own protein which would be available to the cow when she digests bacteria in her abomasum. To put it simply, soluble protein, degraded insoluble available protein, and NPN feed the bacteria which in turn feed the cow. This process may be either helpful or detrimental. The bacterial protein may either improve or reduce the biological value of the feed protein. Biological value is a reflection of the amino acid composition of the protein that is available to the animal. The biological value of bacteria is 68. Thus, proteins with a biological value of less than 68 are improved in quality, while those with a biological value greater than 68 are reduced in quality.

There may be some protein that escapes protein degradation in the rumen. These insoluble available proteins are digested in the abomasum and small intestine to amino acids that are absorbed.

FAT DIGESTION

Fats, as were stated earlier, are made up of triclycerides. Fat that is ingested by the cow is hydrogenated in the rumen. In other words, hydrogen is put into the molecule (due to the excess of hydrogen in the rumen). This process makes unsaturated fat become saturated fat. Therefore, the cow's body fat and milk fat is a saturated type, much the chagrin of human nutritionists. The amount of fat that is fed to cows is small (normally less than 3%); however, workers in Ohio State are getting production responses to high fat rations. These high fat rations are on the order of 5-6% added fat.

There is no appreciable digestion of fats until they reach the small intestine. Here the fat is mixed with bile from the liver and it is emulsified. Lipase, found in the pancreas' secretions, then splits the fats into fatty acids and glycerol. The glycerol, fatty acids and bile form small droplets called micelles that are then absorbed through the villi of the small intestine into the lymph system of the body.

MINERALS

There are many minerals that are important to the cow. Macrominerals are needed in relatively large amounts and microminerals are needed in small amounts. See Table 2. Most of the minerals undergo little if any change in the digestive system. Minerals are absorbed in different sites in the system and some have a dependency on a vitamin or other protein to assist the absorption of the mineral. For example, vitamin D is necessary for proper calcium absorption. Table 3 lists the minerals involved in dairy nutrition and their functions.

Table 2. Macrominerals and microminerals

Macrominerals	Microminerals
Potassium (K)	Cobalt (Co)
Sulfur (S)	Copper (Cu)
Chloride (Cl)	Iodine (I)
Calcium (Ca)	Iron (Fe)
Phosphorous (P)	Manganese (Mn)
Sodium (Na)	Molybdenum (Mo)
Magnesium (Mg)	Zinc (Zn)
	Selenium (Se)
	Florine (F)
	Chromium (Cr)

VITAMINS

As was mentioned in Lesson 1, the B vitamins are synthesized in the rumen by the microorganisms. However, vitamin B_{12} requires cobalt for its production. So in order for the rumen bugs to produce enough vitamin B_{12}, cobalt must be adequate. Vitamins A, D, and E are not synthesized in the rumen; therefore, they must be supplied in the ration. These vitamins can be supplied in either the roughages, concentrates, or by supplemental vitamin additives. Table 4 lists the vitamin's role in dairy cattle nutrition.

In this lesson the individual nutrients have been discussed as to their need and use to the cow. In addition, the discussion as to how the nutrients are digested and absorbed was presented. The next step in the process of feeding cows is a discussion of the feed that can be fed to supply these nutrients to the cow.

Table 3. Animal mineral chart

Mineral	Major Function	Some Deficiency Symptons	Comments
MAJOR OR MACROMINERALS			
Sodium (Na)	Major cation in osmotic pressure and acid base balance in body fluids. Associated with muscle contraction. Important in making bile.	Reduced growth and efficiency of feed utilization in growing animals, reduced milk production and weight loss in adults. Lowered reproduction (fertility in males, and delayed sexual maturity in females). Craving for sodium, evidenced by such things as drinking urine.	
Chloride (Cl)	Major anion involved in osmotic pressure and acid-base balance. Chief anion of gastric juice where it unites with H ions to form hydrochloric acid.	Depressed growth rate. Body weight loss. Depressed appetite. Depressed milk production.	
Calcium (Ca)	Bone and teeth formation; nerve function; muscle contraction; blood coagulation; cell permeability. Essential for milk production.	Rickets in young. Osteomalacia in adults. Tetany (hypocalcemia). Milk fever in dairy cows.	Calcium-phosphorus ratio is important. For ruminants, it may be anywhere from 1:-3:1. Vitamin D is involved. Excess Ca reduces the absorption and utilization of Zn. Excess Mg decreases Ca absorption, replaces Ca in the bone, and increases Ca excretion.

Table 3. Continued.

Phosphorous (P)	Bone and teeth formation; important in lipid transport and metabolism and cell-membrane structure. In energy metabolism. A component of RNA and DNA required for protein synthesis. A constituent of several enzyme systems.	Rickets in young. Osteomalacia in adults. Depraved appetite (pica). Breeding problems. Urinary problems.	Ratio of Ca-P is important. Sufficient vitamin D is necessary for P assimilation and utilization. Excess Ca and Mg cause decrease in P absorption.
Magnesium (Mg)	Essential for normal skeletal development, as a constituent of bone; enzyme activator. Helps to decrease tissue irritability.	Vasodilation, with resulting reduction in blood pressure. Hyperirritability. Tetany (grass tetany, or grass staggers) characterized by loss of appetite, (anorexia), hyperemia, convulsions and death.	Excess of Mg upsets Ca and P metabolism.
Potassium (K)	Major cation of intracellular fluid where it is involved in osmotic pressure and acid-base balance. Muscle activity. Required in enzyme reaction involving creatine. Influences carbohydrate metabolism.	Growth retardation, unsteady gait, general muscle weakness, pica, diarrhea, distended abdomen, emaciation followed by death.	Mg deficiency results in failure to retain K. Excessive levels of K interfere with Mg absorption.

Table 3. Continued.

Sulfur (S)	Required as a component of sulfur-containing amino acids. Important in lipid, carbohydrate and energy metabolism.	Retarded growth. Depressed appetite. Reduced microbial protein synthesis.	Sulfur is related to the amino acids cystine and methionine, and to biotin, thiamin, and coenzyme A.
MINOR OR MICROMINERALS			
Cobalt (Co)	As a component of vitamin B_{12}. Rumen microorganisms use Co for the synthesis of vitamin B_{12} and the growth of rumen bacteria.	Deficiency of Co in cattle and sheep produces symptoms similar to a deficiency of vitamin B_{12}. Ruminants grazing in Co-deficient areas show loss of appetite, reduced growth, and loss in body weight, followed by emaciation, anemia, and eventually death. Frequently a depraved appetite is noted.	Related to vitamin B_{12}. New York is a Co-deficient area.
Copper (Cu)	Necessary for hemoglobin formulation. Essential in enzyme systems, hair development and pigmentation, bone development, reproduction, and lactation.	Fading hair coat. Nervous symptoms. Lameness, swelling of joints, and fragility of bones.	Excess Cu (levels above 250 ppm) is toxic; it accumulates in the liver, and death may result.
Iodine (I)	Needed by the thyroid gland for making thryoxin, a hormone which controls the rate of body metabolism of heat production.		Long-term chronic intake of large amounts of I reduced thyroid uptake of I.

Table 3. Continued.

Iron (Fe)	Iron is a constituent of hemoglobin. Iron plays a role in cellular oxidation.	Fe-deficiency anemia, characterized by smaller than normal number of red cells and less than normal amount of hemoglobin.	Cu is required for proper Fe metabolism. Pyridoxine deficiency decreases the absorption of Fe.
Manganese (Mn)	Essential for normal bone formation. Thought to be an activator of enzyme systems involved in oxidative phosphorylation, amino acid metabolism, fatty acid synthesis, and cholesterol metabolism. Growth and reproduction.	Poor growth. Lameness, shortening and bowing of the legs, and enlarged joints. "Knuckling over" in calves. Impaired reproduction.	Excess Ca and P decreases absorption.
Molybdenum (Mo)	As a component of the enzyme xanthine oxidase - especially important in poultry for uric acid formation. Stimulates action of rumen organisms.	Toxic levels of Mo are of greater practical concern than deficiencies.	Mo is related to microbial action in ruminants. Toxic levels of Mo interfere with Cu metabolism.
Selenium	Not completely known. But involved in vitamin E absorption and/or retention. Also a required nutrient in its own right. Implicated with glutathione peroxidase.	Nutritional muscular dystrophy in lambs and calves. Increased incidence of retained placenta.	Selenium is related to vitamin E absorption. Animals consuming forage or grain produced on seleniferous soils develop blind staggers or alkali disease, characterized by emaciation, loss of hair, soreness and sloughing of hooves, lameness, anemia, excess salivation, grinding of the teeth, blindness, paralysis and death.

Table 3. Continued.

Zinc (Zn)	Needed for bone development. A component of several enzyme systems. Also required for normal protein synthesis and metabolism.	Loss of appetite and stunted growth. Poor hair or feather development; slipping of wool.	Excess Ca reduces the absorption, and utilization of Zn. Excess Zn interferes with Cu metabolism and may cause anemia.

Table 4. Animal vitamin chart

Vitamin	Functions	Some Deficiency Symptons	Comments
THE FAT SOLUBLE VITAMINS			
Vitamin A	Bone growth. Night vision. Epithelial tissue maintenance-respiratory, urogenital and digestive tracts, and the skin.	Stunted growth or loss of weight and loss of appetite, xerophthalmia, night blindness, nervous incoordination as shown by a staggering gait, and sterility in males and females or young which are born weak or dead. Reproductive failure.	Vitamin A is found only in animals; plants contain the precursor, carotene. Animals are able to store considerable vitamin A. Both carotene and vitamin A are readily destroyed by oxidation, thus resulting in considerable losses in processing and storing (as in making or storing of hay).
Vitamin D	Aids in the assimilation and utilization of calcium and phosphorous and necessary in normal bone development of animals, including the bones of the fetus.	Rickets in young.	Most mammals can use either D_2 or D_3. When animals are exposed sufficiently to direct sunlight, the ultraviolet light in the sunlight penetrates the skin and produces vitamin D_3.
Vitamin E	Antioxidant. Muscle structure. Reproduction.	Muscular dystrophy (white muscle disease). Reproductive failure. Steatitis.	Vitamin E is widely distributed in all natural feeds. Utilization of vitamin E is dependent on adequate selenium.
Vitamin K	Essential for prothombin formation and blood clotting.	Prolonged blood clotting time, generalized hemorrhages, and death in severe cases.	Well known antagonists of Vitamin K are dicoumarol and warfarin.

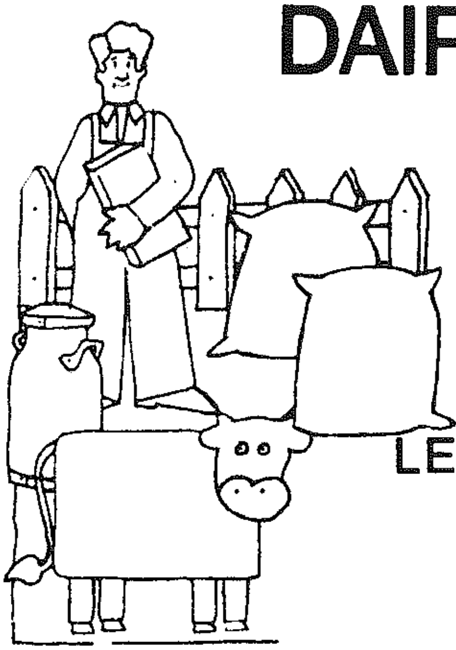
Table 4. Continued

THE WATER SOLUBLE VITAMINS			
Vitamin B_{12}	Coenzyme in several enzyme systems Closely linked with folic acid.	Retarded growth.	
Biotin	Component of several enzyme systems.		Ruminant animals synthesize all they need.
Choline	Involved in nerve impulses. A component of phospholipids. Donor of methyl groups.	Fatty livers in most species. Kidney hemorrhaging.	
Folic acid (folacin)	Related to B metabolism. Metabolic reactions involving incorporation of single carbon units into larger molecules.	Poor growth. Macroxytic anemia.	Folic acid is widely distributed in both plants and animals.
Niacin (nicotinic acid)	Constituent of coenzymes. Hydrogen transport.	Reduced growth and appetite.	Mature ruminants do not need dietary niacin under most conditions because of synthesis of rumen microflora.

Table 4. Continued

Pantothenic acid	Required for energy metabolism.	Mature ruminants synthesize pantothenic acid in rumen. Signs of deficiency in calves are rough coat, dermatitis, anorexia, and loss of hair around eyes.	
Pyridoxine (B_6)	Protein and nitrogen metabolism. Involved in red blood cell formation. Important in endocrine system.	All species exhibit convulsions.	Normally, animal rations are not lacking in vitamin B_6.
Riboflavin (B_2)	Promotes growth and functions. Important in carbohydrate and amino acid metabolism.	Retarded growth in most species.	
Thiamin (B_1)	Energy metabolism. Promotes appetite and growth, required for normal carbohydrate metabolism, aids reproduction.	Anorexia and loss of weight. Cardiovascular disturbances. Lowered body temperature.	Seldom deficient in animals.
Vitamin C (ascorbic acid)	Collagen formation Formation of the intercellular substances of the teeth, bones, and soft tissues, increases resistance to infection, promotes firm gums.	Scurvy; swollen, bleeding and ulcerated gums; loosening of teeth; and weak bones.	Dietary need is limited to man, the guinea pigs, and monkey. Probably required by other species but synthesized in the body.

DAIRY CATTLE NUTRITION



LESSON 3: FEEDS FOR DAIRY CATTLE

The ruminant's anatomy provides for a microbial fermentation digestion of feedstuffs prior to the normal gastric digestion. In essence, we are feeding the bugs which then feed the cow. The purpose of this lesson is to discuss the feeds available to supply the nutrients that undergo this digestive process. There are two basic classes of feeds that we can use to meet the nutrient requirements, roughages and concentrates. Let's begin our discussion of feeds by examining roughages or forages.

ROUGHAGES

"Forage (roughage) is defined as vegetable matter in a fresh, dried, or ensiled state which is fed to livestock (pasture, hay, and silage)."[1] On a dry matter basis, roughages average more than 18% crude fiber. Roughages are, due to their higher fiber content, lower in energy value. In most cases, the forages are homegrown, economical feeds that provide the cow with several nutrients. The ruminant digestive tract allows the cow to utilize forage for many of their required nutrients.

Hay crops, particularly legumes, are excellent sources of proteins and minerals, particularly calcium. The quality of hay crops is closely related to their date of harvest. Early cut hay crops are significantly higher in protein than are later cut hay crops. See Table 1.

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[1] Ensminger & Olentine, Feeds & Nutrition.

Table 1. Nutrient content of legumes and grasses at different stages of maturity

	CP %	NE_1 Mcal/lb	Ca %	P %	ADF[a] %
Alfalfa					
hay SC[b]					
early vegetative 1st cut	23.4	.70	2.45	.30	28
early vegetative 1st cut	21.7	.67	2.12	.30	31
late vegetative 1st cut	19.9	.63	2.45	.30	34
early bloom 1st cut	17.2	.59	1.25	.23	38
mid bloom 1st cut	16.0	.57	1.25	.23	40
fall bloom 1st cut	15.0	.54	1.28	.20	42
mature bloom 1st cut	13.5	.52	1.17	.17	44
Timothy					
late vegetative	11.4	.70	.66	.34	33
early bloom	10.0	.64	.53	.26	37
mid bloom	9.5	.59	.41	.19	40
late bloom	7.7	.56	.38	.18	43
seed stage	6.0	.51	.28	.18	45

[a]Acid detergent fiber.

[b]Sun cured.

Legumes are generally higher in protein and minerals than are the grasses. See Table 2.

Table 2. Nutrient content of legumes vs. grasses

	CP %	NE_1 Mcal/lb	Ca %	P %
Alfalfa early vegetative 1st cut	23.4	.70	2.45	.30
Red clover early bloom	21.1	.70	2.26	.38
Birdsfoot trefoil	15.6	.62	1.75	.22
Timothy late vegetative	11.4	.70	.66	.34
Orchardgrass early bloom	10.2	.64	.58	.55
Brome grass late vegetative	10.5	.64	.39	.35
Corn silage	8.0	.73	.27	.20

While the value in both these tables are "book values", the point can be made that as the maturity of the plant increases, feeding value of the hay crop decreases. Thus the early cutting of the forage is important to save nutrients in the crop. The value of legumes is also demonstrated by the considerably higher levels of protein and calcium in the feeds. The values of hay crop silages are equal to the values of hay if harvested at the same stage of growth. The only difference between hay crop silages and dry hay is the level of moisture in the feeds.

Energy is also supplied by roughages. Early cut hay crops can supply significant amounts of energy. However, corn silage is normally considered the high energy roughage. Corn silage is higher in energy but is lower in protein, mineral and fiber content. DHI forage analysis normally shows that the acid detergent fiber (ADF) of mixed mostly legume hay crops range from 31.8 to 46.4% ADF, while corn silage has an ADF range of 23 to 34.3%. ADF is a measure of the fiber in a feedstuff. It contains the lignin and cellulose of the cell wall. Calcium is particularly low in corn silage. The high energy, low protein and mineral content of corn silage compliments the high protein and minerals in the hay crops.

FORAGE ANALYSIS

The nutrient content of forage is the basis of a balanced feeding program. In order to balance a ration, one has to know what nutrients each feed is supplying. Book values are not good enough. The reason for the lack of reliability of book values is that similar forage varies considerably in nutrient content. See Table 3.

Table 3. Variability in forage analysis[a]

Ingredient	Mixed, mainly legume silage	Corn silage	HM shell corn
	(% dry matter)		
Number of samples	1,401	2,434	190
Dry matter	46.6 33.6-59.5[b]	33.7 26.1-41.2	72.5 67.5-77.4
Crude protein	15.8 11.9-19.6	8.5 7.4- 9.5	10.0 9.3-10.6
Adj. crude protein	14.9 10.9-18.8	8.5 7.4- 9.5	10.0 9.3-10.6
ADF	40.0 34.6-45.3	27.5 22.6-32.3	4.3 3.3- 5.2
NE_1 (Mcal/lb)	.52 .45-.56	.69 .69-.72	---

[a]1980 NYDHIC Forage Laboratory Summary.

[b]Normal range.

As can be seen in Table 3, there is a large variation in nutrient content within classes of forages. A range in protein content of MML silage from 11.9 to 19.6% makes using the average of 15.8% very imprecise. The only way to know what the nutrient content of your forage is is to have it analyzed. Forage analysis can be done by the New York Dairy Herd Improvement Cooperative, Pennsylvania State University, or other labs of feed manufacturers. A John Doe sheet from the NYDHIC Lab is enclosed and is discussed later in this lesson.

The sampling of forages is most important to the accuracy of the forage analysis report. A representative sample must be taken. Follow the guidelines on page 7.

The question is asked "how many forage analyses do I need?" That question has no easy answer. Surely the minimum frequency should be whenever there is a major change in forage. In addition, sampling on the way into storage will not give any information on heat damage of protein in hay crop silage. A sample out of storage is warranted if heat damage is expected. A monthly check on all forages is advisable as well as weekly tests of dry matter. Remember, a good feeding program starts with a good forage analysis.

The forage analysis gives information on dry matter/moisture, protein, energy, ADF and mineral content of the feed. Let's define each of these terms used in the forage analysis report.

Percent moisture - the percent of moisture or water in the feed.

Percent dry matter - 100% minus percent of moisture - the feed free of moisture.

Crude protein - A measure of the total protein equivalent from both natural and non-protein nitrogen sources (NPN).

Available protein - represents the amount of protein that is available to the animal (crude protein minus unavailable protein equals available protein).

Unavailable protein - amount of protein in the acid detergent fiber (ADF) fraction of the feed. Normally 1% protein (dry matter basis) is found in this fraction. Values greater than 1% indicate heat damage.

Adjusted crude protein - equals crude protein if no heat damage or available protein plus 1% (to correct for the 1% protein in the ADF fraction).

Acid detergent fiber - is a newer, more precise way of reporting the fiber fraction of feeds. Contains lignin and cellulose.

Total digestible nutrients (TDN) - measure of energy.

Estimated net energy (ENE) - is a measure of energy equal to the amount of energy available for maintenance, fattening, and milk secretion.

Net energy of lactation (NE_l) - a measure of energy equal to the amount of energy available for maintenance and milk secretion. It is a more specific measure for energy for the dairy cow.

One might note that the NYDHIC report does not have a figure for digestible protein. The reason for this is that the National Research Council (NRC) no longer reports the digestible protein content of feeds or requirements since the digestibility of protein is directly related to the percent protein in the diet. Therefore, the digestible protein value varies from ration to ration. The NRC presents protein requirements "..... only as total crude protein from feed composition tables to calculated quantities of protein required in a mixed diet."[2]

The three energy terms listed on the report form are all calculated values. Total digestible nutrients (TDN) is probably the most familiar term. Figure 1 contains a partition of energy use in the animal. TDN is quite similar to DE which is in Figure 1. However, note that DE does not account for any urinary, gaseous or heat increment energy losses. Net energy is the preferred energy term for use in formulating dairy rations since it best represents the feed energy which is available for utilization by the animal.

Hay - Sampling On The Way Into Storage

1. Put aside three to four bales from each load as they go into storage.

2. Core sample these bales at the end of the day (if core sampler is not available, reach into the center of the bale and pull a sample.

   a. If hay is from different fields having a large variation in legumes or time of baling, sample the fields separately.

3. Composite the bale samples making sure not to shatter or lose the leaf.

Hay - Sampling Out Of Storage

1. Determine types of hay in storage by date of cut, maturity and percent legume.

2. Pull several representative bales.

3. Core sample and composite as above.

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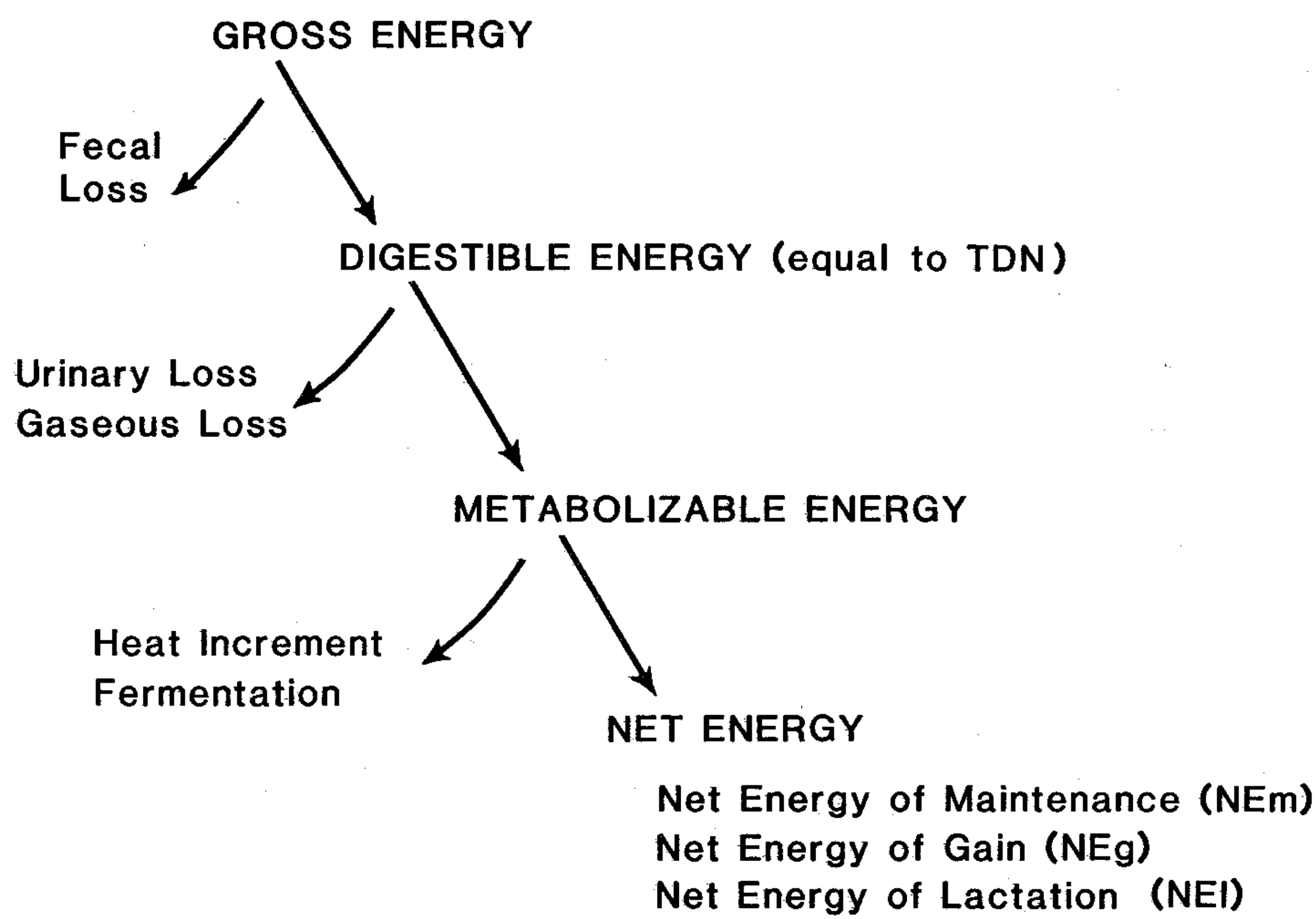
[2]NRC, Nutrient Requirements of Dairy Cattle, 1978.

Figure 1. ENERGY PARTITION



Silage - Upright Silos

1. Sample during filling so that the forage analysis is available for feed programming before the silo is opened.

2. Take several grab samples from each load of forage as it is being blown into the silo. Make notes what changes are made from field to field. Perhaps bright colored ribbon placed in the silo will help to identify the transition in feeds.

3. Composite the sample thoroughly, subsample and freeze.

4. Sampling fermented silage - fill the silage cart and sample as above.

Silage - Horizontal Silos

1. Rake whole working surface.

2. Take grab samples from the raked material.

3. Mix thoroughly, subsample, freeze.

CONCENTRATES

Concentrates are feeds that are high in energy and low in fiber (less than 18%). Concentrate feeds can be subclassed into energy concentrates and protein concentrates. Concentrates are grains or seeds and their by-products. Table 4 lists the composition of several concentrate feeds in both high energy and high protein classes.

Table 4. Nutrient composition of concentrate feeds[a]

	NE_l Mcal/lb	CP %	Ca %	P %
	(DM basis)			
Ground ear corn	.84	9.3	.05	.26
Cracked shelled corn	.84	10.0	.03	.31
Ground shelled corn	.92	10.0	.03	.31
Barley	.87	13.9	.05	.37
Wheat, soft white winter	.92	11.5	.06	.41
Rye	.84	13.8	.07	.36
Oats	.79	13.6	.07	.39
Hominy	.97	11.8	.06	.58
Beet pulp	.81	8.0	.75	.11
SBM 44%	.84	49.6	.36	.75
Linseed meal	.84	38.8	.43	.93
Brewers grains-dried	.68	26.0	.29	.54
Distillers grains w/soluble	.92	29.8	.16	.79
Corn gluten feed	.86	25.0	.33	.86
Soybeans	.99	41.7	.28	.66
Wheat midds	.84	18.7	.12	1.01
Wheat bran	.72	18.0	.12	1.32

[a]NRC, 1978.

COMMON FEEDS

A discussion of feeds in dairy nutrition would be incomplete without addressing the feeds in common use or that are readily available. Let's look into these now.

HIGH MOISTURE CORN

One of the feeds most often asked about is high moisture corn. High moisture corn is either whole shelled, ground shelled, or ground ear corn that is harvested between 25 and 30% moisture. It is either stored as silage or treated with organic acids to preserve it. The nutrient content of high moisture corn is equal to dry corn on a dry matter basis. Thus one pound of dry matter from high moisture corn equals 1 pound of dry matter from dry corn.

The advantages of high moisture corn are:

1. Earlier harvesting.

2. Less harvesting loss at the higher moisture content.

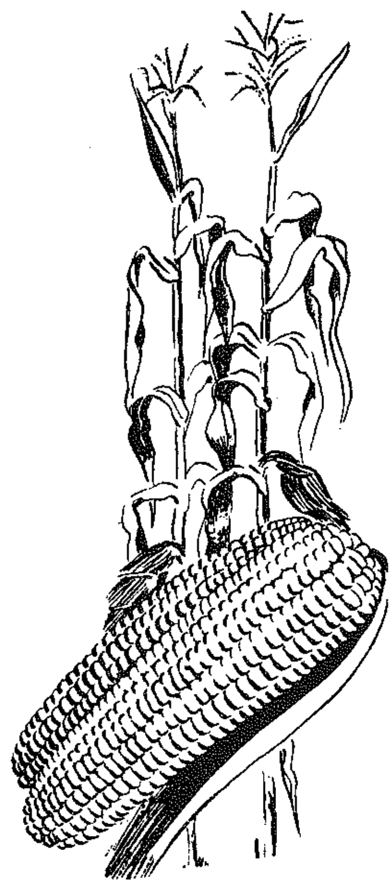
3. No artificial drying.

4. High moisture corn is palatable.

The disadvantages include:

1. Unless it is stored in an oxygen limiting silo or is treated, at least 2 inches must be fed out daily in order to keep ahead of spoilage.

2. Unless acid treated, spoilage is rapid after removed from storage.



HMEC vs. HMSC

The choice between high moisture ear or high moisture shelled corn should take into consideration not only the nutrient value of the corn, but also the available harvesting and handling equipment. The nutrient content of high moisture shelled corn and high moisture ear corn is found in Table 5. The energy values in the 1978 NRC publication are equal for high moisture cracked shelled corn and high moisture ear corn. Ear corn is the cob and the kernal with no trash (leaves, stalk, etc.). The reason for this is the method for feeding of the two feedstuffs. High moisture shelled corn is normally processed by rolling. High moisture ear corn is ground. The difference in particle size of the two feeds results in equal energy values. The rolled high moisture shelled corn results in equal energy because there is less surface area for the bacteria to attach and digest. If the high moisture shelled corn were ground, there would be a 10% increase in the energy value. Note Table 4.

Table 5. Nutrient composition of high moisture corn[a]

Item	HMSC	HMEC
	---(100% DM Basis)---	
Crude protein, %	10.4	9.3
ADF, %	4.3	11.7
Calcium, %	.027	.05
Phosphorous, %	.30	.25
Magnesium, %	.12	.11
Potassium	.38	.43
Sodium, %	.0079	.0139
Iron, ppm	64.	72.
Zinc, ppm	24.	23.
Copper, ppm	3.	3.
Manganese, ppm	10.	12.

[a]NYDHIC Forage Testing Laboratory Summary, January, 1981.

The higher level of fiber in the ear corn may be useful in keeping the cows on feed and preventing a milk fat depression. Feeding programs can be developed for both high moisture shelled corn and high moisture ear corn; however, close attention must be paid to mineral and vitamin nutrition when using either feed.

WET BREWERS GRAINS

Wet brewers grains are a by-product of the beer industry. The brewers grains provide an excellent source of insoluble protein, acid detergent fiber, phosphorous and energy. While the fiber level is high in wet brewers grains, it should be considered a concentrate feed. The energy level of wet brewers grains appears to be higher than in the dried grains (.77 vs .68 Mcal). This is unexplained at this time. The nutrient content of wet brewers grains follows.

DRY MATTER	CRUDE PROTEIN	NE_l	Ca	P	ADF
20-25%	25-27%	.77	.31	.52	23

The problems of wet brewers grain feeding is the storage of the grains. The feed has a limited "shelf life" in warm weather. The wet brewers grains should be fed out within 5-7 days in the summer and 10-12 days in the winter. However, long term storage of wet brewers grains is possible with properly designed structures. Levels of bound protein should be checked periodically. Some heat damage may occur with wet brewers grains.

WET DISTILLERS GRAINS

Wet distillers grains are also available. The average composition of wet distillers grains is found below.

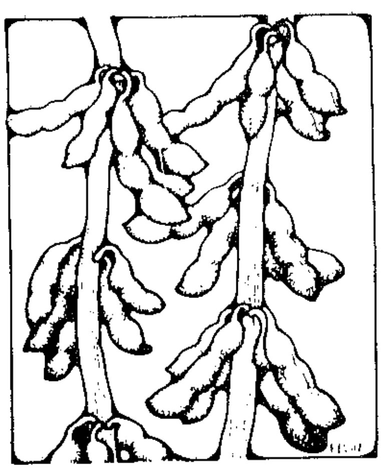
DRY MATTER	CRUDE PROTEIN	NE_1	Ca	P
30-33%	34-35%	.92	.10	.40

The samples that have been taken of wet distillers grains have shown a considerable amount of heat damage (from 10-30% of the protein). Thus, forage analysis is needed to check bound protein levels. Wet distillers grains is higher in protein and energy than wet brewers grains. Storage of wet distillers grains should be considered as its "shelf life" is limited like wet brewers grains.

RAW SOYBEANS

Feeding of raw soybeans may be done successfully. However, due to the high fat content one must be careful to handle the feed properly. The nutrient content of raw soybeans is 40% crude protein, 18-20% fat, 5-7% ADF, .2% calcium, .7% phosphorous. The following are guidelines for the use of raw soybeans in dairy rations.

1. All soybeans should be ground or cracked before feeding to improve their digestibility.



2. Feed containing ground or cracked soybeans should not be stored longer than 7 days in warm weather. If stored longer than this, the oil on the soybeans may become rancid and reduce palatability.

3. Urea and raw soybeans should not be mixed together in grain rations. Raw soybeans contain the enzyme urease which releases ammonia from the urea. This may cause a palatability problem and a reduction in feed intake.

4. Raw soybeans should be limited to no more than 10-25% of the grain mixture. This should be about 4-6 pounds of raw soybeans per cow per day. Higher levels contribute significant amounts of fat to the ration and may alter rumen fermentation.

WHOLE COTTONSEED

Whole cottonseed has been fed as a component of dairy rations for many years in Arizona and California. Recently, this feed has become available in New York. Average nutrient content is 22-24% crude protein, 20-22% fat, 30-35% ADF, .15% calcium and .7% phosphorous. The energy value is about 98% TDN or 1.04 Mcal of NE_1 per pound. Current feeding guidelines indicate a maximum level of 6-8 pounds per cow per day.

There are several other by-product feeds that may be fed with good results. If any of these are available, the nutritional as well as economic aspects should be assessed prior to feeding. Cooperative Extension personnel can help in assessing these feeds.

THE FEED TAG

A feed tag should accompany each delivery of commercial feed or mineral. The purpose of the feed tag is to inform you of the nutrient content and ingredient composition of the product received. The feed tag also indicates that the product is registered with the Department of Agriculture and Markets in New York.

The feed tag for a commercial grain or protein supplement will contain the following minimum guaranteed analysis:

1. Minimum crude protein
2. Minimum crude fat
3. Maximum crude fiber

This is the minimum required information. Some companies may list additional analysis information. A list of ingredients which comprise the feed will also be provided.

Some feeds will contain urea or some other non-protein nitrogen compound. If this is the situation, it will be stated on the tag as in the following example:

> Crude Protein 40.0% Minimum
> (This includes not more than 10.4%
> equivalent crude protein from
> non-protein nitrogen.)

One question of interest in this situation relates to urea content. Urea is the most common form of NPN added and will be listed as an ingredient on the feed tag when used. How much urea does this feed contain? Since feed grade urea usually contains 281% crude protein, then one pound of urea would contain 2.81 pounds of crude protein. Thus, in this case, the feed contains 3.7% urea (10.4 ÷ 2.81).

IDENTIFICATION NUMBERS				NY DHI 327 11/81		DATES			
LAB	ST	CO	FARM	SAMPLE DESCRIPTION	CODE	SAMPLED	LAB REC'D	DRPL REC'D	PRINTED
999999	21	99	9999	MML SILAGE	271	08-11-79	08-13-79	08-15-79	08-16-79
							HARVESTED		
							06-28-79		

FOR NORTHEAST DHIA SUPERVISOR

DESCRIPTION	KIND	% DRY MATTER	NET ENERGY (LACTATION)	% PROTEIN
SUCCULENT ROUGHAGE	3	40	43	

FORAGE ANALYSIS REPORT

SAMPLES ANALYZED BY:

FORAGE TESTING LABORATORY
NY DHIC
730 WARREN ROAD
ITHACA, NEW YORK 14850
607-257-1272 EXT. 36

DOE, JOHN
ANY STREET
ANY TOWN
NEW YORK 00000

STANDARD ANALYSIS RESULTS

DESCRIPTION	AS SAMPLED BASIS	DRY MATTER BASIS
% MOISTURE	60.0	
% DRY MATTER	40.0	
% CRUDE PROTEIN	7.7	19.3
% AVAILABLE PROTEIN	5.9	14.9
% UNAVAILABLE PROTEIN	1.8	4.4
% ADJUSTED CRUDE PROTEIN	6.4	15.9
% ACID DETERGENT FIBER	16.0	40.0
% T.D.N.	24.0	60.0
ESTIMATED NET ENERGY - MCAL/LB.	.17	.43
NET ENERGY (LACTATION) - MCAL/LB.	.21	.52

NUTRIENTS SUPPLIED

25.0 POUNDS OF THIS FEED EQUALS TEN POUNDS OF DRY MATTER AND SUPPLIES:

1.6	POUNDS
4.0	POUNDS
6.0	POUNDS
4.3	MCALS
5.2	MCALS

MINERAL ANALYSIS RESULTS

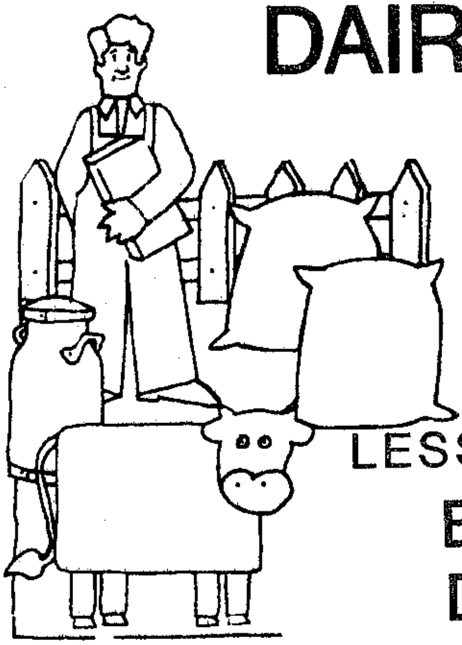
DESCRIPTION	AS SAMPLED BASIS	DRY MATTER BASIS	NUTRIENTS SUPPLIED	
% CALCIUM	.500	1.250	56.7	GRAMS
% PHOSPHORUS	.10	.25	11.3	GRAMS
% MAGNESIUM	.10	.25	11.3	GRAMS
% POTASSIUM	.80	2.00	90.7	GRAMS
% SODIUM	.0100	.0250	1.1	GRAMS
PPM IRON	100	250	1134	MILLIGRAMS
PPM ZINC	13	33	149	MILLIGRAMS
PPM COPPER	4	9	40	MILLIGRAMS
PPM MANGANESE	15	38	172	MILLIGRAMS
% SULFUR XXX				

SEE REVERSE SIDE FOR EXPLANATIONS

ADDITIONAL ANALYSES	AS SAMPLED BASIS	DRY MATTER BASIS
% PROTEIN EQUIVALENT FROM **UREA**		
% PROTEIN EQUIVALENT FROM **AMMONIA**		
% NITRATE ION		
% SOLUBLE PROTEIN	3.9	9.7
% PROTEIN SOLUBILITY	–	50.0

SMITH, JANE
ANY STREET
ANY CITY
NEW YORK 00000

DAIRY CATTLE NUTRITION



LESSON 4: BALANCING DAIRY RATIONS

In this lesson we are going to get down to work. With the understanding of digestive anatomy, digestion and feedstuffs, we are ready to assemble a bit more information so that we can begin balancing rations. Once we know the basics of balancing rations, then we can progress to feeding the various classes of dairy animals and understanding how to avoid nutritional problems.

BALANCED RATIONS

"A balanced ration is one which provides an animal the proper proportions and amounts of all the required nutrients for a period of 24 hours."[1] The balanced ration must supply all the nutrients required, not only for maintenance of the animal, but also for the growth, reproduction, and milk production that is demanded of the dairy cow.

A balanced ration leads to the efficient use of nutrients, since they are neither overfed or underfed. Overfeeding nutrients is costly and underfeeding limits production, thereby reducing income. Thus, the benefits of a balanced ration are the economical feeding of the animal, the optimum feeding for production and the minimization of nutrition related problems.

---

[1] Ensminger & Olentine, Feeds & Nutrition.

There are several items that need to be known in order to produce a balanced ration.

First, what animal is being fed? If it is a cow, it's body weight, lactation number, fat test, and milk production are needed. If it's a heifer, it's body weight and frame size are important.

Second, the nutrient requirements of the animal are needed. Table 1 is an adaptation of the 1978 NRC nutrient requirements of dairy cattle. In order to calculate requirements, add maintenance requirements and nutrients required/# of milk x lb. of milk. For example, a 1300# cow producing 50# of 3.5% milk, the protein requirement is 1.06 + 50(.082) = 5.16# C.P.

Third, is the feed available, its nutrient content (by forage analysis) and the quantity available to feed. A silo capacity chart and forage inventory worksheet are enclosed with this lesson.

Fourth, if a least cost ration is to be balanced, the price of the feeds both homegrown and purchased is needed.

Finally, dry matter intake of the animal is important. There are several equations that estimate the maximum dry matter intake. Table 2 is adapted from the NRC publication. Another estimate of dry matter intake is:

$$1.85 \times \text{Body Wt. (in 100 lbs)} + .305 \times 4\% \text{ FCM (lbs)}$$

The equation for converting to 4% Fat Corrected Milk is:

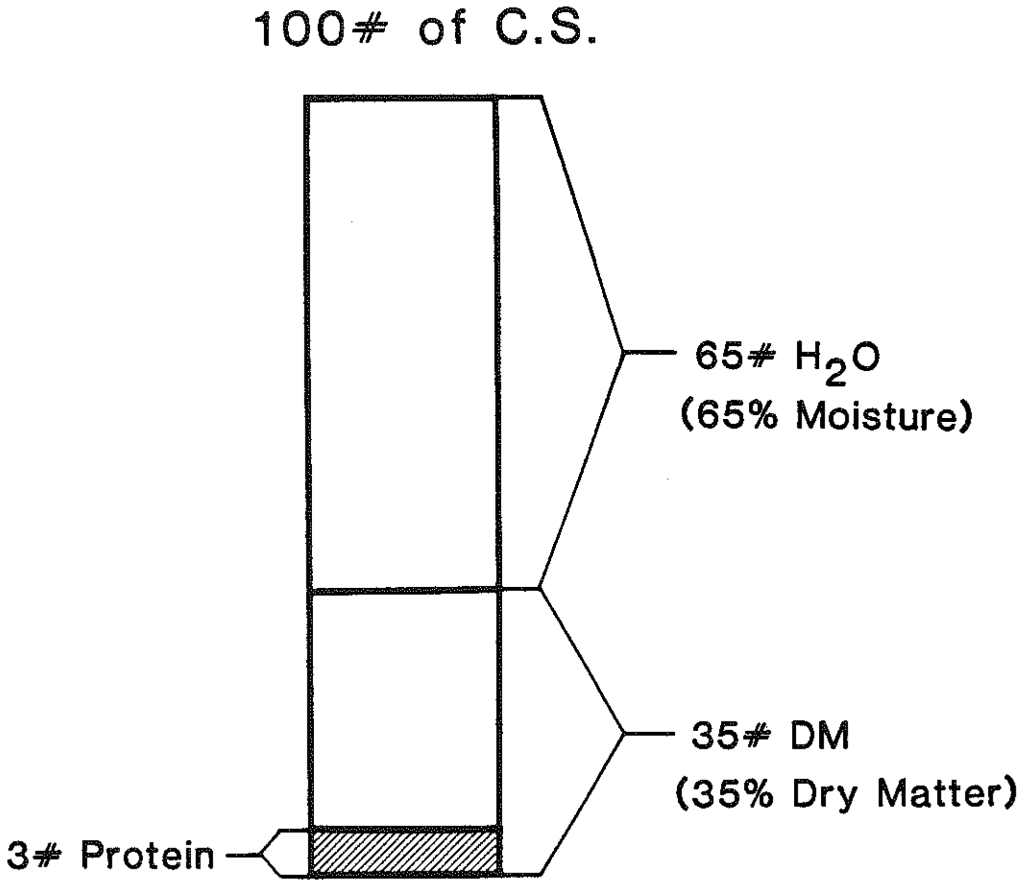
$$.4 \times \text{milk (lbs)} + 15 \times \text{fat (lbs)} = 4\% \text{ FCM (lbs)}$$

The estimate of dry matter intake is an important factor in balancing rations. The total nutrient supply must be contained in no more than the maximum amount of dry matter intake for the animal being balanced for. If the nutrients cannot be supplied in the maximum dry matter intake, then the ration is not balanced. Since the equations for dry matter intake are estimates, the best measure of dry matter intake of your herd is your own figures and calculations based on actual intakes.

DRY MATTER

Since feeds vary in their moisture or dry matter content, it is difficult to compare feeds unless a common base is used. A common base that is used is 100% dry matter (or dry matter basis). Once put on a dry matter basis, all feeds can be evaluated at that common base. Thus it is important to be able to convert from the wet feed (as fed basis) to the common base (dry matter basis). Figure 1 shows how much water, protein, and dry matter is in 100 pounds of 65% moisture corn silage. The appropriate calculations to determine protein content on a DM and wet basis are included in the figure. Dry matter intake cannot be calculated unless feeds are put on a DM basis. Some examples follow:

Figure 1. Partition of Dry Matter in Corn Silage.



% Protein (as fed)

3#/100# = 3%

% Protein (DM)

3#/35# = 8.6%

Table 1. Dairy nutrient requirements of dairy cattle[a]

Body weight (lbs)	Total protein (lbs)	TDN (lbs)	NE_1 Mcal	Ca (g)	P (g)	Vitamin A (1,000 IU)
Maintenance of Mature Lactating Cows[b]						
800	0.77	6.45	6.65	14.5	11.8	28
900	0.83	7.05	7.27	15.9	12.7	31
1000	0.89	7.63	7.86	17.2	13.6	35
1100	0.95	8.19	8.45	18.1	14.5	38
1200	1.01	8.75	9.02	19.5	15.4	41
1300	1.06	9.29	9.57	20.9	16.8	45
1400	1.12	9.82	10.12	21.8	17.7	48
1500	1.17	10.34	10.66	23.1	18.6	52
1600	1.22	10.85	11.19	24.0	19.5	55
1700	1.27	11.36	11.71	25.4	20.4	59
Maintenance and Pregnancy (last 2 months of gestation)						
800	1.45	8.40	8.65	24.0	17.2	28
900	1.57	9.17	9.45	26.8	19.1	31
1000	1.69	9.93	10.22	29.0	20.4	35
1100	1.80	10.66	10.98	31.7	22.7	38
1200	1.92	11.38	11.72	34.0	24.0	41
1300	2.03	12.08	12.44	36.3	25.8	45
1400	2.13	12.78	13.16	38.5	27.2	48
1500	2.24	13.45	13.85	40.8	29.0	52
1600	2.34	14.12	14.54	43.1	30.4	55
1700	2.44	14.78	15.22	45.4	32.2	59
Milk Production (nutrients required per lb of milk)						
% Fat						
2.5	0.072	0.260	0.27	1.09	0.77	-
3.0	0.077	0.282	0.29	1.13	0.77	-
3.5	0.082	0.304	0.31	1.18	0.82	-
4.0	0.087	0.326	0.34	1.22	0.82	-
4.5	0.092	0.344	0.36	1.27	0.86	-
5.0	0.098	0.365	0.38	1.31	0.86	-
5.5	0.103	0.387	0.40	1.36	0.91	-
6.0	0.108	0.410	0.42	1.41	0.95	-
Body Weight Change (nutrients per lb of weight change)						
Loss	-0.32	-2.17	-2.23			
Gain	0.50	2.26	2.32			

[a]Adapted from Nutrient Requirements of Dairy Cattle, No. 3, Fifth Revised Edition, 1978 National Research Council, Washington, DC.

[b]To allow for growth, add 20% to the maintenance allowance during the first lactation and 10% during the second lactation for all nutrients except Vitamin A.

Table 2. Expected maximum daily dry matter intake

Body weight (lbs)	900	1100	1300	1500	1700
	-----Dry matter intake, % of body weight------				
FCM[a] (lbs)					
20	2.5	2.4	2.3	2.2	2.2
30	2.9	2.7	2.6	2.5	2.4
40	3.2	3.0	2.8	2.7	2.6
50	3.5	3.2	3.0	2.9	2.7
60	3.9	3.5	3.3	3.1	2.9
70	4.2	3.8	3.5	3.3	3.1
80	4.6[b]	4.1	3.7	3.5	3.3
90	4.9[b]	4.3[b]	4.0	3.7	3.5
100	5.2[b]	4.6[b]	4.2	3.9	3.6
FCM (lbs)	-------Dry matter intake, lbs per day--------				
20	22.7	26.5	30.2	33.9	37.6
30	25.8	29.5	33.2	36.9	40.6
40	28.9	32.5	36.3	40.0	43.7
50	31.9	35.6	39.3	43.0	46.7
60	35.0	38.7	42.4	46.0	49.7
70	38.0	41.7	45.4	49.1	52.8
80	41.1[b]	44.8	48.5	52.2	55.8
90	44.1[b]	47.8	51.5	52.2	55.8
100	47.2[b]	50.9	54.5	58.3	62.0

[a]4% fat corrected milk.

[b]May be higher than is normally achieved.

As Fed to Dry Conversion

$$\frac{\text{\% Nutrient as fed}}{\text{\% DM}} \times 100 = 100\% \text{ nutrient on dry matter basis}$$

Example:

8% crude protein hay crop silage as fed 45% DM

$$\frac{8}{45} \times 100 = 17.8\% \text{ crude protein on a dry matter basis}$$

Dry Matter to As Fed Conversion

$$\text{\% Nutrient on a dry matter basis} \times \frac{\text{\% dry matter}}{100} = \text{\% nutrient on an as fed basis}$$

Example:

Corn silage 8% crude protein on a DM basis - 35% DM

$$8 \times \frac{35}{100} = 2.8\% \text{ crude protein as fed}$$

Now try your hand at it.

1. If hay crop silage is 17.8% crude protein on a dry matter basis (45% dry matter) what is it on an as fed basis?

2. Convert the 2.8% crude protein as fed, 35% dry matter corn silage to dry matter basis.

These conversions become important as we progress to balancing rations.

TECHNIQUES OF RATION BALANCING

There are several techniques of balancing rations. They vary from a trial and error method to the least-cost rationing with the use of computers. We will learn how to evaluate the nutrient content of rations and balance a dairy ration in this lesson. In addition, least costing will be discussed.

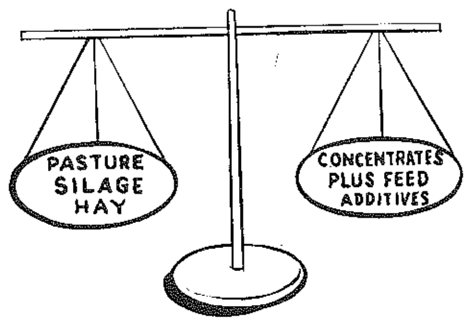
The evaluation of a ration's nutrient content is relatively easy arithmetic. The easiest way to accomplish an evaluation is to follow these steps.

into consideration additional growth of heifers and the body condition of the animals.

FORAGE TO CONCENTRATE RATIO

One concept that is effective in balancing rations is to balance diets for an optimum forage to concentrate ratio. The following minimum proportions of forage are recommended.

	F:C
Corn silage programs	
High grain (>60%)	55:45
Medium grain (50-60%)	50:50
Low grain (<50%)	45:55
Alfalfa	
>18% crude protein	55:45
16-18% crude protein	50:50
<16% crude protein	45:55
Grasses	
>16% crude protein	50:50
14-16% crude protein	40:60
<14% crude protein	30:70



These values are thumb rules. The objective is to maintain a rumen environment conducive to optimum animal productivity. The variation in forage to concentrate ratio is based on the different rates of digestion among forages. First, legumes digest in the rumen at a much faster rate than grasses. In order to maintain a continuous fiber load in the rumen to satisfy the fiber digesting bacteria's requirements, it is necessary to maintain a higher ratio. As forage matures, the cell wall becomes more lignified. This reduces the rate and extent of digestion. As a result, it is necessary to decrease the forage to concentrate ratio in order to maintain the fiber load, dry matter intake, and meet the energy requirments of the cow. It must be remembered that our goal is to obtain maximum dry matter intake. The forage to concentrate ratios are guidelines to obtain this goal. Rations that are higher in concentrates tend to decrease the amount of dry matter that is consumed by the cow. Therefore, by maximizing the utilization of forage, more dry matter intake may result.

FEEDING FREQUENCY

More frequent feeding improves the utilization of nutrients in the rumen by maintaining a more stable fermentation. Variation in rumen pH and other metabolites is minimized. There is less chance of a cow going off feed by feeding more frequently. In addition, some increases in dry matter intake may occur. For lactating cows, high production groups and medium production groups should be fed at least twice a day. More frequent feeding may be beneficial. Low groups can be fed once per day.

The time that the feed bunk is empty should be minimized to insure the cow's free access to the feed. It is suggested that the feed bunk be empty no more than one hour per day. If there is any feed left over in the bunk, this should be cleaned out and not fed to the milking herd. The leftover feed may have started a secondary fermentation which, if left in the bunk, will taint the fresh feed that is being put in the bunk and tend to decrease dry matter intake. In order to maximize dry matter intake, it is preferred that fresh feed be available at all times.

The addition of buffers to a ration may assist in stabilizing the rumen environment when wet, fermented feeds are being fed. The inclusion of buffers in the early lactation ration may help cows to reach their maximum of dry matter intake earlier. Buffers in the ration also seem to ease the stress when shifting groups.

FREE CHOICE FEEDING

The free choice feeding of minerals or any other feedstuff is not recommended. The cow is not able to eat to her mineral requirements other than perhaps for sodium. Individual cows may also exhibit a preference for one forage or feed versus another. Therefore, if the feeds are offered free choice, one cannot determine whether an individual is receiving all of the nutrients that she needs.

PROTEIN SOLUBILITY

In order to understand protein solubility, one should first define it. Protein solubility in the sense that it is most often used is a misnomer. Nitrogen solubility is a more accurate term since non-protein nitrogen (NPN) plays a very important role in the protein nutrition of dairy cows. Protein solubility is the proportion of protein and other nitrogen sources that are subjected to microbial degradation in the rumen.

The composition of crude protein varies widely among feedstuffs and can be affected by factors such as feed type, degree of maturity, fertility program, variety, storage, climate and type of processing. The protein in feedstuffs can be divided into three fractions (refer to Lesson 2 for background information on proteins).

Soluble Protein - Protein extracted from a feedstuff incubated with a buffer (pH 6.5) at 40 C in one hour. This protein is completely soluble in a liquid portion of the rumen and is rapidly attacked and degraded by the bacteria. Soluble protein is composed of both non-protein nitrogen (NPN) and true protein, which vary tremendously depending on the protein source. Forages have a high percentage of the soluble protein in the NPN form. The soluble protein in silage is essentially 100% NPN.

Bound Protein - That fraction commonly measured in the ADF (acid detergent fiber) fraction in feedstuffs. The amounts of bound protein are highly variable and greatly affected by heat. The bound protein is completely unavailable to the animal; in calculations of the protein required in a ration, the forage protein content is commonly adjusted for this bound protein value.

Insoluble Available Protein - Protein not soluble in a salt solution and not readily soluble in a fluid in the rumen. Insoluble available protein excludes bound protein. This protein is more slowly attacked by the bacteria. The rate at which this fraction is degraded depends on the protein source and the physical form of the diet. Pichard and Van Soest at Cornell demonstrated that a significant part of the insoluble protein can be degraded within 10-15 minutes in the rumen. Results vary widely among feedstuffs. Protein that is not degraded escapes from the rumen and is almost completely digested in the lower tract. Figure 2 shows the protein partition in feedstuffs.

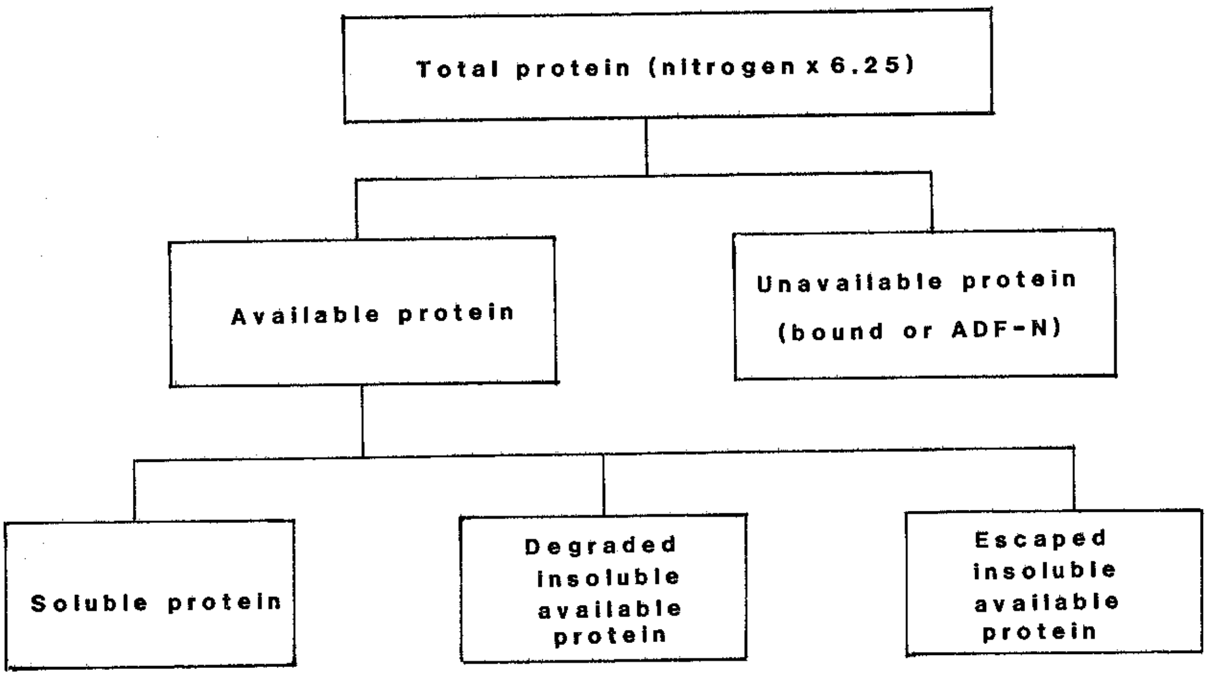


Figure 2. **Protein partition of feedstuffs.**

In Figure 3, the protein metabolism of the cow is depicted. Essentially, the bacteria in the rumen rapidly break down the soluble proteins to amino acids and ammonia. The ammonia is utilized by the bacteria to produce microbial protein. The insoluble available protein not degraded, plus bound protein and bacterial protein pass down to the lower gut to be digested and absorbed, as was discussed in Lesson 2. The bound feed protein is not digested and passes out in the feces.

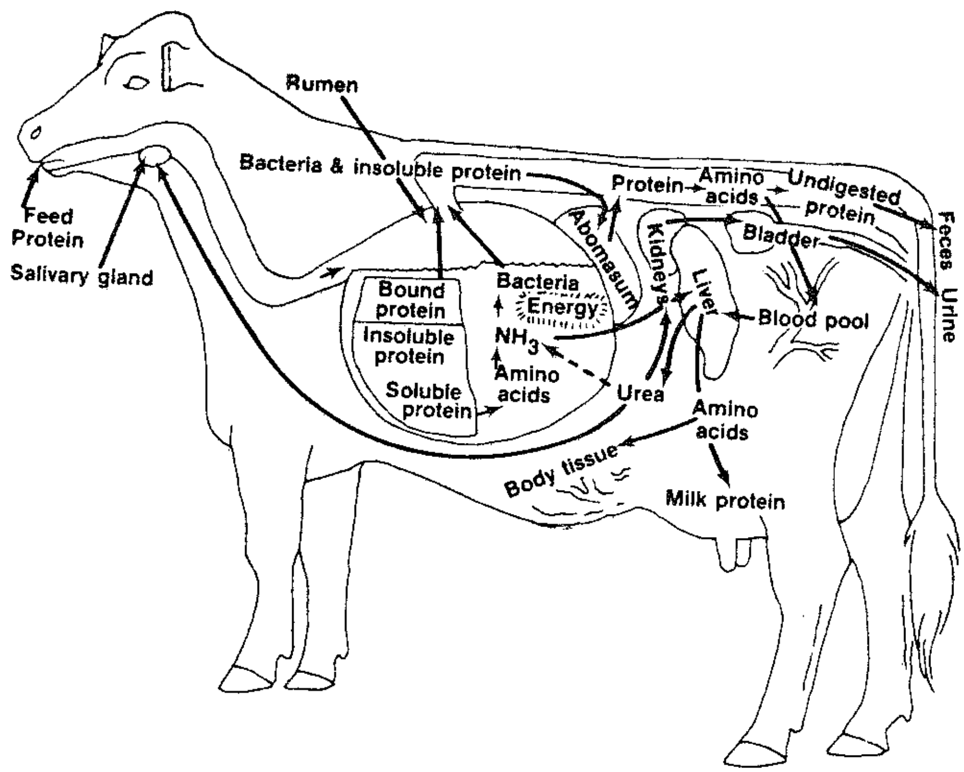


Figure 3. Protein metabolism in the cow.

The excess ammonia from rapid soluble protein breakdown in the rumen is absorbed from the rumen, synthesized into urea in the liver, and excreted via the urine. To decrease the loss of soluble protein (excess ammonia), soluble energy is needed to supply the fuel necessary to help in the incorporation of ammonia into bacterial protein. The energy is best supplied by feedstuffs high in starch and sugars, such as corn, hominy, and oats. When the soluble energy is high, the amount of ammonia lost is decreased. The starches and sugars should be present at the same time as the soluble proteins and degrade at the same rate as the soluble proteins. Insoluble protein being slowly degraded in the rumen is an important ammonia and amino acid source for the fiber digesting bacteria which grow at a slower rate.

At the present time, the cow's protein requirement is now based on maintenance and milk production. This approach may give less than satisfactory results, possibly due to the protein solubility level in the ration.

To reduce the response variability, the total protein requirement of the cow should be partitioned into the bacterial requirement for protein, and the cow's requirement for protein. The objective would be to meet a microbial requirement for soluble protein for optimum fiber digestion and to bypass the right amount of dietary protein (insoluble available protein) to mix with the microbial protein for the optimal amount of protein to be absorbed.

The problem at this point is to estimate how much soluble protein the bacteria need for optimum production and further to estimate how much dietary bypass or insoluble available protein is best. The best that can be done at this point is to generally recommend that, in early lactation, the cow receive the maximum amount of insoluble available protein. As lactation progresses, more soluble protein can be included. A safe range to work in for looking at protein solubility is to have the amount of soluble protein to be between 25 and 35%.

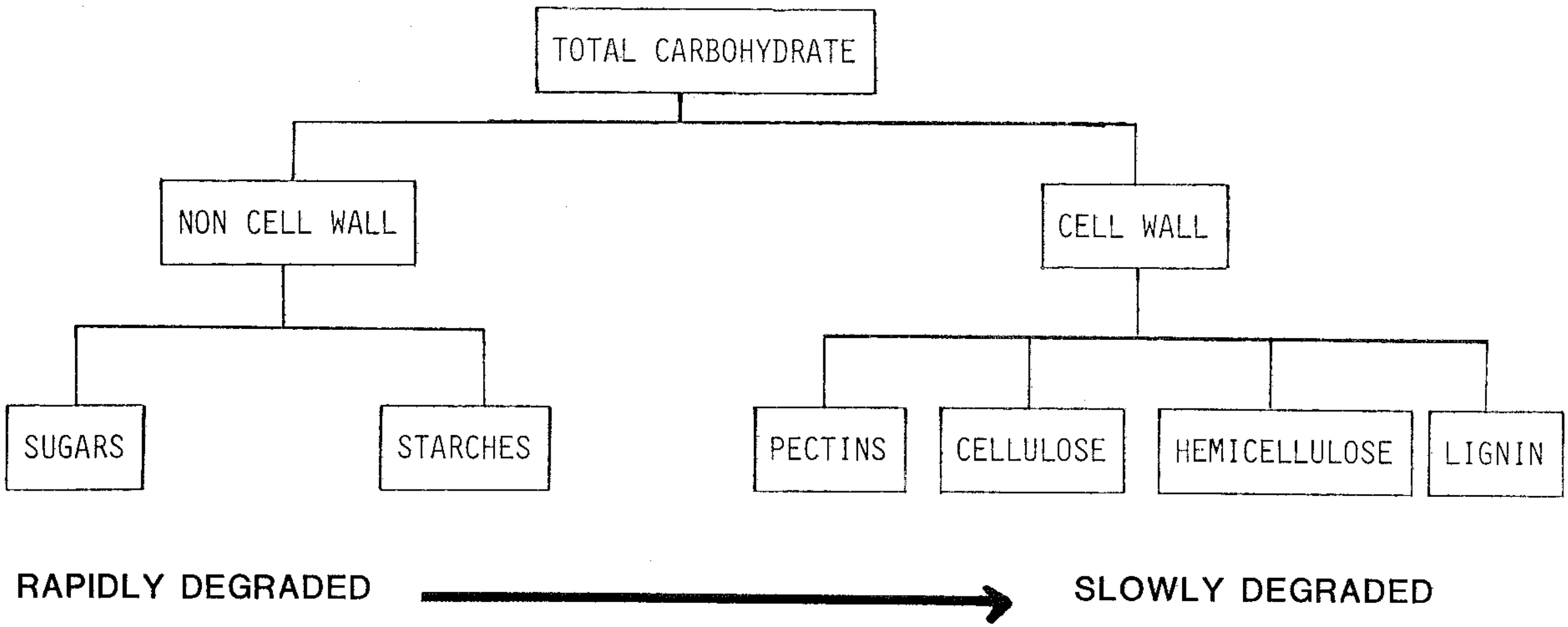
CARBOHYDRATES IN DAIRY FEEDS

Carbohydrates in feeds consumed by ruminants can be divided into two major functions: cell wall and non cell wall (see Figure 4). The cell wall is composed of pectins, hemicellulose, cellulose and lignins. The cell wall is slowly digested in the rumen. The more lignified the cell wall the less digestible it is. The lignin increases with maturity and reduces the extent of digestion. Pectins are very rapidly digested in the rumen and can be found in significant quantities in plant species such as legumes.

Starches and sugars are in the non cell wall fraction and are rapidly degraded in the rumen, sugars almost immediately. Some starches such as in dry corn meal digest relatively slowly when compared to barley or wheat starch. Excess amounts of starch and sugar can imbalance the bacteria in the rumen and cause digestive upsets.

The new method of detergent analysis helps define some of these fractions (Figure 4). Neutral detergent fiber (NDF) estimates the cell wall of feed except for pectins which are washed out during the analysis. Pectins digest as rapidly as starches. Acid detergent fiber (ADF) estimates the cellulose and lignin and is used as a good prediction of digestibility of forages. The detergent fiber analysis scheme:

Figure 4. Fractions of carbohydrates in feedstuffs



ADF = CELLULOSE + LIGNIN

NDF = ADF + HEMICELLULOSE

Hemicellulose = NDF - ADF

Cellulose = ADF - Lignin

Pectins + starch + sugars =

100 - [fat + (NDF - (NDF Protein + NDF Ash)) + Protein + Ash]

In order to balance the rumen the cow needs to consume enough NDF (cell wall) to maximize dry matter intake. The requirement is 1.1% x body weight. For a cow weighing 1300 lbs this means 14.3 lb of NDF. This means, in terms of dry matter intake, a range of 30-36% of the dry matter.

Be sure to feed the NDF in balance with the starches and sugars. The daily feeding program should be outlined carefully to assure a balanced fermentation.

GUIDELINES FOR:

- **CHANGING RATION PROTEIN DEGRADABILITY**
- **BALANCING CARBOHYDRATE DIGESTIBILITY**
- **INCREASING PROTEIN AND CARBOHYDRATE UTILIZATION**

1. Feed lower solubility ingredients or concentrates when feeding ensiled products.

2. If possible, feed the urea in the bunk as a part of the ensiled product, or put the urea in the silo at ensiling.

3. In stanchion barn feeding (meal feeding), try feeding the high producing cows grain more than two times per day. Also try feeding some hay or hay crop silage before grain feeding.

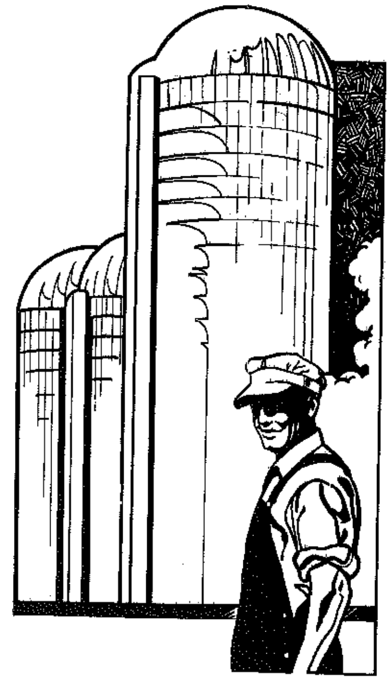
4. If the feeding of high solubility grains or urea grains represents a potential dollar savings, feed only to mid or tail end lactation cows.

5. Grain fed in the parlor should be a low protein solubility and degradability feed.

6. Grain fed in gate or magnetic feeders with blended ration situations should be of lower solubility and degradability.

7. When mixing ingredients with ensiled forages for blended diets, use low solubility ingredients such as soybean meal, dried brewers grains, or distillers grains. This is more important when urea is included in the mixed ration. Balance carbohydrates.

8. If high solubility and/or degradability ingredients or commercial supplements are to be used, feed them in a bunk in a blended ration. This insures that the cow does not eat all the soluble or degradable nitrogen at one time unless the bacteria have time to assimilate the ammonia efficiently.



9. If feeding high protein solubility ingredients or feeds, be sure to have rapidly degradable carbohydrate ingredients such as corn.

10. If hay is part of the ration, use intermediate solubility feeds or ingredients.

11. If corn silage is a major part of the ration, use a higher percentage of an intermediate degradability protein source. If hay crop silage is a major forage, use a higher percentage of proteins that are resistant to degradation.

SUMMARY

In summary, the goal of feeding management is to maximize dry matter intake, minimize shock of ration changes to the rumen, and meet the nutrient requirements for both the rumen and the cow. In order to do this, we must take care to provide not only the proper amounts of nutrients in the ration, but also to provide them in such a way that each cow receives her daily need. In order to do this, we must take into account all of the recommendations for protein solubility regulation and also manage the feed bunk so that feed is being offered frequently and that any refused feed is cleaned up prior to the next feeding. Thus, top quality feeds, put together in a balanced ration in conjunction with regular feeding schedules, will help to maximize milk production and economic return.

WRAP UP

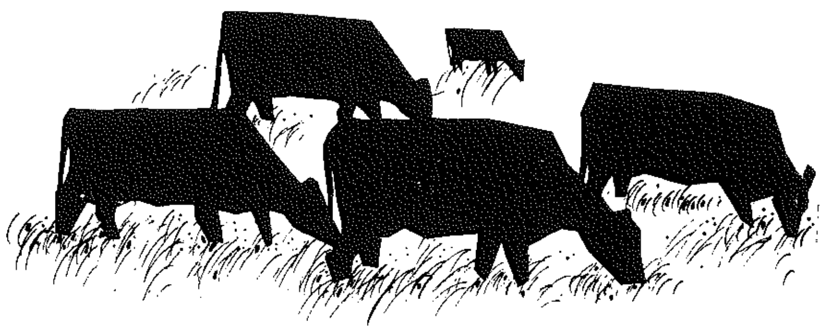
The proper feeding of dairy cattle has been the theme of this home study course. Many topics have been discussed. While feeds, feeding systems and feeding management ability varies from farm to farm, the following points are important to all systems and managers.

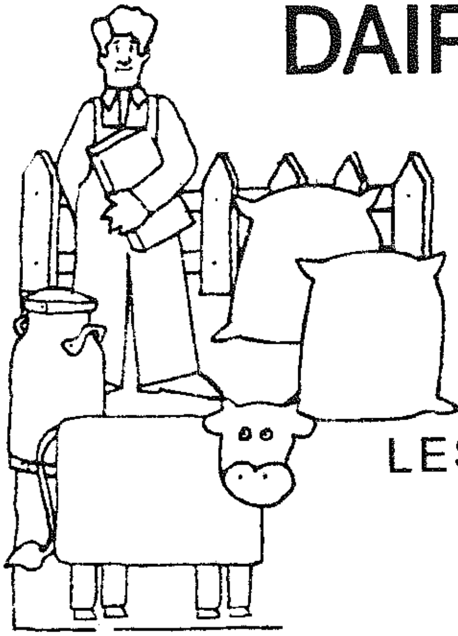
1. Forage analysis is the corner stone from which economical balanced rations can be formulated. The lack of forage analysis makes ration balancing impossible and "seat of the pants" feeding decisions result in varied outcomes.

2. Balanced rations can incorporate several different types of feeds, including by-product feeds into profitable feeding regimes. Overfeeding and underfeeding are detrimental to the cow and the pocketbook.

3. The sensible management of the feed bunk can increase dry matter intake and milk production. Feeding frequency and regularity are considerations for the high producing herd.

We hope that this home study course has been useful to you. We have attempted to explain the physiology of the cow so that you could gain an appreciation of the reasons why feeding practices may or may not work. In addition, we have tried to discuss some items such as protein solubility, which are becoming more and more important as dairy nutritionists learn more about the cow. The day may come when crude protein is no longer a consideration in balancing rations, but rather insoluble available protein is important. Dairy nutrition is a dynamic field. The basics of dairy nutrition and their practical application have been presented to permit your growth and knowledge of nutrition.





DAIRY CATTLE NUTRITION

LESSON 5: NUTRITION & REPRODUCTION

It has been felt that although nutrition plays an important role in reproduction and that nutritional deficiencies can severely affect the process, such deficiencies will rarely be seen under today's modern feeding systems. However, many are pointing to feeding programs as the cause of breeding problems. Information is available on the effects of severe deficiencies, interaction of many nutrients, and the excessive intakes of some nutrients. As production per cow increases, the effects of nutrition on reproduction should receive increased emphasis.

ENERGY

The phenomenon of negative energy balance, when the cow cannot meet her energy needs in early lactation and must mobilize body fat, occurs during the period just prior to and sometimes during the period when the cow should be inseminated and become pregnant. Lower breeding efficiency and poor reproductive performance has been associated with weight loss in dairy cattle. Conception rates in cows gaining weight were higher (67%) than in cows losing weight (47%). In addition, services per conception were lower in the

conception were lower in the gaining group (1.5) versus the weight loss group (2.3).

Since negative energy balance has such an effect on reproduction, it is important that a balanced, palatable ration be fed during early lactation in order to maximize dry matter intake and energy intake. Energy is important for proper reproductive health. Inadequate energy intakes and poor body condition have been associated with:

1. Delayed onset of puberty.

2. Diminished intensity of estrus and more silent heats.

3. Anestrus.

4. Prolonged interval from calving to conception.

5. Delayed return to estrus and ovulatory activity after calving.

6. Decreased conception rate.

Accurate feed intakes and forage analysis are required to develop feeding programs that are adequate in feed energy for the high producing dairy cow, and for the maintenance of her reproductive health.

PROTEIN

There is evidence that prolonged, inadequate protein intake reduces reproductive performance, but short-term deficiencies can be met by using the limited protein reserves in the cow's body.

The 1978 NRC publication indicates that excess protein intake is not harmful to the cow. However, recent work suggests that feeding 10-30% excess protein impairs reproductive performance. In both field and controlled studies, cows receiving excess protein required more services per conception than cows receiving 90% of their protein requirements. However, the cows receiving excess protein may come into heat sooner.

Cornell researchers could not repeat the results above when first calf heifers were fed 15-20% excess protein. Therefore, excess protein may cause reproductive problems in some situations. In any case, the overfeeding of protein is discouraged because it is costly and wasteful.

PHOSPHOROUS

Phosphorous is the mineral that has most commonly been associated with reproductive disorders in dairy cows. Inactive ovaries (anestrus), delayed sexual maturity and low conception rates have been associated with low phosphorous intakes. A recent study indicates that the NRC recommendations are adequate to maintain growth and reproductive functions in heifers. Increasing phosphorous supplementation above NRC recommendations has no effect on the days to first estrus or services per conception.

In contrast, Michigan workers reported that reproductive performance on lactating cows was not affected when phosphorous levels were either 85% or 135% of NRC recommendations. An interesting finding was that cows fed excess phosphorous produced less milk. For top performance phosphorous supplementation should meet, but not exceed, requirements.

CALCIUM

Most experimental work relating calcium to reproduction has centered on the effect of calcium:phosphorous ratios. Controlled experiments demonstrated no effect of altered calcium:phosphorous ratios on reproduction in heifers or lactating cows. Calcium:phosphorous ratios between 1.5:1 and 2.5:1 should not result in problems. Remember that the amount of calcium and phosphorous consumed is more important than the ratio. The minimum amounts (grams) of calcium and phosphorous should be provided before examining the ratio. The ratio can be fine, but cows can be consuming excess or deficient amounts.

SELENIUM

Adequate selenium is required for good health and reproduction. The incidence of retained placenta is increased in selenium-deficient animals and selenium deficiency has been related to sporadic abortions, a high incidence of embryonic fetal loss, poor fertility, increased incidence of metritis and mastitis and a higher level of general infection in some problem herds. The exact role of selenium and its importance in causing these problems in dairy cattle has not been fully explained.

Nevertheless, based on the information that is currently available, selenium supplementation is advisable. The diet should contain 0.1 ppm of selenium on a dry matter basis. However, selenium is a toxic substance. Excessive supplementation must be avoided. The legal amount is 0.1 ppm supplemental selenium in the total ration dry matter. Injection of selenium in addition to feed supplementation, should be performed under the guidance of a veterinarian.

IODINE

Iodine influences reproduction via its action on the thyroid gland. Iodine deficiency impairs reproduction through low thyroid function. The low thyroid function reduces conception rate and ovarian activity. Cows should consume 10-15 milligrams of iodine per day.

The effects of excessive iodine intakes have been reported. Today, it appears that iodine toxicity may be more important than an iodine deficiency. The problem is most often associated with feeding several mineral mixes each of which contains EDDI for the prevention of foot rot. EDDI has never been adequately proven to prevent foot rot and its feeding for this purpose should be done only at the direction of a veterinarian. Excessive iodine intakes have been associated with various health problems including abortion and decreased resistance to infection and disease. Iodine levels in the diet should be maintained at less than 50 milligrams per day.

POTASSIUM

Limited research suggests that feeding high levels of potassium may delay the onset of puberty, delay ovulation, impair corpus luteum development and increase the incidence of anestrus in heifers. Other research reports indicate lower fertility in cows fed high levels of potassium or on diets in which the potassium:sodium ratio was too wide.

OTHER MINERALS

Copper and manganese deficiencies have been associated with impaired ovarian functions, silent heats and abortions. Fluoride toxicity lowers fertility.

VITAMINS

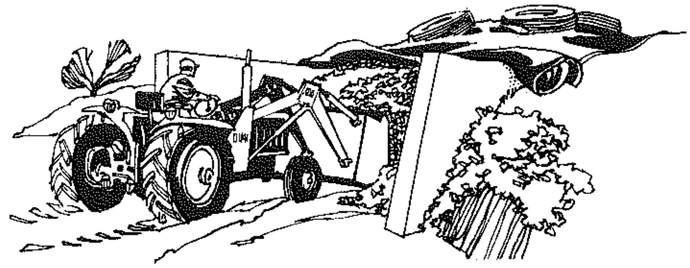
The vitamin requirements of dairy cows are met by a combination of rumen and tissue synthesis, natural feeds, and feed supplementation. Most commercial concentrates contain supplemental vitamins so that the probability of infertility due to a vitamin deficiency is greatly reduced.

VITAMIN A

Vitamin A is required for maintaining healthy tissue in the reproductive tract. In deficient cattle, delayed sexual maturity, abortion or the birth of dead or weak calves, retained placenta and metritis have been reported. The recommended daily supplementation for dairy cows is 30,000 to 50,000 units. In herds feeding commercial concentrate mixes these levels are usually provided. Excessive vitamin A supplementation should be avoided as the normal metabolism of the vitamin A precurser, beta carotene, may be impaired.

BETA CAROTENE

Beta carotene is a substance found in many plants that the cow converts to vitamin A. It is known to be in high concentration in fresh green roughages while grains contain relatively low amounts. Silages, especially alfalfa, contain moderate levels, while corn silage is a poor source. Dry hay, especially alfalfa, is an excellent source of carotene. Despite high levels at harvest, beta carotene levels decrease in storage, with the extent of the destruction being dependent on the storage conditions.



The interest in beta carotene stems from research done in Germany suggesting that dairy cows and heifers consuming diets low in beta carotene suffered reproductive problems:

1. Delayed uterine involution.

2. Delayed first estrus after calving.

3. Delayed ovulation.

4. Increased incidence of cystic ovaries.

5. More early embryonic death and abortions.

Beta carotene supplementation reportedly restored reproductive functions to normal, but vitamin A was not effective.

In a recent study, Israeli researchers attempted to repeat the German results. They were not successful. Limited field studies in the United States using small numbers of animals, tend to support the German results. But, the beta carotene status of cows in commercial herds has not been adequately determined and the effects of supplementation have not been adequately documented under field conditions in this country. Until more information is available, it can only be recommended that the beta carotene supplementation be considered in well fed herds when all other possible causes of reproductive problems, including management, have been eliminated.

VITAMIN D

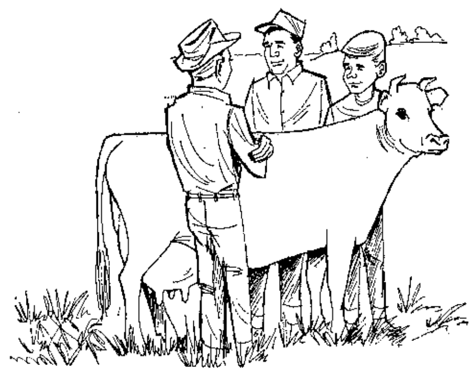
This vitamin is required for normal calcium and phosphorous metabolism. However, deficiencies are seldom encountered in commercial herds. Cows receiving a normal amount of natural light manufacture their own vitamin D. Most commercial concentrates contain supplemental vitamin D in amounts sufficient to meet the cow's requirements of 10,000 international units per day.

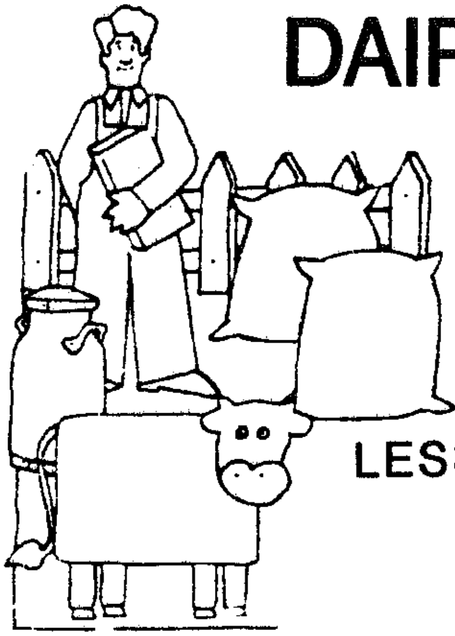
VITAMIN E

Today there is no documented evidence that vitamin E deficiency is a significant cause of reproductive failure in dairy herds. Moreover, the vitamin E requirement of milking cows is not known with certainty. Interest in vitamin E has increased recently with the observation that selenium may be important in health and reproduction because actions of vitamin E and selenium are closely related. Normal sources include commercial concentrates, vitamins - minerals, premixes, and green forages.

SUMMARY

As can be seen by this lesson, proper nutrition and good reproductive performance go "hand in hand". The cooperation of the dairyman, the veterinarian, the AI technician and the feed consultant, is essential to maintaining high fertility in the dairy herd.





DAIRY CATTLE NUTRITION

LESSON 6

NUTRITIONAL PROBLEMS

KETOSIS

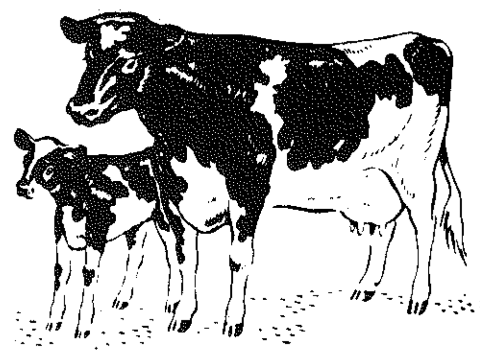
Ketosis or acetonemia is a common metabolic disease of dairy cattle that results in excess ketones in the blood, urine and milk. Ketones are normally found in low levels of the blood and some tissues utilize them as energy sources. The ketone bodies are the result of the mobilization of body fat. The ketotic cow has a low blood glucose level in addition to the high ketones.

There are two major types of ketosis, primary and secondary. Secondary ketosis exists when a health problem such as metritis, nephritis, hardware, retained placenta, displaced abomasum or any other problem causes the cow to go "off feed" or reduce intake. This causes the mobilization of body fat to meet energy needs. An elevated temperature, caused by infection, usually accompanies secondary ketosis. The infection or other problem must be eliminated before the ketosis symptom can be alleviated.

Primary ketosis usually occurs a few days to a few weeks post calving. No other health problem is associated with primary ketosis. The basic problem of ketosis is a lack of energy intake and, therefore, energy available for the stress of milk production.

There are several nutritional factors that may predispose the cow to ketosis. They are:

1. Glucose drained for lactose production - Lactose (milk sugar) is synthesized in the udder from glucose. Glucose is needed in large quantities to make lactose. This high demand for glucose is the primary factor involved in initiating the problem of ketosis.



2. Excess condition at calving - Excess condition may enhance the probability of ketosis since there is a possibility that the excess fat results in greater and more prolonged mobilization of fat post calving. Lack of condition at calving may also be a problem since there is little or no fat to be mobilized, thereby decreasing the amount of energy available for the milk production stress.

3. Inadequate energy intake after calving - Inadequate energy (dry matter intake) after calving forces the high producer to mobilize more fat. The inadequate energy intake may be the result of limit feeding because of the unfounded worries of udder edema and mastitis. The fat cow may also have an inadequate energy intake since she may be "satisfied" and may not be as "hungry" or as aggressive at the feed bunk.

4. Mineral or vitamin deficiencies - While clear cut evidence is lacking, cobalt and vitamin B_{12} deficiencies may predispose the cow to ketosis. Vitamin B_{12} is important in the conversion of propionate to succinate on its way to glucose. Cobalt is needed for the ruminal synthesis of vitamin B_{12}. However, most rations are adequate in cobalt.

   Niacin, a B vitamin, has recently been suggested as important to the prevention of ketosis. During the period of high productivity in early lactation, the cow goes into negative energy balance. Niacin supplementation at 12 g/day to ketotic cows helped to alleviate the ketotic condition. The feeding of 6-8 g/day of niacin may be useful in preventing ketosis in some cases. The supplementation of certain B vitamins in ruminant rations <u>may</u> become necessary <u>at high levels of productivity</u> and good management as is indicated with the niacin work.

At this time there is no definite approach to assure the prevention of ketosis. However, the following feeding practices seem to help.

1. Have cows in good condition at freshening - not too fat, not too thin.

2. Avoid rapid changes in feeds or feeding - this may throw the cow "off feed". Feed good quality roughages and feed often - this tends to increase dry matter intake and energy intake.

3. Feed a ration balanced for protein, energy and minerals during the dry period and early lactation.

4. In problem herds, the feeding of propylene gycol or sodium propionate may be helpful in early lactation. These two compounds are glucogenic; they enhance glucose production.

MILK FEVER

Parturient paresis (milk fever) is a metabolic disease affecting the dairy cow usually within 72 hours of calving. The disease is characterized by a normal or subnormal temperature and low blood calcium.

At parturition, the initiation of milk production greatly increases the calcium requirement. If the cow cannot meet that increase, low blood calcium and milk fever are the result. The calcium nutrition late in gestation is important to the prevention of milk fever. In order to understand milk fever, the calcium homeostatic mechanism needs to be discussed.

Calcium is absorbed from the small intestine. It can then be deposited in the bone or used for other bodily functions like milk production. Bone provides the cow with a "calcium reserve". During the dry period, dietary absorption of calcium is the major supply for the cow. Calcium mobilization from the bone is minimal pre-calving. Active absorption of calcium from the gut is dependent on the physiological status of the animal and the vitamin D status. Both the mobilization of the calcium from the bone and the active absorption of the calcium require time to get "in gear" to increase the amount of calcium available to the cow.

Let's examine the situation at parturition. The dry cow, with relatively low calcium requirement, is not absorbing as much calcium and is not mobilizing calcium from the bone. At parturition, the calcium demand greatly increases and the active absorption of calcium from the gut and the mobilization of calcium from the bone is required. However, the mechanisms for absorption and bone mobilization take time to gear up for that demand. The result is a drop in blood calcium and milk fever. This will occur even if the dry cow was being fed plenty of calcium. In essence, famine in the midst of plenty.

In fact, the feeding of excess calcium during the dry period may enhance the probability of milk fever, since the mechanisms for calcium mobilization and absorption are shut down. How do we combat this problem? The most effective way to fight milk fever is to get those mechanisms moving. The way to get those mechanisms in gear is to feed adequate but not excessive calcium two weeks of the dry period. See Table 1 for the results of a calcium deficient feeding program in four commercial Jersey herds. The calcium intake should not exceed 100 grams per day in dry cows (75 grams for Jerseys).

Table 1. Calcium and phosphorous intakes and incidence of milk fever of Jersey cows fed a control diet or a calcium ration two weeks prepartum

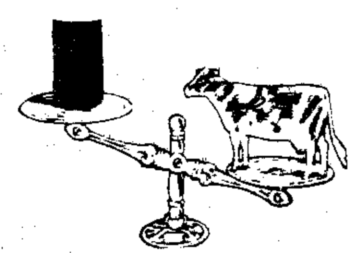
Herd	Treatment	Ca	P	Milk Fever
		---g/day---		
1	Control	40	27	2/17
	Ca-deficient	18	28	0/14
2	Control	46	51	6/14
	Ca-deficient	15	30	0/10
3	Control	162	60	7/11
	Ca-deficient	14	25	0/6
4	Control	173	60	5/18
	Ca-deficient	13	27	0/7

The levels of both calcium and phosphorous should meet requirements. The calcium to phosphorous ratio should be in the range of 1.5 - 2.5:1. The feeding of 20-30 million international units per day of vitamin D is effective in preventing milk fever. However, the timing is important. The feeding of vitamin D, 3-7 days prior to calving reduces milk fever incidence by 80%. But, if fed for less than 3 days, it is not effective, and if fed for more than 7 days tissue calcification may occur. Twenty five hydroxycholecalciferol, a vitamin D metabolite may provide a safer vitamin treatment in the future.

The best recommendation for reducing the incidence of milk fever is to feed a ration adequate but not excessive in calcium and phosphorous and maintain a Ca:P ratio in the range of 1.5 - 2.5:1 during the dry period.

FAT COW SYNDROME

Fat cow syndrome is not one, but a series of maladies that affect cows in early lactation. Milk fever, ketosis, displaced abomasum retained placenta, metritis, and mastitis are some of the symptoms of the fat cow syndrome. The problem with the fat cow begins in late lactation when production drops more rapidly than intake. Excessive energy intakes during the dry period contributes to the problem. Thus, the cow becomes overconditioned.



Proper feeding and management can prevent this syndrome. These practices help:

1. Group cows according to production and feed them rations balanced for crude protein, energy, minerals and vitamins. In some situations intake may

1. List the nutrient requirements and dry matter intake for the particular group.

2. List the feeds, their nutrient content and dry matter.

3. List the amount of feeds being fed.

4. Multiply the pounds of feed times the percent dry matter divided by 100 to get pounds of DM feed.

5. Multiply the pounds of dry matter fed by the percent nutrient expressed as a decimal, or as an amount/lb which equals the amount of nutrient fed. Add up each feed's contribution to the nutrient and compare to the nutrient requirements.

These steps are easy; however, the Ration Evaluation Worksheet from Bill Menzi, Regional Extension Specialist, Montour Falls, NY (see page 9) simplifies the calculations. The example on this page will clarify the narration.

Example 1:

A 1300# cow producing 60 lb of 3.5% milk requires 5.98 lb crude protein (CP), 28.77 Mcal net energy lactation (NE_l) in a maximum DMI of 40.98 or 41 lb.

Dan Dairyman is feeding:

30 lb CS
30 lb HCS
18 lb HMEC
4.5 lb SMB

The nutrient composition of the feeds is:

	% DM	% CP	Mcal/lb NE_l
CS	35	8	.6
HCS	45	16	.55
HMEC	70	9	.9
SBM	89	49.6	.84

The calculations are found on the 1st worksheet (see page 9). A blank worksheet is also attached for your future use.

Once the totals are completed and the comparison is made to both nutrient requirements and dry matter intake, adjustments can be made to either increase or decrease the amount of nutrient in the ration. For example, if protein was low, perhaps more soybean meal should be put into the ration. If energy was too high, substitute concentrates with more forage. In the example, the ration is balanced.

Another technique that is useful to determine the amount of grain and the amount of protein required to balance a forage base is depicted on the ration balancing worksheet. Calculations similar to the ration evaluation are made; however, additional steps calculate the pounds of grain needed and the percent of protein needed in that grain (see example 2). Similar calculations can be made to balance for minerals.

The final technique that is commonly used is the Pearson Square Method. This method, while used most frequently in determining grain mixes, can be used for total balanced rations by using a series of squares. See the chart and example on page 12.

Example 2:

Fred Farmer has CS, HCS, and hay to feed his 1300# cows that are producing 60 lb of 3.5% milk.

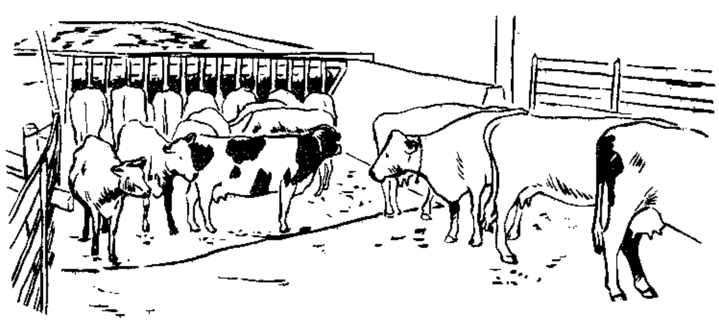
The nutrient composition of the forages is:

	% DM	% CP	Mcal/lb NEl
CS	30	8	.69
HCS	40	17	.58
Hay	85	15	.53

Fred needs to purchase grain that has a NE_l of .8 Mcal/lb. What should the protein content of the feed be? He is feeding:

CS	25 lb
HCS	30 lb
Hay	5 lb

Thus, Fred needs to feed 17.23 lb of a 15.67% CP grain ration.



RATION EVALUATION WORKSHEET

	Lb Fed	x	.DM	=	Lb DM Fed	x	Crude Protein (CP) and Mcal/lb				
Hay	____	x	____	=	____	x	____	CP	=	____	lb CP
							____	Mcal/lb	=	____	Mcal
Corn Silage	30	x	.35	=	10.5	x	.08	CP	=	.84	lb CP
							.7	Mcal/lb	=	7.35	Mcal
Hay crop silage	30	x	.45	=	13.5	x	.16	CP	=	2.16	lb CP
							.55	Mcal/lb	=	7.42	Mcal
High moisture corn	18	x	.70	=	12.6	x	.09	CP	=	1.13	lb CP
							.9	Mcal/lb	=	11.34	Mcal
Grain mixture	____	x	____	=	____	x	____	CP	=	____	lb CP
							____	Mcal/lb	=	____	Mcal
Other SBM	4.5	x	.89	=	4.0	x	.496	CP	=	1.98	lb CP
							.84	Mcal/lb	=	3.36	Mcal

Total CP Supplied 6.11

Total Mcal Supplied 29.47

Total DM Supplied 40.6

Expected DMI 41

Required CP 5.98

Required Mcal 28.17

RATION BALANCING WORKSHEET

Part I DETERMINE TOTAL FORAGE DRY MATTER FED

CS	Forage #1:	25 lbs fed	x .3	Dry matter fraction	=	+ 7.5	lbs DM
HCS	Forage #2:	30 lbs fed	x .4	Dry matter fraction	=	+ 12.0	lbs DM
Hay	Forage #3:	5 lbs fed	x .85	Dry matter fraction	=	+ 4.25	lbs DM
	Forage #4:	____ lbs fed	x ____	Dry matter fraction	=	+ ____	lbs DM
				FORAGE TOTAL DRY MATTER	=	23.75	lbs

Part II ENERGY

Step 1: Determine Mcal Net $Energy_{milk}$ available from forage on a dry matter basis.

Forage #1:	7.5 lbs DM	x .69	Mcal/lb	=	+ 5.18	Mcal
Forage #2:	12.0 lbs DM	x .58	Mcal/lb	=	+ 6.96	Mcal
Forage #3:	4.25 lbs DM	x .53	Mcal/lb	=	+ 2.25	Mcal
Forage #4:	____ lbs DM	x ____	Mcal/lb	=	+ ____	Mcal
			FORAGE TOTAL	=	14.39	Mcal

Step 2: Determine Mcal Net $Energy_{milk}$ needed from grain.

Total Net $Energy_{milk}$ needed:		28.17	Mcal
Minus Forage Total Net $Energy_{milk}$	-	14.39	Mcal
Net $Energy_{milk}$ needed from grain		13.78	Mcal

Step 3: Determine lbs of grain to be fed.

13.78 Mcal needed from grain ÷ .8 Mcal/lb grain = 17.23 lbs grain/day.

Part III PROTEIN

Part 1: Determine lbs of crude protein available from forage on a dry matter basis.

Forage #1:	7.5	lbs DM	x	.08	protein fraction	=	+	.6 lbs
Forage #2:	12.0	lbs DM	x	.17	protein fraction	=	+	2.04 lbs
Forage #3:	4.25	lbs DM	x	.15	protein fraction	=	+	.64 lbs
Forage #4:	____	lbs DM	x	___	protein fraction	=	+	____ lbs
					FORAGE TOTAL PROTEIN	=		3.28 lbs

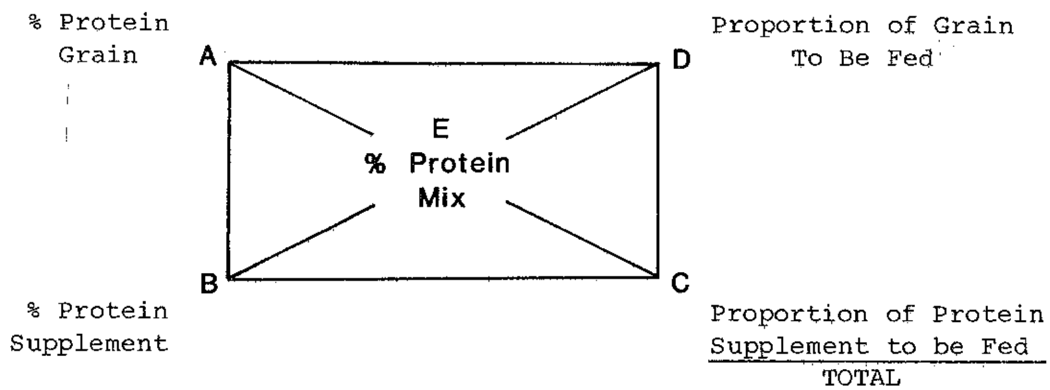
Step 2: Determine lbs crude protein needed from grain.

Total crude protein needed	5.98	lbs
Minus forage total crude protein	- 3.28	lbs
Crude protein needed from grain	2.7	lbs

Step 3: Determine percent crude protein needed in grain.

$$\frac{2.7 \text{ lbs crude protein} \times 100}{17.23 \text{ lbs grain}} = 15.67\% \text{ crude protein}$$

<u>PEARSON SQUARE</u>



E - A = C
B - E = D
C + D = TOTAL

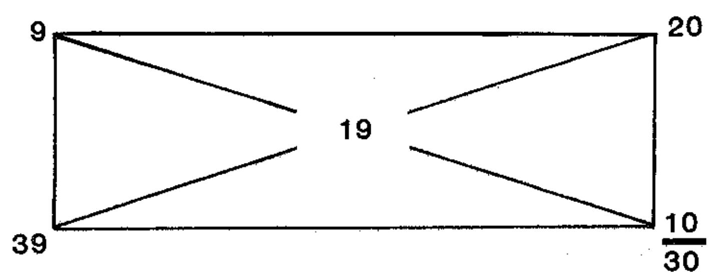
To get % of each component of mix, divide proportion by total

i.e. $\frac{D}{\text{Total}}$ = % Concentrate to be Fed

$\frac{C}{\text{Total}}$ = % Protein Supplement to be Fed

<u>Example 3</u>:

Corn

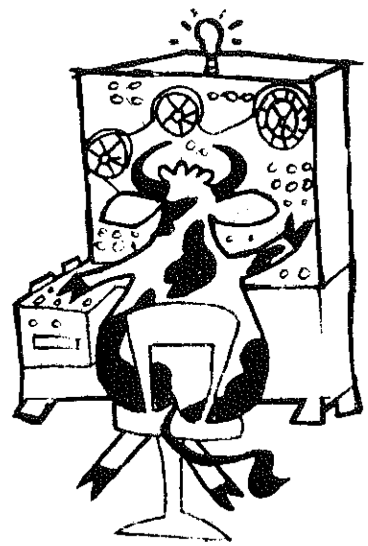


Protein Supplement

% Corn = $\frac{20}{30}$ = 67%

% Protein Supplement = $\frac{10}{30}$ = 33%

LEAST-COST RATIONS



The computer assisted balancing of least-cost rations is a useful tool in forward planning of both feeding and cropping programs. In addition to the forward planning aspect of least-cost rations, least-cost rations should be considered when:

1. feed is in short supply

2. when purchased alternatives exist

The computer program that is available was developed and modified by Cornell animal scientists and agricultural economists. The program is on the Michigan State University computer and access is available through your local Cooperative Extension Association.

We are now at the end of the basics. At this time anatomy, digestion, and ration balancing should be understood. In our remaining lessons, nutritional problems, feeding management, and practical feeding guidelines will be discussed.

YEARLY FORAGE REQUIREMENTS

Dairy cattle will eat a consistent amount of forage drymatter based on their body weight and forage quality. The better the feed, the more they will eat.

By knowing the average size and number of animals, quality of forage, and number of days desired to feed, it's relatively easy to calculate a farm's yearly forage drymatter needs.

Number or cows x lbs of drymatter/day x number of days = lbs of drymatter/year

Dividing the lbs drymatter by the percent drymatter of the feed gives the lbs of as fed feed.

TO ESTIMATE YOUR FARM FORAGE NEEDS:

1) Take the number of animals by body weight.

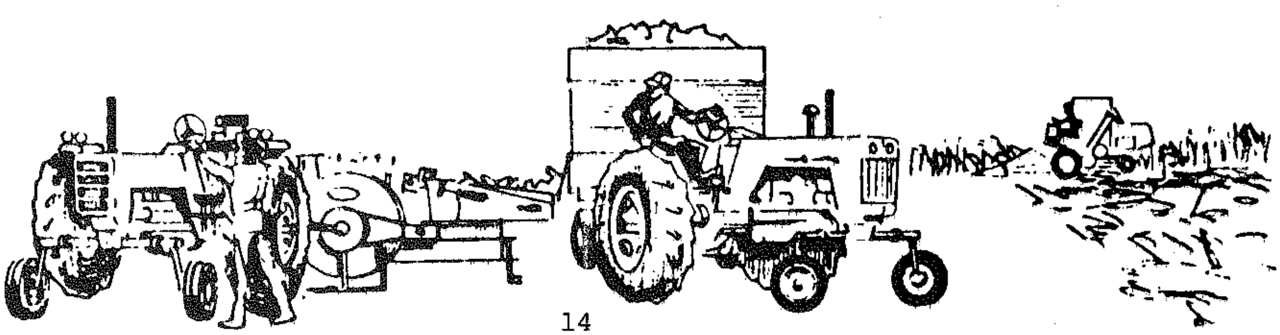
2) Find the estimated drymatter intake/day according to quality and hay to corn silage ratio (inside table).

3) Figure the number of feeding days, (365, unless out on pasture of fed from other than farm feed stocks).

4) Follow the outline on the back page to estimate the total tons drymatter needed.

5) Divide by the percent drymatter of the as fed feed.

Corn Silage	30 - 35%	(average range) drymatter
Hay	85 - 90%	(average range) drymatter
Hay Crop silage	55 - 65%	(average range) drymatter



COW

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY
(includes waste)

Weight of Cow (lbs.)	2/3 Hay 1/3 Silage Hay	2/3 Hay 1/3 Silage Silage	1/2 Hay 1/2 Silage Hay	1/2 Hay 1/2 Silage Silage	1/3 Hay 2/3 Silage Hay	1/3 Hay 2/3 Silage Silage	Hay or Silage
800	11.3	5.5	8.4	8.4	5.5	11.3	16.8
1000	14.0	7.0	10.5	10.5	7.0	14.0	21.0
1200	16.9	8.3	12.6	12.6	8.3	16.9	25.2
1300	18.2	9.0	13.6	13.6	9.0	18.2	27.2
1400	19.7	9.7	14.7	14.7	9.7	19.7	29.4
1600	22.5	11.1	16.8	16.8	11.1	22.5	33.6

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY
(includes waste)

Weight of Cow (lbs.)	2/3 Hay 1/3 Silage Hay	2/3 Hay 1/3 Silage Silage	1/2 Hay 1/2 Silage Hay	1/2 Hay 1/2 Silage Silage	1/3 Hay 2/3 Silage Hay	1/3 Hay 2/3 Silage Silage	Hay or Silage
800	13.0	6.4	9.7	9.7	6.4	13.0	19.4
1000	16.2	8.0	12.1	12.1	8.0	16.2	24.2
1200	19.4	9.6	14.5	14.5	9.6	19.4	29.0
1300	21.2	10.4	15.8	15.8	10.4	21.2	31.6
1400	22.7	11.2	16.9	16.9	11.2	22.7	33.9
1600	25.9	12.8	17.4	17.4	12.8	25.9	38.7

POUNDS OF FORAGE DRY MATTER PER DAY - SUPERIOR QUALITY
(includes waste)

Weight of Cow (lbs.)	2/3 Hay 1/3 Silage Hay	2/3 Hay 1/3 Silage Silage	1/2 Hay 1/2 Silage Hay	1/2 Hay 1/2 Silage Silage	1/3 Hay 2/3 Silage Hay	1/3 Hay 2/3 Silage Silage	Hay or Silage
800	15.3	7.6	11.5	11.5	7.6	15.3	22.9
1000	19.2	9.4	14.3	14.3	9.4	19.2	28.6
1200	23.0	11.4	17.2	17.2	11.4	23.0	34.4
1300	24.9	12.3	18.6	18.6	12.3	24.9	37.2
1400	26.8	13.2	20.0	20.0	13.2	26.8	40.0
1600	30.7	15.1	22.9	22.9	15.1	30.7	45.8

HEIFER

POUNDS OF FORAGE DRY MATTER PER DAY - POOR QUALITY
(includes 10% waste)

Weight of Heifer	2/3 Hay 1/3 Silage: Hay	2/3 Hay 1/3 Silage: Silage	1/2 Hay 1/2 Silage: Hay	1/2 Hay 1/2 Silage: Silage	1/3 Hay 2/3 Silage: Hay	1/3 Hay 2/3 Silage: Silage	Hay or Silage
300	Never feed young replacements poor feed						
500	5.0	2.5	3.8	3.7	2.5	5.0	7.5
700	7.0	3.0	5.0	5.0	3.0	7.0	10.0
900	9.8	4.8	7.3	7.3	4.8	9.8	14.6
1100	10.6	5.2	7.9	7.9	5.2	10.6	15.8

POUNDS OF FORAGE DRY MATTER PER DAY - AVERAGE QUALITY
(includes 10% waste)

Weight of Heifer	2/3 Hay 1/3 Silage: Hay	2/3 Hay 1/3 Silage: Silage	1/2 Hay 1/2 Silage: Hay	1/2 Hay 1/2 Silage: Silage	1/3 Hay 2/3 Silage: Hay	1/3 Hay 2/3 Silage: Silage	Hay or Silage
300	3.4	1.6	2.5	2.5	1.6	3.4	5.0
500	6.8	3.2	5.0	5.0	3.2	6.8	10.0
700	10.0	5.0	7.5	7.5	5.0	10.0	15.0
900	13.1	6.5	9.8	9.8	6.5	13.1	19.6
1100	15.4	7.6	11.5	11.5	7.6	15.4	23.0

POUNDS OF FORAGE DRY MATTER - SUPERIOR QUALITY
(includes 10% waste)

Weight of Heifer	2/3 Hay 1/3 Silage: Hay	2/3 Hay 1/3 Silage: Silage	1/2 Hay 1/2 Silage: Hay	1/2 Hay 1/2 Silage: Silage	1/3 Hay 2/3 Silage: Hay	1/3 Hay 2/3 Silage: Silage	Hay or Silage
300	4.9	2.1	3.5	3.5	2.1	4.9	7.0
500	8.4	4.2	6.3	6.3	4.2	8.4	12.6
700	12.0	6.0	9.0	9.0	6.0	12.0	18.0
900	14.2	7.0	10.6	10.6	7.0	14.2	21.2
1100	15.4	7.6	11.5	11.5	7.6	15.0	23.0

erage Number Mature Cows ____________

erage Body Weight ____________

erage Number of Heifers (900 lbs) ____________

erage Number of Heifers (500 lbs) ____________

erage Number of Calves (300 lbs) ____________

YEARLY FORAGE DRY MATTER NEEDS (From Table)

Hay & Corn Silage

	Average Number of Animals	×	Average Number of Days	×	Lbs. Drymatter (Table)	÷	2000	=	Drymatter Tons Needed
ows - Hay	________	×	________	×	________ Hay	÷	2000	=	________ Tons Hay
ows - Corn Silage	________	×	________	×	________ Corn Silage	÷	2000	=	________ Tons Corn Silag
eifers 900 lbs. Hay	________	×	________	×	________ Hay	÷	2000	=	________ Tons Hay
eifers 900 lbs. Corn Silage	________	×	________	×	________ Corn Silage	÷	2000	=	________ Tons Corn Silag
eifers 500 lbs. Hay	________	×	________	×	________ Hay	÷	2000	=	________ Tons Hay
eifers 500 lbs. Corn Silage	________	×	________	×	________ Corn Silage	÷	2000	=	________ Tons Corn Silag
alves 300 lbs. Hay	________	×	________	×	________ Hay	÷	2000	=	________ Tons Hay
alves 300 lbs. Corn Silage	________	×	________	×	________ Corn Silage	÷	2000	=	________ Tons Corn Sila

otal Tons Drymatter Needed ____________ ÷ ____________ (% DM Hay) = ____________

____________ ÷ ____________ (% DM Hay Crop Silage) = ____________

otal Tons Corn Silage Drymatter Needed ____________ ÷ ____________ (% DM) = ____________

Forage Inventory and Allocation

In order to develop a year-round feeding program for the dairy herd, it is necessary to know how much of any given forage is available to feed.

The procedure to figure your own farm forage inventory is easy and all of the information necessary is on this sheet.

1) Determine the amount of silage drymatter in your silo(s) and record on the back page. (Be sure to account for any removed; procedure is illustrated inside.)

2) Divide the drymatter figures recorded by the percent drymatter of your feed. (Your DHI Supervisor or Extension Agent can help you determine the percent drymatter of your feed.)

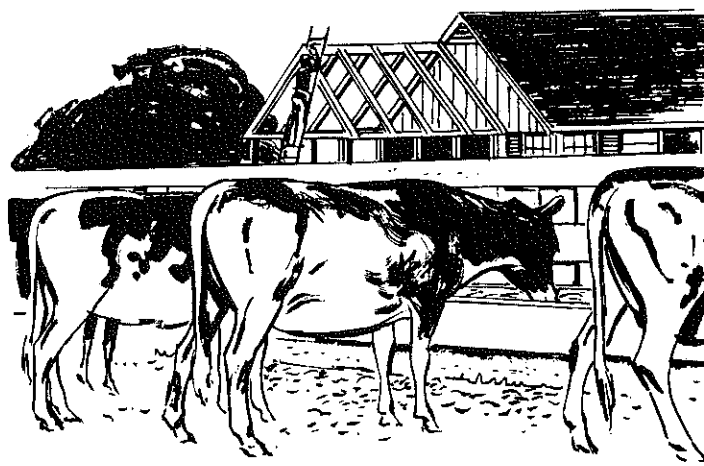
3) Total the tons of "as fed" feed available and subtract a storage and feeding loss (8 - 15%).

4) Divide the available tons of feed by the number of feeding days. (Days to next harvest, subtract for cows on pasture.) Then divide by the number of animals. Multiply by 2,000 to find the pounds/head/day available to feed.

DAIRY CATTLE NUTRITION

LESSON 7: FEEDING HEIFERS

The proper feeding of calves and heifers is important to the dairy business. Quality heifers are needed to replace the milking herd. The main goal in the heifer enterprise is to produce a healthy heifer that freshens at 24 months of age. In order to achieve this goal one has to have heifers reach breeding weight by 13-15 months of age. See Figure 1 for the average normal growth curves of the five major dairy breeds. The proper feeding of heifers is required to achieve this.



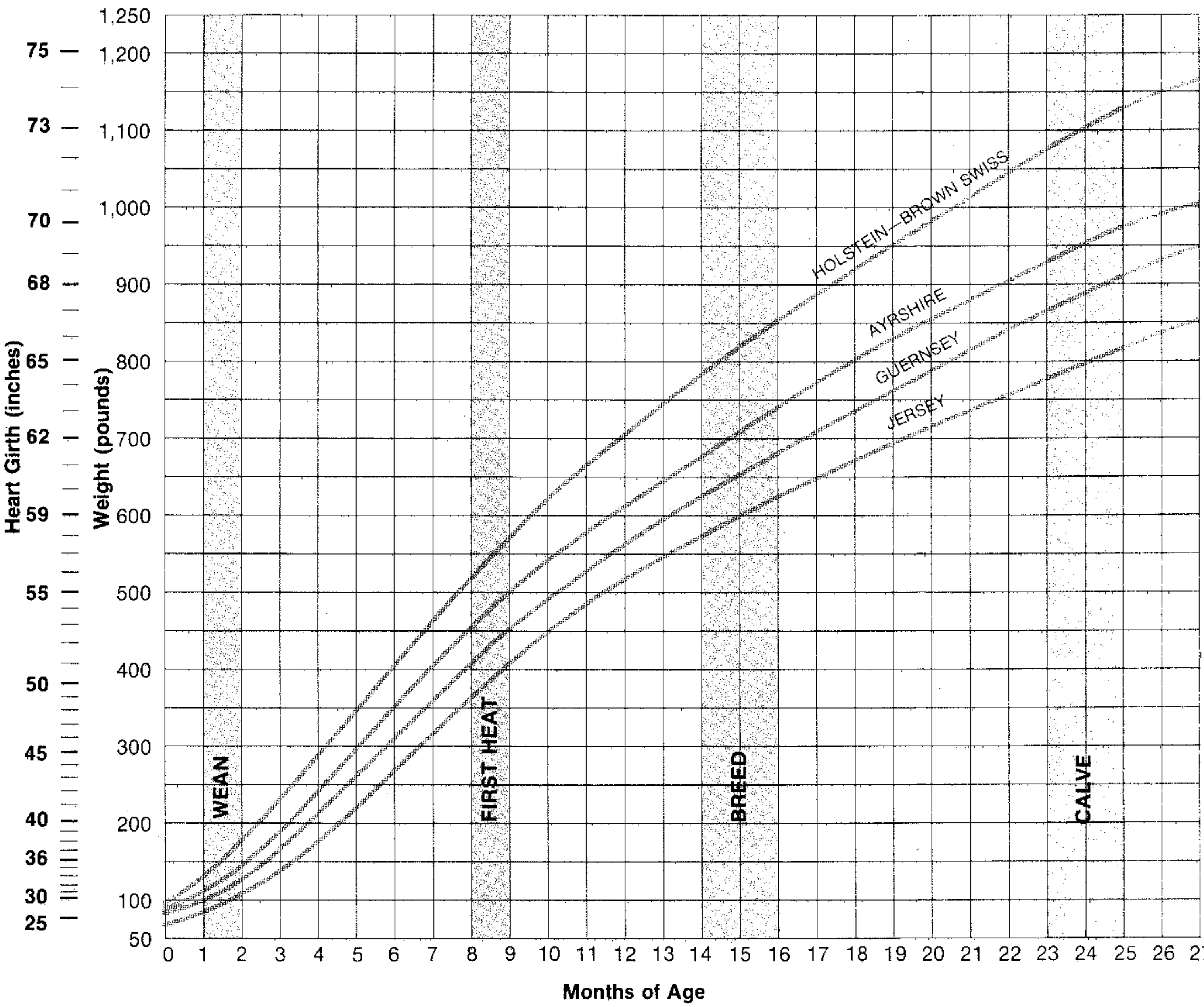
LIQUID FEED

There are several methods of liquid feeding. The use of first milk colostrum immediately after birth is imperative to the health and survival of the neonatal calf. First milk colostrum provides the needed antibodies to protect the calf. See Figure 2 which shows the absorption of these antibodies with relation to the time at first feeding. The earlier feeding, the more calf protection. After feeding colostrum for the first wo or three days, the use of fertmented colostrum, discarded milk or milk replacers can be successful for the next 4-8 weeks. The feeding of 8-10% of the calf's body weight in liquid feed is recommended. After 4-7 days

Figure 1.

Minimum Growth Curve
for Dairy Heifers

Name/number ____________________
Other ID ____________________



	Date	*Heart Girth Inches*	*Weight*	*Body Condition Sco*
Birth				
Weaning				
4 months				
6 months				
8 months				
Breeding				
20 months				
Freshening				

once a day feeding may be practiced; however, calves housed in cold housing, particularly calf hutches should not fe bed once a day for best performance in the winter. Water should be available as well as a palatable calf starter and hay during the liquid feeding period. When the calf is consuming 1 1/2 to 2 pounds of grain per day on a regular basis, she can be weaned.

After weaning, good quality hay, water, and free choice calf starter or an all-in-one calf feed and water should be fed. In most cases, grain should be limited to about 5 pounds per day to increase forage consumption. All-in-one calf starter should be fed free choice; hay is not required.

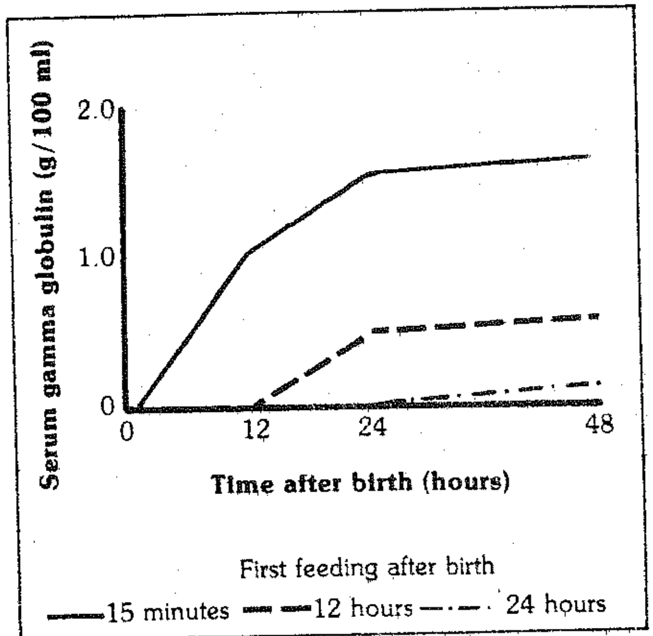


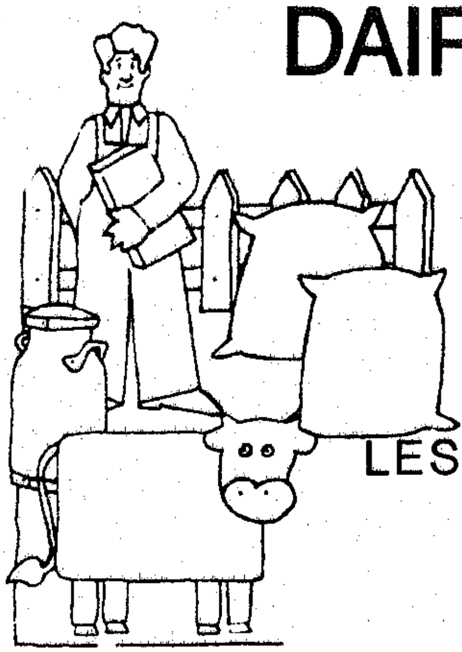
Figure 2. Effect of time of first feeding of colostrum on serum gamma globulin levels in calves.

By the time the calf is 8 months old, good quality forage will provide most of the required nutrients. Balance dairy heifer rations to be sure that all nutrient requirements are met. See Table 1 for general specifications for heifer calves. Additional information on calf and heifer feeding is contained in Animal Science Mimeograph Series No. 12.

Table 1. General specifications for rations of heifers of various body weights

Item	Large Breeds				Small Breeds			
	200	400	600	800	200	400	600	800
Dry matter intake (lbs/day)	5.7	10.7	15.3	19.0	4.7	9.6	14.1	14.4
Dry matter, % of body weight	2.85	2.68	2.55	2.38	2.35	2.40	2.35	1.80
	----------(% of DM)----------							
Crude protein	14	10	9	9	14	10	9	9
TDN[a]	70	65	61	58	68	62	57	56
Phosphorous	.30	.27	.24	.22	.30	.24	.21	.22
Calcium	.39	.35	.32	.29	.38	.32	.28	.29
Ca:P ratio (minimum)	1.3:1	1.3:1	1.3:1	1.3:1	1.3:1	1.3:1	1.3:1	1.3:1
Ca:P ratio (maximum)	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1

[a]Total digestible nutrients.



DAIRY CATTLE NUTRITION

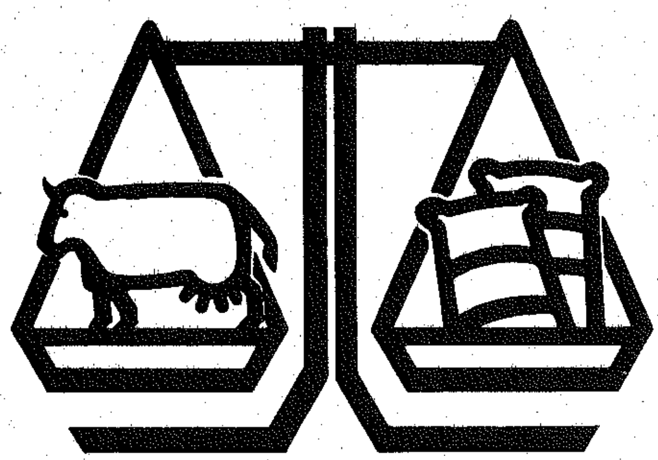
LESSON 8: FEEDING MANAGEMENT

In this lesson, feeding management will be discussed. Feeding management is taking the balanced ration and supplying it to the cow so that performance can be maximized with nutritional problems minimized. The goals of feeding management are:

1. To maximize dry matter intake.

2. To minimize the shock of ration changes to the rumen.

3. To meet the nutrient needs of both the rumen and the cow.



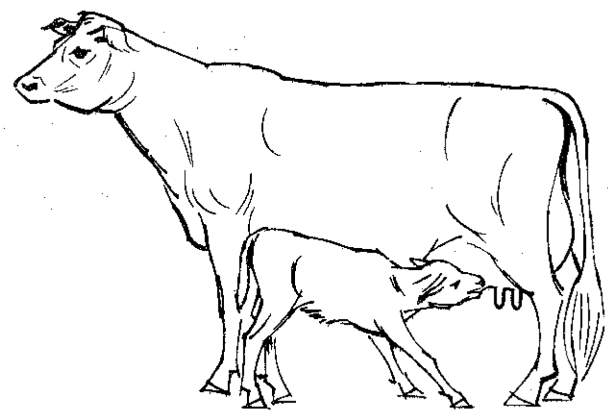
The cow goes through several changes during the lactation cycle that make feeding management important to nutrition and profitability. The lactation cycle begins with the dry cow.

The proper feeding of dry cows is imperative to have them calve, ready for milk production with no health problems. Since the nutrient requirements of the dry cow are low, a close watch has to be kept on the intake of energy, protein and minerals.

During the last two weeks of the dry period, cows can gradually be fed grain up to 1/2 - 1% of body weight to adapt the rumen microorganisms to higher levels of grain feeding. At this time a ration lower in calcium may be helpful to "gear up" the calcium mobilization and absorption for the high calcium demand at freshening.

Exceeding nutrient requirements is not only wasteful and expensive, but also detrimental to the health of the cow.

The initiation of lactation at calving imposes heavy nutrient demands on the cow. In addition to this large demand on nutrients, the cow's appetite has not reached its peak. Therefore, the cow cannot eat enough to meet her energy requirements. This is referred to as negative energy balance. Figure 1 shows the relationship between milk production, dry matter intake and body weight changes throughout a whole lactation.



In feeding for top production, it is important to meet the nutrient requirements of high levels of milk production while still feeding the cow like a ruminant. One must provide the early lactation cow with adequate amounts of protein, minerals, and vitamins and allow the cow to lose body weight to meet a portion of her energy requirements. The forage to concentrate ratio should be looked at and rarely should the ratio be less than 40:60. In fact, the type of forage fed will determine the forage to concentrate ratio.

Balancing for extreme levels of production in a group situation is unwise. If rations are balanced for 85 pounds of milk or more, the level of protein required may actually decrease dry matter intake and therefore be counter-productive. For those cows that produce milk in excess of 100 pounds, they must either eat more feed or be more efficient in their utilization of the feed.

The fresh cow should be placed in either a special fresh cow group or in the high group in order to challenge the milk production. The practice of placing the fresh cow in either a low or medium production group may work. However, the ration changes that occur with each group switch, coupled with the social changes, may have detrimental affects on milk production.

The second stage of lactation is when dry matter intake becomes more closely aligned with nutrient requirements. Perhaps it is at this point that more concentrates may be fed without many off feed problems.

Table 1 Approximate Dry Matter Capacity of Silos[1]

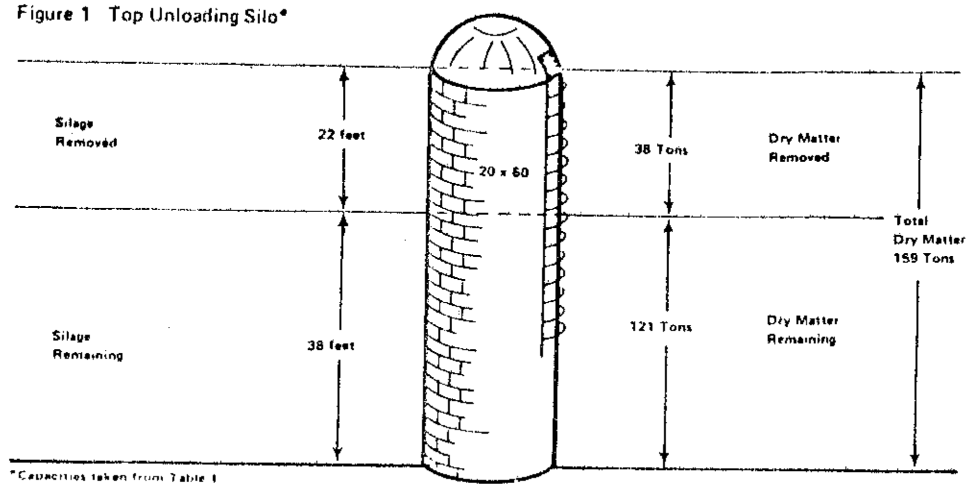
Depth of Settled Silage (feet)	Inside Diameter of Silo										
	10	12	14	16	18	20	22	24	26	28	30
2	0	1	1	1	2	2	2	2	3	3	4
4	1	2	2	3	4	5	5	6	8	9	10
6	2	2	3	4	5	7	8	10	11	13	15
8	3	4	5	7	9	11	13	16	18	21	24
10	4	5	7	9	11	14	17	20	24	28	32
12	5	7	9	11	14	18	22	26	30	35	40
14	5	8	11	14	17	22	26	31	36	42	48
16	6	9	12	17	21	26	32	37	44	51	58
18	7	11	14	19	24	29	35	42	49	57	65
20	8	12	16	21	27	33	40	47	56	66	74
22	9	14	19	24	30	38	48	54	64	74	85
24	11	15	21	27	34	43	52	61	72	83	96
26	12	17	23	30	38	48	58	68	81	94	107
28	13	19	26	35	44	53	64	76	90	104	119
30	15	21	29	38	47	59	71	84	99	115	132
32	16	23	32	41	52	65	78	93	109	127	145
34	18	25	34	45	57	70	85	101	119	137	158
36	19	28	37	48	62	76	92	109	129	150	172
38	21	30	41	53	67	82	100	118	139	161	185
40	22	32	44	57	72	89	107	127	150	173	199
42	24	34	47	61	77	95	115	137	161	186	214
44	26	37	50	65	82	102	123	146	172	200	229
46	27	39	53	69	88	108	131	155	183	212	244
48	29	42	56	74	93	115	140	166	195	226	260
50	31	44	60	78	99	122	148	175	206	239	274
52	32	47	64	83	105	129	157	186	219	254	291
54	34	49	67	88	111	137	165	197	231	267	306
56	36	51	71	93	117	144	174	207	243	282	324
58	38	54	74	98	123	151	183	218	261	297	339
60	40	56	78	102	129	159	192	228	273	309	357
62					135	167	201	239	287	324	374
64					142	174	210	250	301	339	391
66					149	182	219	260	314	354	407
68					155	190	228	271	328	369	424
70					162	198	237	282	342	384	441
72								293	356	400	458
74								305	371	415	476
76								316	385	431	493
78								328	400	446	511
80								339	462	462	528

To find the tons remaining in a silo after part of the silage is removed: (1) find the tons of silage when the silo was filled, (2) find the tons in a silo filled to the height equal to the depth of silage removed, (3) subtract the number of tons in Step (2) from the number of tons in Step (1). Example: A 20 foot silo filled to a settled depth of 60 feet and 22 feet were fed off. (1) 20 x 60 equals 159 tons (2) 20 x 22 equals 38 tons (3) 159 minus 38 equals 121 tons remaining.

1 Adapted from the National Silo Association's Silo Dry Matter Capacity Tables

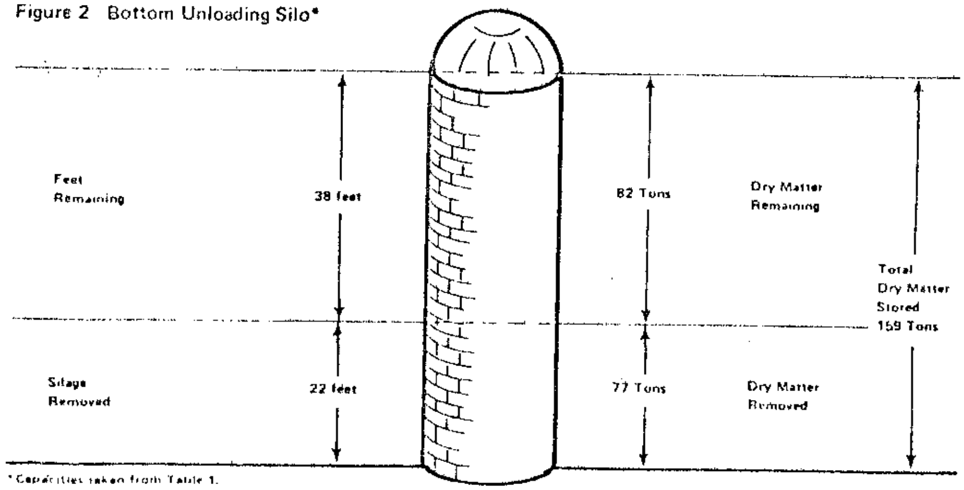
"Amount of Silage in Partially Unloaded Silos"

Figure 1 Top Unloading Silo*



*Capacities taken from Table 1

Figure 2 Bottom Unloading Silo*



*Capacities taken from Table 1.

Bunker Silo Capacities

Average Width	Average Depth of Silage in Bunker							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons Dry Matter Per One Foot of Length							
12 feet	.4	.53	.66	.78	.93	1.1	1.2	1.3
15 feet	.5	.66	.83	1.0	1.2	1.3	1.5	1.7
20 feet	.7	.9	1.1	1.3	1.5	1.8	2.0	2.2
30 feet	1.0	1.3	1.7	2.0	2.3	2.6	3.0	3.3
40 feet	1.3	1.8	2.2	2.6	3.1	3.5	4.0	4.4
50 feet	1.7	2.2	2.7	3.3	3.9	4.4	5.0	5.5
60 feet	2.0	2.6	3.3	4.0	4.6	5.3	5.9	6.6
70 feet	2.3	3.1	3.8	4.6	5.4	6.2	6.9	7.7
80 feet	2.6	3.5	4.4	5.3	6.2	7.0	7.9	8.8
90 feet	3.0	4.0	4.9	5.9	6.9	7.9	8.9	9.9
100 feet	3.3	4.4	5.5	6.6	7.7	8.8	9.9	11.0

FORAGE AVAILABLE: PER HEAD - PER DAY

FORAGE CAPACITY

SILO	TYPE	DIMENSIONS	DRYMATTER CAPACITY		DRYMATTER OF FORAGE		AS FED CAPACITY
#1	______	______	______	÷	______	=	______
#2	______	______	______	÷	______	=	______
#3	______	______	______	÷	______	=	______
#4	______	______	______	÷	______	=	______
#5	______	______	______	÷	______	=	______
#6	______	______	______	÷	______	=	______

AL STORAGE CAPACITY → HAY CROP SILAGE ______ TONS - ______ = ______
% storage & feeding loss — Tons available feed

AL STORAGE CAPACITY → CORN SILAGE ______ TONS - ______ = ______
% storage & feeding loss — Tons available feed

AL STORAGE CAPACITY → DRY HAY

______ × ______ ÷ 2000 = ______ - ______ = ______
Number of bales — avg. wgt./bale — tons hay — % storage & feeding loss — Tons available feed

	Tons Feed	÷	Number of Feeding Days	÷	Number of Animals	× 2000 =	lbs/head/day
'n Silage	______	÷	______	÷	______	× 2000 =	______
Crop Silage	______	÷	______	÷	______	× 2000 =	______
Hay	______	÷	______	÷	______	× 2000 =	______

(Compare total available to feed to your calculated forage requirements.)

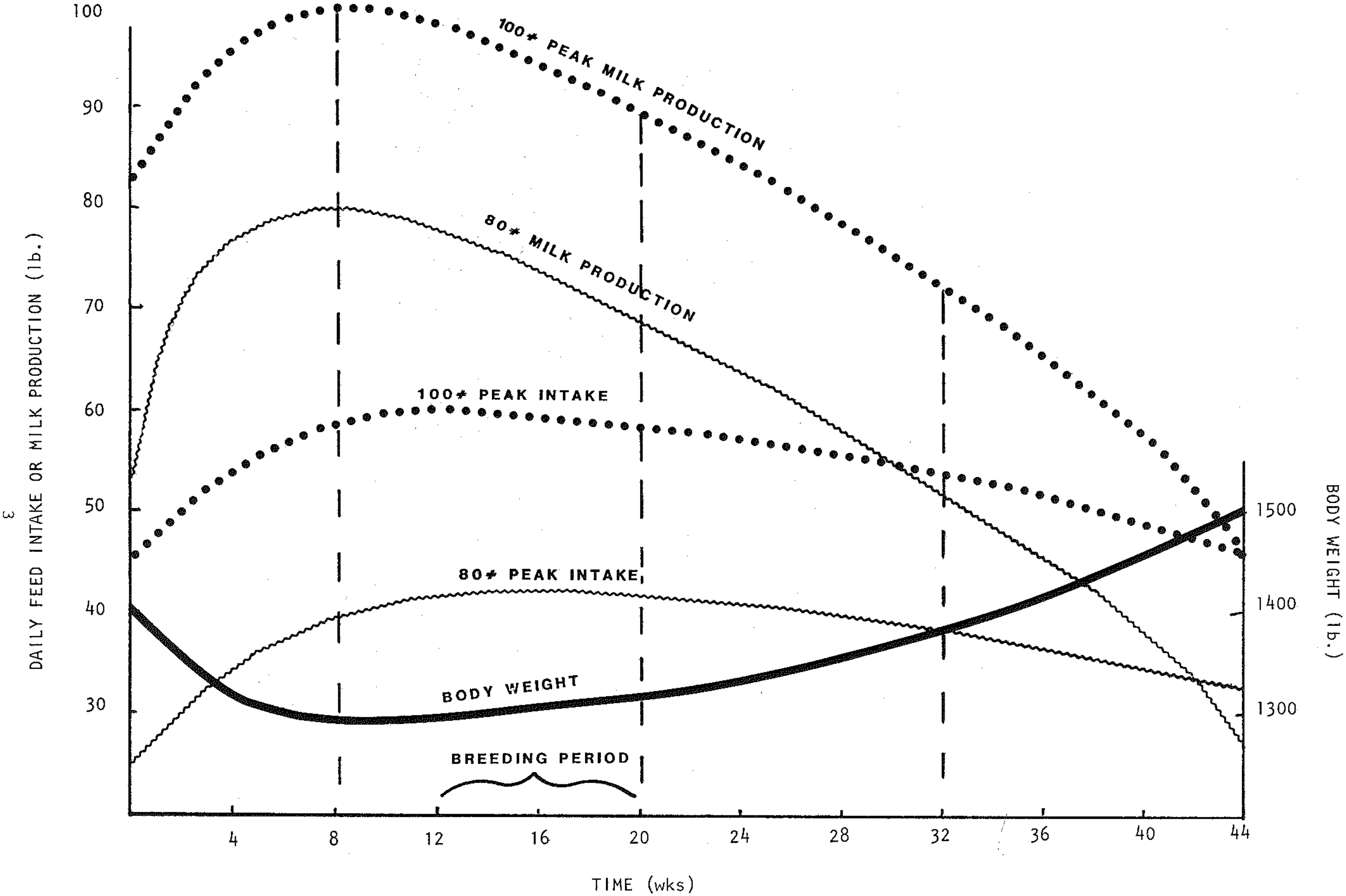


FIGURE 1. Changes in Milk Production, Feed Intake and Body Weight during a lactation.

The last stage of lactation is when the dry matter intake is sufficient to put the cow into a positive energy balance. In other words, the cow is consuming more energy than she needs. It is at this point in the lactation that body condition can be replaced for the next lactation. However, overconditioning in late lactation is to be avoided as is the overfeeding of minerals.

The changes that the cow goes through in the lactation cycle point out the need for feeding management and goals. A discussion of the practical aspects of feeding management follows.

A major consideration in the feeding management of a dairy herd is the grouping of the cows. Grouping in a confinement barn should be considered as well as in a free stall barn. Grouping according to production, stage of lactation, reproductive status, etc. will help to minimize the effects of cows stealing feed from their neighbors and ease management of the herd. The objective in grouping is to minimize the variation within groups. The smallest group that can be considered is one cow. This one cow group is essentially what one would feed in a confinement stall barn.

We should consider our grouping strategy, recognizing the physiological differences that exist during the course of lactation. First, all dry cows should be separate. Next, the lactating herd can be divided according to the stage of lactation or milk production. The initial consideration is the fresh cow. If possible, she should be handled separately. She does not eat as much initially, she is increasing in milk production rapidly, and she is moving from a dry cow high forage ration, to a low forage lactation ration. The rumen and the cow are going through some large changes.

Subsequent grouping depends on space and labor. Heat detection and other features of herd management can be simplified if cow's are grouped by production level and/or stage of lactation. A more uniform milk out in the parlor will occur when cows are grouped by production level. The grouping of cows helps to meet our primary objectives of maximizing dry matter intake, minimizing "shock" of ration changes to the rumen, and meeting the nutrient requirements for both the cow and the rumen.

By grouping the cows according to stage of lactation or milk production, we can more nearly meet that group's nutrient requirements and thus optimize production. Switching of groups does pose some problems. At the time of group changes, milk production frequently declines. This is due to both nutritional and social effects. It is important during these group changes that the dietary changes be small and that perhaps extra grain be fed in the parlor at the change or supplemental grain is provided at that time via concentrate feeders. The important criteria for switching groups should include not only milk production, but also the need to take need to be limited to control body condition.

2. Feed grass hay, haylage, pasture, or limit feed corn silage to dry cows to maintain body condition.

3. Maintain a 12-13 month calving interval since long dry periods enhance the probabilities of overconditioning.

4. Avoid sudden changes in the ration at calving.

MILK FAT DEPRESSION

In recent years, dairy cattle have been fed increasing amounts of concentrates in order to achieve greater energy intakes. As a result of this practice, some herds have experienced problems with low milk fat tests. Various buffers have been used in an attempt to remedy or alleviate this problem. In order to study this milk fat depression a bit further, we have to review the basic function in the rumen.

Rumen microorganisms produce volatile fatty acids (VFA's) as a product of carbohydrate fermentation. These VFA's are a primary source of energy for the cow. Acetate is generally the VFA present in the greatest concentration and is a primary precursor for milk fat synthesis. However, the actual amounts of the individual VFA produced and the ratios of the various acids can vary greatly. A major factor which influences the VFA production is the type of ration fed. It has been demonstrated that:

1. The acetate to propionate ratio is generally correlated to roughage:concentrate ratio. On high concentrate ratios the A:P ratio may be 1:1 while on high roughage ratios the A:P ratio may be 3:1.

2. Grinding, pelleting and fine chopping of the feed tends to narrow the A:P ratio.

3. Forage quality may alter the A:P ratio. Low quality forage usually has a wider A:P ratio than high quality forage.

The VFA production tends to produce an acidic environment in the rumen. However, the rumen has its own natural buffering agents to maintain normal pH values in the rumen. These natural agents include saliva, bicarbonate, and phosphates.

Saliva is a primary source of buffering action in the rumen. It is estimated that a 1500 pound cow may produce 420 pounds of saliva per day. This amount of saliva would contain approximately 2.4 pounds of sodium bicarbonate, 0.2 pounds of salt, and 0.8 pounds of sodium phosphate. Thus, a reduction in daily salivary secretion could reduce buffering capacity in the rumen.

The type of diet fed has a direct effect upon the amount of saliva produced. The following points summarize the relationship between diet and saliva secretion:

1. As a diet moisture goes up, the quantity of saliva produced goes down.

2. Saliva production may be 3-4 times greater when hay is fed as when concentrates are fed.

3. Grinding, pelleting and fine chopping of feeds tends to reduce saliva production.

If we look at today's feeding programs, one will note that we are feeding higher moisture feeds, higher levels of concentrates, and the amount of long forage is limited. All of these factors would tend to decrease the amount of saliva and therefore natural buffering capacity of the rumen. Figure 1 depicts the effects of forage:concentrate ratio on the proportions of VFA's, rumen pH, and relative severity of milk fat depression.

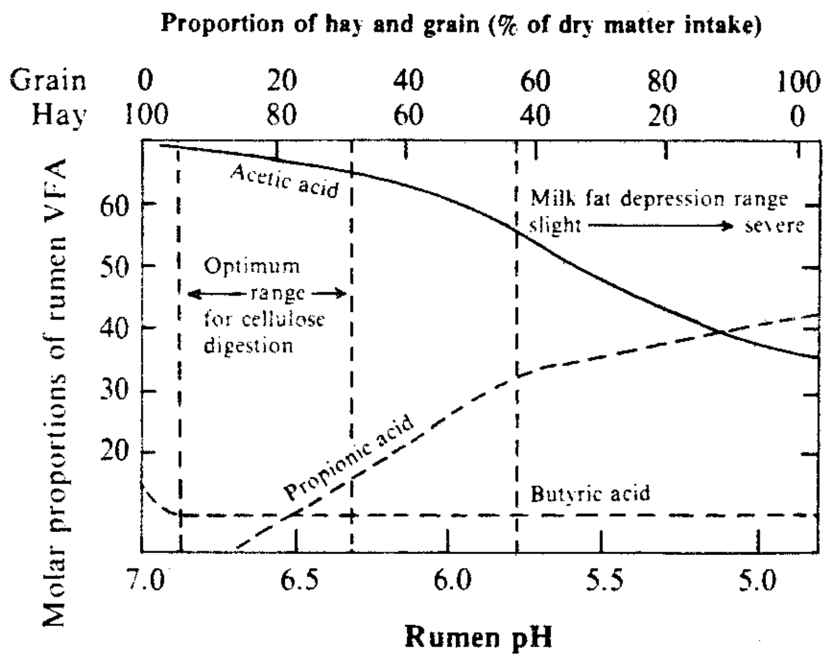


Figure 1. Effect of rumen pH and fermentation on butterfat depression. Redrawn from C. L. Davis, *Use of Buffers in the Rations of Lactating Dairy Cows, Regulation of Acid-Base Balance* (Piscataway, N.J.: Church and Dwight, 1979), p. 51.

The effect of roughage characteristics on milk fat test was examined by workers from Georgia. They fed alfalfa hay from the same source, either as long, chopped or pelleted hay. The results of this study are contained in Table 2. As a result of this limited study, the workers concluded that 12.5 minutes of chewing time per pound of ration DM consumed was necessary to maintain that 3.5% butter fat test. This study, is at least partially related to the effective fiber concept. Long, coarse fibers tend to stimulate rumen contractions, increase saliva flow and result in a wider acetate to propionate ratio. These are also the primary reasons for suggesting the addition of a long, coarse fiber source in herds with depressed butter fat.

Table 2. Feed intake, milk production and chewing time in dairy cattle[a]

	Form of Alfalfa Hay		
Item	Long	Chopped	Pelleted
Hay intake, lbs DM	31.7	40.3	31.1
Grain intake, lbs DM	15.9	15.9	15.9
Total intake, lbs DM	47.6	56.2	47.0
Milk, lbs/day	40.8	44.1	39.5
Fat, %	3.65	3.42	2.93
Chewing time, min/day	732	723	328
Chewing time, min/lb DM	16.6	12.6	6.9

[a]Sudweeks et al., 1979.

As dairy cows have been fed high levels of concentrates, more fine chopped feeds, and wetter feeds, the incidence of milk fat depression has increased. A partial explanation has been that on high grain diets, less rumination activity and saliva production occurs. Thus a more acidic ruminal environment is produced since normal rumen buffering activity decreases. As rumen pH declines, a higher proportion of the VFA's will be propionate. Basically, this means that the A:P ratio becomes narrower.

At the present time, the exact mechanism by which various buffers alter the rumen environment are not completely understood. However, at least four possible mechanisms of action have been proposed. They are:

1. Buffers increase rumen pH, alter the VFA production or absorption.

2. They increase rumen osmotic pressure which may alter rumen dry matter content and rate of passage of feed through the rumen.

3. They influence the uptake of fatty acids by the mammary glands.

4. Some buffers may increase intestinal pH and improve small intestine enzyme activity.

The use of buffers to alleviate milk fat depression should only be considered a temporary measure. During this time, an attempt should be made to define and correct the basic problem causing the depression. Experience indicates that added sodium bicarbonate partially alleviates the butter fat depression in only 40-50% of the cases with results being highly unpredictable. Sodium bicarbonate is by far the most widely used rumen buffer in use today. However, magnesium oxide has also been used as a buffer in depressed butter fat situations. Since the mechanism of action of magnesium oxide is different than bicarb, many reports indicate a beneficial affect when both are used. A summary of the recommended uses for these buffers will follow.

Limestone is another buffer that is being used to some extent. However, limestone's buffering activity takes place in the small intestines. It appears that limestone alters the pH in the small intestine so that starch digestibility is increased.

Buffers may be useful in selected situations but are not always the answer to all depressed butter fat situations. They should be considered only as a short-term solution until the primary cause can be defined and alleviated. However, do not expect results in all cases, since the responses have been highly variable in both research and commercial situations. Suggested guidelines for the use of buffers are:

1. Sodium bicarbonate

   a. add about .3 pounds/cow/day in milk cases of butter fat depression.

   b. In severe cases it may require up to 1 pound/cow/day and palatability may be a problem.

   c. In diets of early lactation cows adding 0.3-0.6 pounds/cow/day may stimulate feed intake and improve milk production.

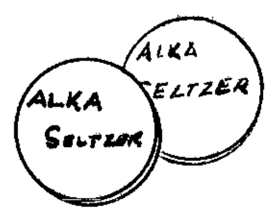
   d. Sodium bicarbonate buffers the rumen and is not effective in altering intestinal pH.

2. Magnesium oxide

   a. Adding about .2-.3 pounds of magnesium oxide/day may help in mild butter fat depression.

   b. Up to 0.5 pounds may be needed in severe cases.

   c. Magnesium oxide buffers the rumen and should not be added to alter intestinal pH.



3. Sodium bicarbonate plus magnesium oxide

   a. Since they work by different mechanisms, there may be an advantage to using both rather than either one individually.

   b. Approximately 0.3-0.6 pounds of sodium bicarbonate and 0.2-0.8 pounds of magnesium oxide appear to work well.

4. Limestone

   a. Is primarily used to alter intestinal pH and should improve milk production and fat test.

   b. About 0.5-0.6 pounds/cow/day of limestone should be used.

   c. It is vital to check fecal pH before adding limestone. If it is below 6.5, then limestone may be useful. If it is greater than 6.5, there is probably no reason to add limestone.

   d. Added limestone should only be put in the ration of early lactation cows or the excess calcium intake may cause problems.

Recent research indicates that the use of sodium bicarbonate in dairy rations may have an additional benefit. When early lactation cows are fed complete rations, the addition of sodium bicarbonate may improve feed intake and thereby milk production. Cows fed buffers appeared to have peaked in feed intake about 1-2 weeks earlier than cows fed the control ration. In addition, the addition of buffers to rations after shifting groups seems to lessen the affect of milk production decline upon this switch. The inclusion of buffers or sodium bicarbonate for one week is necessary to help in this situation.

As was mentioned earlier in this section, the use of buffers in a milk fat depression is highly variale. A close examination of the ration contents should be examined prior to the use of buffers. This examination should include an examination of the forage to concentrate ratio. Perhaps the adjustment of the feeding program would be more beneficial than the addition of buffers to the cow's diet.

SUMMARY

In this lesson, we have examined several of the nutritional problems that may be encountered in feeding dairy cattle. Several recommendations were made to help alleviate these nutritional problems.

DAIRY CATTLE NUTRITION HOME STUDY COURSE

GLOSSARY

ADF - acid detergent fiber, a measure of the fiber fraction of feeds; contains lignin and cellulose

A:P - acetate to propionate ratio

Ca - calcium

CP - crude protein, a measure of the total protein equivalent of feeds from both natural and NPN sources

CS - corn silage

DE - digestible energy

DM - dry matter, moisture free

DMI - dry matter intake

ENE - estimated net energy; a measure of energy

F:C - forage to concentrate ratio

FCM - fat corrected milk

g - gram, a unit of weight; 454 grams equal 1 pound

GE - gross energy

HCS - hay crop silage

HMEC - high moisture ear corn

HMSC - high moisture shelled corn

IU - international units

lb - pounds

Mcal - megacalorie, a unit of measurement for energy; 1 million calories

ME - metabolizable energy

NDF - neutral detergent fiber, a measure of the cell wall constituents; hemicellulose, cellulose and lignin

NE - net energy

NE_l - net energy for lactation; a measure of energy

NPN - non protein nitrogen

P - phosphorous

ppm - parts per million

TDN - total digestible nutrients; a measure of energy similar to digestible energy

VFA - volatile fatty acids; a major source of energy for ruminants; acetic, propionic and butyric acids are the major VFA's

DAIRY CATTLE NUTRITION HOME STUDY COURSE

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DAIRY FEEDING CONVERSION FACTORS

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The formulation and evaluation of dairy rations entails a variety of calculations and conversions. Even though these calculations are relatively simple, confusion often exists when units of measurement must be converted between different systems. This paper will provide a listing of the most common conversion factors and examples of their use.

Conversion Factors

Units Provided	Units Desired	Multiply By
lb.	kg.	0.4536
lb.	g.	453.6
oz.	g.	28.35
oz.	lb.	0.0625
kg.	lb.	2.2046
g.	lb.	0.0022046
g.	oz.	0.03527
kg	mg	1,000,000
kg	g	1,000
g	mg	1,000
mg	micro-g	1,000,000
mg	micro-g	1,000
mg/g	mg/lb	453.6
mg/kg	mg/lb	0.4536
micro-g/kg	micro-g/lb	0.4536
micro-g/kg	micro-g	1,000
ppm	micro-g/g	1.0
ppm	mg/kg	1.0
ppm	mg/lb	0.4536
mg/kg	%	0.0001
ppm	%	0.0001
mg/g	%	0.1
g/kg	%	0.1
%	ppm	10,000
Mcal	Kcal	1,000
Kcal/kg	Kcal/lb	0.4536
Kcal/lb	Kcal/kg	2.2046
Mcal/kg	Mcal/lb	0.4536
Mcal/lb	Mcal/kg	2.2046

Examples:

a. A cow is consuming 46 pounds of dry matter. How many kilograms is this?

$$46 \times 0.4536 = 20.86$$

b. A ration contains 125 ppm of iron. How many milligrams is this per pound of dry matter?

$$125 \times 0.4536 = 56.7$$

What % iron is in the ration?

$$125 \times 0.0001 = .0125\%$$

c. It is permissible by FDA regulations to supplement 0.3 ppm selenium to the total ration dry matter of a dairy cow. How many milligrams of selenium could be supplemented per day for a cow consuming 42 pounds of dry matter?

$$(0.3 \times .4536) \times 42 = 5.7 \text{ mg}$$

d. A selenium premix contains 200 ppm. What % selenium is this?

$$200 \times 0.0001 = .02\%$$

e. A mineral mix contains .003% iodine. How many ppm is this?

$$.003 \times 10{,}000 = 30 \text{ ppm}$$

List of Abbreviations

Feeding Management

(in alphabetical order)

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
CP	Crude Protein
CS	Corn Silage
DE	Digestible Energy
DIP	Degraded Intake Protein
DM	Dry Matter
DMD	Dry Matter Digestibility
DMI	Dry Matter Intake
ENE	Estimated Net Energy
FCM	Fat Corrected Milk
GE	Gross Energy
HMEC	High Moisture Ear Corn
HMSC	High Moisture Shell Corn
ME	Metabolizable Energy
MMG	Mixed Mostly Grass
MML	Mixed Mostly Legume
NDF	Neutral Detergent Fiber
NEg	Net Energy (growth)
NEl	Net Energy (lactation)
NEm	Net Energy (maintenance)
NIR	Near Infrared Reflectance
NPN	Non-Protein Nitrogen
NRC	National Research Council
NSC	Non-structural Carbohydrates
PPM	Parts Per Million
RFV	Relative Feed Value
SBM	Soybean Meal
SIP	Soluble Intake Protein
TDN	Total Digestible Nutrient
TMR	Total Mixed Ration
TP	Total Protein
UIP	Undegraded Intake Protein

(OVER)

List of Abbreviations *(continued)*

Feeding Management

Elements:

Ca	Calcium
Cu	Copper
Fe	Iron
K	Potassium
Mb	Molybdenum
Mg	Magnesium
Mn	Manganese
N	Nitrogen
Na	Sodium
P	Phosphorus
S	Sulfur
Zn	Zinc

Units of measure:

cal	Calorie
g	Gram
kcal	Kilocalorie (1000 calories)
kg	Kilogram
l	Liter
lb	Pound
Mcal	Megacalories (1,000,000 calories)
mg	Milligram (1/1000 gram)
ml	Milliliter (1/1000 liter)