PROTEINS AND THEIR COST: AN INTERNATIONAL COMPARISON

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Introduction

Students working in the field of international food economics ultimately find themselves comparing country with country in terms of diet composition, caloric intake and protein consumption. The data which supply calorie and protein intakes are often taken from a selected country's food balance sheet. This sheet indicates on a country-wide basis what food items were available during a given time period for human consumption. Supplied with population figures for the country during the same time span, calculations can be made which result in the number of calories and the grams of protein available each day to an average person of this selected population.

Household budget surveys are used to collect information on consumption patterns, both in terms of quality and cost, which can be useful to people working as food planners. The food balance sheet and the household budget survey are mentioned here to illustrate techniques used by planners to gain some feeling for the realities of a particular location's food situation.

These two techniques vary greatly. The food balance sheet uses the largest possible parameters--the population statistics and agricultural production statistics--to work from in condensing and deducing available per capita daily intake of calories and protein. The household budget

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survey represents a technique based on the opposite approach, that is: 1) collect data on a selected group of households, 2) calculate actual consumption during this short period, and then 3) project these results for the larger population. By using either approach the student is provided with values of "apparent consumption" for calories and protein.

Table 1 is included here to illustrate how values obtained from various countries, in this case from food balance sheets, are used for general comparison. In Table 1 values are combined into regional areas to give a "world view" of the calorie and protein supplies (1, p. 317).

TABLE 1. SUMMARY OF AVERAGE PER CAPITA CALORIC AND PROTEIN SUPPLIES IN SELECTED AREAS[a]

REGION and Subregion	Population in millions in 1960	Calories in diet (average)	Calories derived from cereals, starchy roots, and sugar as percentage of total calories	Total Protein, grams/day	Animal Protein, grams/day
FAR EAST (inc. China Mainland)	1,603	2,060	81	56	8
South Asia	534	1,970	78	50	7
SE Asia, mainland	67	2,030	78	49	13
SE Asia, major is.	120	2,070	81	45	7
NEAR EAST	132	2,470	72	76	14
AFRICA	215	2,360	74	61	11
N. Africa	27	2,260	75	66	16
W. & Central Africa	90	2,360	74	50	5
LATIN AMERICA	211	2,510	63	67	24
Mexico & Central America	60	2,370	65	63	19
Mexico		2,440	65	68	20
Central America		2,130	71	58	14
Brazil	70	2,650	64	67	19
River Plate countries	25	3,040	54	96	55

continued . . .

TABLE 1. (continued)

WESTERN EUROPE	322	2,910	55	83	39
NORTH AMERICA	192	3,110	40	93	66
Low Calorie Countries	2,038	2,150	78	58	9
High Calorie Countries	856	3,050	57	90	44

a/ From data in Appendix Table 4, Food and Agriculture Organization of the United Nations, Third world food survey, Freedom from Hunger Campaign, Basic Study No. 11, 1963, 102 pp.

In this essay I propose to take a closer look at protein and discuss it as a food nutrient that must be evaluated on the basis of its quality and its cost to the people consuming it. It is believed this type of an evaluation is the logical "next step to follow" the collection of survey and food balance sheet data on protein consumption. This discussion will enable the reader to appreciate the "bigger picture" when he finds himself making comparisons and judgements about dietary protein intake when only gross or crude values are available to quote.

To make international dietary comparisons, one must select suitable parameters which allow for only minimum distortion due to monetary or social variables. Admittedly this is a difficult task. A technique which describes food protein's cost, expressed as the laboring time needed to purchase that amount, will be discussed and presented as a possible technique useful in international food comparisons and in understanding a given local food protein situation.

When locations are compared on this basis many facts can be learned. It is possible to determine where a location or country is, in terms of the time spent earning food. Perhaps this is an indicator of "development." Also one is able to identify a protein source for which modern technology can improve its competitiveness.

Proteins

Proteins themselves are a distinct group of compounds. They are composed of carbon, oxygen, hydrogen, nitrogen and some sulphur. The structure of a protein can be described as being a relatively long chain composed of identifiable links called amino acids. The term amino acid is a descriptive chemical name indicating the presence of a nitrogen containing functional group (amino) and a carboxylic acid functional group in each amino acid. There are believed to be twenty-five different amino acids that link together in innumerable combinations to form the proteins as we know them.

Amino acids are classified into groups as being essential or non-essential. The classification "non-essential" simply indicates those amino acids which can be synthesized in sufficient quantities by the species in question, so that none need be consumed. Essential amino acids are those which must be present in food, because the body is unable to synthesize the carbon skeleton upon which the amino acid is constructed. Adult man requires eight essential amino acids, and babies nine.

Protein Quality

Proteins vary in quality. When comparing the protein content of various food items and then relating it to the cost of those same items, protein quality differences must not be forgotten.

In its simplest evaluation, a protein's quality reflects its ability to provide the essential amino acids to the animal consuming it. Two factors are relevant here. First, the essential amino acids must be present in the food protein and second, that protein must be digestible. Evaluating proteins experimentally, one must determine the amino acid content of a given protein, and then the digestibility of that protein by the animal.

Various classifications have been arranged to describe a protein's quality. All are based on animal feeding experiments that evaluate a protein in terms of its growth promotion. Early, it was learned that whole egg protein ranked above all other proteins in quality. This was true because egg protein is highly digestible and its essential amino acid pattern most closely resembles the essential amino acid content of rat protein, the experimental animal. Therefore, most classifications are arranged to compare all other proteins to egg protein.

One classification system uses the "biological value" of a protein. The biological value of a protein is a function of the available content of essential amino acids, (2, p. 28).

A second classification system is the "Essential Amino Acid Index." It is defined as the geometric mean of "the egg ratios," i.e., the ratios of the essential amino acids in a protein relative to their respective amounts in whole egg protein, (2, p. 284).

These two classification systems yield data that are highly correlated and can be directly related by the following equation;

Biological Value = 1.09 (EAA) - 11.73, (2, p. 288).

For purposes of later comparison a table of biological values and Essential Amino Acid Index Values for 200 food proteins is included as an appendix to this essay, (2, p. 292-295).

Table 2 (1, p. 315) gives the essential amino acids. Dried beans and especially the meals listed are very low in methionine, a sulphur containing amino acid. Rice, corn and wheat are very low in lysine.

TABLE 2. PERCENTAGE OF IDEAL CONCENTRATION OF ESSENTIAL AMINO ACIDS OBSERVED IN TYPICAL PROTEINS (USING EGG AS 100 PERCENT)[a,b]

(percentage concentration in whole egg protein)

Foodstuffs	Histi-dine	Threo-nine	Valine	Leu-cine	Iso-Leucine	Lysine	Methi-onine	Phenyl-alanine	Tryp-tophan
Beef	157	90	73	87	84	141	84	70	92
Fish muscle	124	96	86	106	105	148	100	79	109
Soybean meal, low fat	138	80	76	89	97	111	53	95	127
Whole rice	81	78	88	91	84	52	106	89	118
Whole wheat	100	67	62	78	64	44	78	91	109
Cottonseed meal	128	61	69	67	64	57	53	107	118
Whole corn	119	76	76	167	103	38	97	89	55
Peanut flour	100	57	66	79	66	57	25	88	72
Dried roast beans	104	79	78	78	89	106	62	89	73
Sesame meal	106	81	67	70	63	38	53	78	93

a/ Data mainly taken from Hopper, T. H., "Amino acid composition of foodstuffs," In: Altschul, A.M. (ed.), Processed plant protein foodstuffs (New York, Academic Press) 1958, pp. 877-891.

b/ Data mainly taken from Heinz (H.J.) Company. "The Heinz handbook of nutrition: a comprehensive treatise on nutrition in health and disease," Rev., 2nd ed., (New York, McGraw-Hill) 1965, pp. 462.

It should be understood that in the complete absence of any one of the essential amino acids, normal maintenance, growth, and survival are not possible.

How much importance should be placed on the fact that a given amino acid is low in a food item? To illustrate how a limiting amino acid affects a growing child, Table 3 is included (1, p. 318). Nitrogen retention values are a measure of growth, i.e., the larger values represent greater amounts of growth over this experimental period. According to Table 3, skim milk in all cases resulted in the most nitrogen retained by the child. When the limiting amino acid is added to the protein source, nitrogen retention increases significantly.

TABLE 3. THE EFFECT OF LIMITING AMINO ACIDS ON NITROGEN BALANCE IN CHILDREN FED THREE CEREAL GRAINS[a/]

	Nitrogen		
Protein Source	Intake Milligrams per Kilogram per Day	Absorbed Percent of Intake	Retained Percent of Intake
Skim Milk	454	79.5	18.6
Corn Masa	461	74.8	2.3
CM + Lysine + Tryptophan	464	71.0	17.8
Skim Milk	310	80.3	24.8
Wheat Flour	328	85.4	8.2
WF + Lysine	335	86.0	17.9
Skim Milk	317	80.4	28.1
Rice	320	76.9	18.7
R + Lysine	320	79.7	24.7

a/ Note: Protein fed at 2-3 gm./kg. body weight/day. From: Bressani, R., Improvement of nutritional status in developing countries by food production: cereals. Int. Congr. Nutr. Proc. 1966. (preprint).

Several points now are made to relate the previous discussion to nutritonal practice. Biological values of proteins are difficult to use when combining several protein sources into a diet. Thus if two items have low values but compliment each other well in their overall amino acid pattern, the resultant value may be greater than the sum of both single values (3).

The principle upon which the Essential Amino Acid Index is based, could be applied to the prediction of protein quality of a given diet. Given the dietary ingredients and their amounts, and the amino acid content of each ingredient, one could calculate and classify a particular diet in terms of its protein quality. Needless to say a computer would be helpful in that endeavor.

Protein Deficiency

Protein is reported to be in low supply where malnutrition and/or certain diseases are found. Why are protein dietary levels important under these conditions?

Certain compounds in the body, called enzymes, are required to accomplish food digestion. They are composed almost entirely of proteins. Enzymes are continually being used up and reformed, thus requiring a sufficient supply of amino acids.

The chemistry of immunity to disease is the chemistry of proteins, (4, p. 32). The body's reaction to an invasion of disease organisms is to produce antibodies and blood globulins which engulf and destroy the foreign particles. Antibodies and blood globulins are proteins.

Clearly, dietary protein levels are important to normal food digestion and disease resistance.

Retail Food Prices

As a basis for protein cost comparisons, retail food prices were collected for selected locations. Since international comparisons are to be made, an attempt was made to collect data that is comparable in all aspects.

Problems in collecting food prices are many, particularly from developing countries. In addition to the price cycles, reflecting seasonality of certain food items, a price must be selected for a comparable quality item.

Various types of sources were consulted to obtain these prices. They included publications of the various governments' agricultural and statistical departments, and also included various household budget surveys. Ultimately, a publication of the International Labor Organization was located which quoted retail prices for thirty-five food items from 150 cities (5, p. 394-423). While the prices used from this are probably not without error, all are reported as of a given date and for items of comparable quality. They are useful as indicating trends even though their preciseness may be suspect.

Income and Wages

In devising a system that allows meaningful international comparisons of food protein costs, it would be most helpful if a factor or technique could be incorporated into an expression of the "real cost" of protein at each location. It was decided to do this by expressing protein costs in terms of the laboring time required in order to purchase 25 grams protein at each location.

Before laboring time can be calculated, a measure of income must be chosen which can be comparable from city to city. How is this to be accomplished?

Per capita incomes expressed in U.S. dollars are often used as income indicators when comparing one country with another. Its use is rejected here for two reasons. First, there are inherent difficulties in currency conversions due to the differences between official rates of exchange and the street rates. Second, per capita income really describes no one in any country. Therefore, it is quite difficult to find it meaningful in the context used here as an income value.

A more meaningful method to choose an income level, is to define an individual who appears at each location, and use his income as the basis for comparison. Ideally, his relative social position would be equivalent in all locations from which comparisons are to be drawn. The income level chosen is thus on a comparable basis at each location.

Table 4 below, using 1953 data, illustrates the type of international comparisons just described (6, p. 415). However in arranging this particular table, all wages and food prices were first converted into U.S. dollars at existing official exchange rates.

TABLE 4. NUMBER OF HOURS OF WORK NECESSARY TO PURCHASE THE SAME AMOUNT OF FOOD WHICH ONE HOUR'S WORK IN THE OCCUPATION INDICATED WOULD PURCHASE IN THE UNITED STATES, 1953

Country	Meteorologist		Letter Carrier		Stenographer Typist		Average Industrial Wage Earner	
	hr.	min.	hr.	min.	hr.	min.	hr.	min.
Union of S. Africa	0	59	1	50	1	26	0	58
Canada	0	45	1	4	1	28	1	3
Belgium	1	3	2	16	1	49	2	16
Denmark	1	13	1	35	1	21	1	18
Finland	1	22	2	20	2	5	1	49
France	1	35	3	34	3	2	3	42

continued. . .

TABLE 4. (continued)

Germany (Fed.R.)	2	5	5	16	5	0	3	14
Ireland	1	7	2	47	1	55	2	16
Italy	3	34	5	16[a]	-	-	4	10
Netherlands	1	26	2	38	2	34	2	51
Norway	1	13	1	55	1	40	1	31
Sweden	0	55	1	37	1	27	1	15
Switzerland	1	9	1	58	2	2	1	40
United Kingdom	1	11	1	37	1	37	1	37
Australia	0	53	1	3	1	1	0	57

a/ Messenger; information not available concerning letter carrier.

Table 4 indicates 1953 comparisons for primarily European nations. Four workers were chosen to quantify income levels. Time units needed to purchase a given quantity of food are contrasted between location and type of worker. In this case the author neglected to define just how "food" was quantified, i.e., what items made up food. However, it was reported that food costs were determined and then converted to index numbers using the U.S.A. values = 100.

It is interesting to note that only five out of a possible fifty-nine values were greater than the U.S. equivalent, by more than 300%. For most countries included in this table, it can be said that increased food costs as expressed in time units, were less than three times the U.S. value. More than fifty percent of the values were in the range of equal to or less than two times greater than U.S. labor unit.

Price and wage data to be presented here were collected in 1957. Thus four years elapsed between the date this data is based upon, and that used for calculating values presented in Table 4. Excluding Boston, the locations chosen included major cities in "developing" countries. The major link that should be made between the two studies is the concept of costs expressed as time units. It appears to be a helpful tool in making international comparisons of food costs.

Methods

Briefly, ten food items were priced in seven cities, the cost of protein in each item calculated and then expressed in monetary and time unit values. International comparisons in time units can then be made of protein cost by food item.

Two cereals, one tuber and six foods of animal origin were selected. The limitation of food selection was based on the existence or non-existence of retail price data. While foods from animal sources are often thought of as being the main protein suppliers, it must be remembered that starchy-staple foods generally supply significant amounts of protein because they make up a large share of the total diet. This is especially true in low-income countries.

Twenty-five grams protein was selected as the protein quantity unit to talk about for the following reason. When speaking in general about an adult's daily recommended protein allowance, fifty grams seems to be in the "ball-park." One half of this daily amount is an amount that under average conditions might come from one food source.

Considering the ten foods included in this study, potatoes, milk and eggs may seem to be items not applicable to intakes of this protein unit. Since potatoes are low in protein and are consumed in a form which contains large amounts of water, it would not be expected that they would be eaten in sufficient amounts to supply twenty-five grams of protein. However, it is certainly possible to consume twenty-five grams of protein in the form of milk or eggs. Four eggs and two and one-half cups of milk, each supply twenty-five grams protein. In all cases then except potato, a twenty-five gram protein unit is reasonable to use as an expression of one-half the daily adult protein allowance.

The income level selected for use is the hourly wage rate reported for a bricklayer in 1957 at the same cities from which the food prices were collected, namely Bangkok, Boston, Colombo, Guatemala City, Khartoum, Kingston and Lagos (5, pp. 321-346). Only in the case of Kingston was wage data for a bricklayer unavailable. A structural steel erector's wage was used instead. That selection was based upon data from many cities which suggested the two worker types commanded a similar wage.

Discussion of Data

Inspecting the column entitled cents/g. protein in Table 5, foods can easily be ranked according to their protein cost per gram. Beans are the cheapest protein source in Boston,with flour a close second. Beef, the most expensive, costs 1.21 cents per gram of protein.

The last column entitled Protex, is a protein index that brings in the wage rate as a factor for evaluation. The protex value is simply the cost of twenty-five grams protein divided by the hourly wage rate of the bricklayer all multiplied by 100. It represents the percentage of one hour's labor that is required to purchase twenty-five grams protein in the form of the particular food item in question. (Tables 5-11 present all data collected and calculated for the seven cities.)

Hierarchies

Relative food protein costs are summarized in Table 13. Here the protein cost of egg is set equal to 100 and all other items are ranked according to it at each location. Index values become useful when comparing various locations in terms of variations of rankings.

Inspection of Table 13 and Figure 1 clearly indicates that beans are the cheapest protein source in most locations. Milk and egg costs were similar at Boston, Khartoum and Colombo, but not at Guatemala City, or Kingston. They make an interesting contrast since both are exceptionally good proteins. Compared to eggs, milk in Kingston was a very good buy.

TABLE 5. BOSTON: FOOD PROTEIN COST HOURLY WAGE[a/] INDEX

Item	Unit	Cents	Protein	Cents/ g. Prot.	Cents/25g.	Protex
			(percent)			
Flour	kg	22.3	10.5	0.21	5.25	1.5
Rice	kg	44.3	6.7	0.66	16.50	4.7
Beef	kg	259.3	21.5	1.21	30.25	8.6
Pork	kg	192.9	18.8	1.03	25.75	7.4
Fresh fish	kg	89.1	17.6	0.51	12.75	3.6
Salted fish	kg	-	24.0	-	-	-
Milk	kg	26.8	3.5	0.77	19.25	5.5
Eggs	kg	101.7	12.9	0.79	19.75	5.6
Beans	kg	40.6	22.5	0.18	4.50	1.3
Potatoes	kg	10.4	2.1	0.50	12.50	3.6

a/ Wage - hourly wage of bricklayer = 350 cents (minimum).

TABLE 6. LAGOS: FOOD PROTEIN COST HOURLY WAGE[a] INDEX

Item	Unit	Pence	Protein (percent)	Pence/ g. Prot.	Pence/25g.	Protex
Flour	kg	-	10.5	-	-	-
Rice	kg	23.9	6.7	0.36	9.00	64.3
Beef	kg	53.4	21.5	0.25	6.25	44.6
Pork	kg	-	18.8	-	-	-
Fresh fish	kg	60.8	17.6	0.35	8.75	62.5
Salted fish	kg	74.1	29.0	0.26	6.50	46.4
Milk	kg	-	3.5	-	-	-
Eggs	kg	45.6	12.9	0.35	8.75	62.5
Beans	kg	13.3	22.5	0.06	1.50	10.7
Potatoes	kg	4.7	2.1	0.22	5.50	39.3

a/ Wage - 14.0 pence, average rate, bricklayer.

TABLE 7. KHARTOUM: FOOD PROTEIN COST HOURLY WAGE[a] INDEX

Item	Unit	Piastres	Protein	Piastres/ g. Prot.	Piastres/ 25 g.	Protex
			(percent)			
Flour[b]	kg	6.0	10.5	0.057	1.425	16.76
Rice	kg	6.0-9.5 (8.0)	6.7	0.119	2.975	35.00
Beef	kg	20.0	21.5	0.093	2.325	27.35
Pork	kg	40.0	18.8	0.213	5.325	62.65
Fresh fish	kg	30.0	17.6	0.170	4.250	50.00
Salted fish	kg	48.4	29.0	0.167	4.175	49.12
Milk	kg	6.4	3.5	0.183	4.575	53.82
Eggs[c]	kg	21.1	12.9	0.164	4.100	48.24
Beans	kg	6.0	22.5	0.027	0.675	7.94
Potatoes	kg	5.0	2.1	0.238	5.950	70.00

a/ Wage - 8.50 piastres, average rate, bricklayer.

b/ Flour - imported.

c/ Eggs - imported.

TABLE 8. COLOMBO: FOOD PROTEIN COST HOURLY WAGE[a] INDEX

Item	Unit	Rupees	Protein (percent)	Rupees/ g. Prot.	Rupees/ 25 g.	Protex
Flour[b]	kg	0.51	10.5	0.0048	0.120	27.91
Rice	kg	0.44	6.7	0.0066	0.165	38.37
Beef	kg	1.98	21.5	0.0092	0.230	53.49
Pork	kg	2.84	18.8	0.0151	0.378	87.91
Fresh fish	kg	6.31	17.6	0.0359	0.898	208.84
Salted fish	kg	4.52	29.0	0.0156	0.390	90.70
Milk	kg	1.19	3.5	0.0340	0.850	197.67
Eggs	kg	3.86	12.9	0.0299	0.748	173.95
Beans	kg	-	22.5	-	-	-
Potatoes	kg	0.71	2.1	0.0338	0.845	196.51

a/ Wage - 0.43 rupees, average rate, bricklayer.

b/ Flour - controlled price.

TABLE 9. GUATEMALA CITY: FOOD PROTEIN COST HOURLY WAGE[a/] INDEX

Item	Unit	Centavos	Protein (percent)	Centavos/ g. Prot.	Centavos/ 25 g.	Protex
Flour	kg	24.0	10.5	0.228	5.70	22.80
Rice	kg	24.0	6.7	0.358	8.95	35.80
Beef	kg	217.0	21.5	1.009	25.23	100.92
Pork	kg	120.0	18.8	0.638	15.95	63.80
Fresh fish	kg	109.0	17.6	0.619	15.48	61.92
Salted fish	kg	163.0	29.0	0.562	14.05	56.20
Milk	kg	19.4	3.5	0.554	13.85	55.40
Eggs	kg	105.0	12.9	0.814	20.35	81.40
Beans	kg	26-33 (30)	22.5	0.133	3.33	13.32
Potatoes	kg	22.0	2.1	1.048	26.20	104.80

a/ Wage - 25.0 Centavos, average rate, bricklayer.

TABLE 10. BANGKOK: FOOD PROTEIN COST HOURLY WAGE[a/] INDEX

Item	Unit	Bahts	Protein (percent)	Bahts/ g. Prot.	Bahts/25g.	Protex
Flour	kg	3.85	10.5	0.037	0.925	43.02
Rice	kg	1.84	6.7	0.027	0.675	31.40
Beef	kg	15.12	21.5	0.070	1.750	81.40
Pork	kg	10.00	18.8	0.053	1.325	61.62
Fresh fish	kg	12.73	17.6	0.072	1.800	83.72
Salted fish	kg	5.75	29.0	0.020	0.500	23.25
Milk	kg	-	3.5	-	-	-
Eggs	kg	15.79	12.9	0.122	3.050	141.86
Beans	kg	2.75	22.9	0.012	0.300	13.95
Potatoes	kg	7.50	2.1	0.357	8.925	415.11

a/ Wage - minimum rate, 2.15 Bahts, bricklayer.

TABLE 11. KINGSTON: FOOD PROTEIN COST HOURLY WAGE[a] INDEX

Item	Unit	Pence	Protein (percent)	Pence/ g. Prot.	Pence/25g.	Protex
Flour	kg	12.1	10.5	0.115	2.875	8.71
Rice	kg	28.7	6.7	0.428	10.700	32.42
Beef	kg	66.9	21.5	0.307	7.675	23.25
Pork	kg	61.7	18.8	0.328	8.200	24.85
Fresh fish	kg	50.3	17.6	0.286	7.150	21.67
Salted fish	kg	40.8	29.0	0.141	3.525	10.68
Milk	kg	15.3	3.5	0.437	10.925	33.11
Eggs	kg	96.5	12.9	0.748	18.700	56.67
Beans	kg	-	22.5	-	-	-
Potatoes[b]	kg	12.8	2.1	0.610	15.250	46.21

a/ Wage - 2.75 Shillings, minimum wage, structural steel erector.

b/ Potatoes - imported.

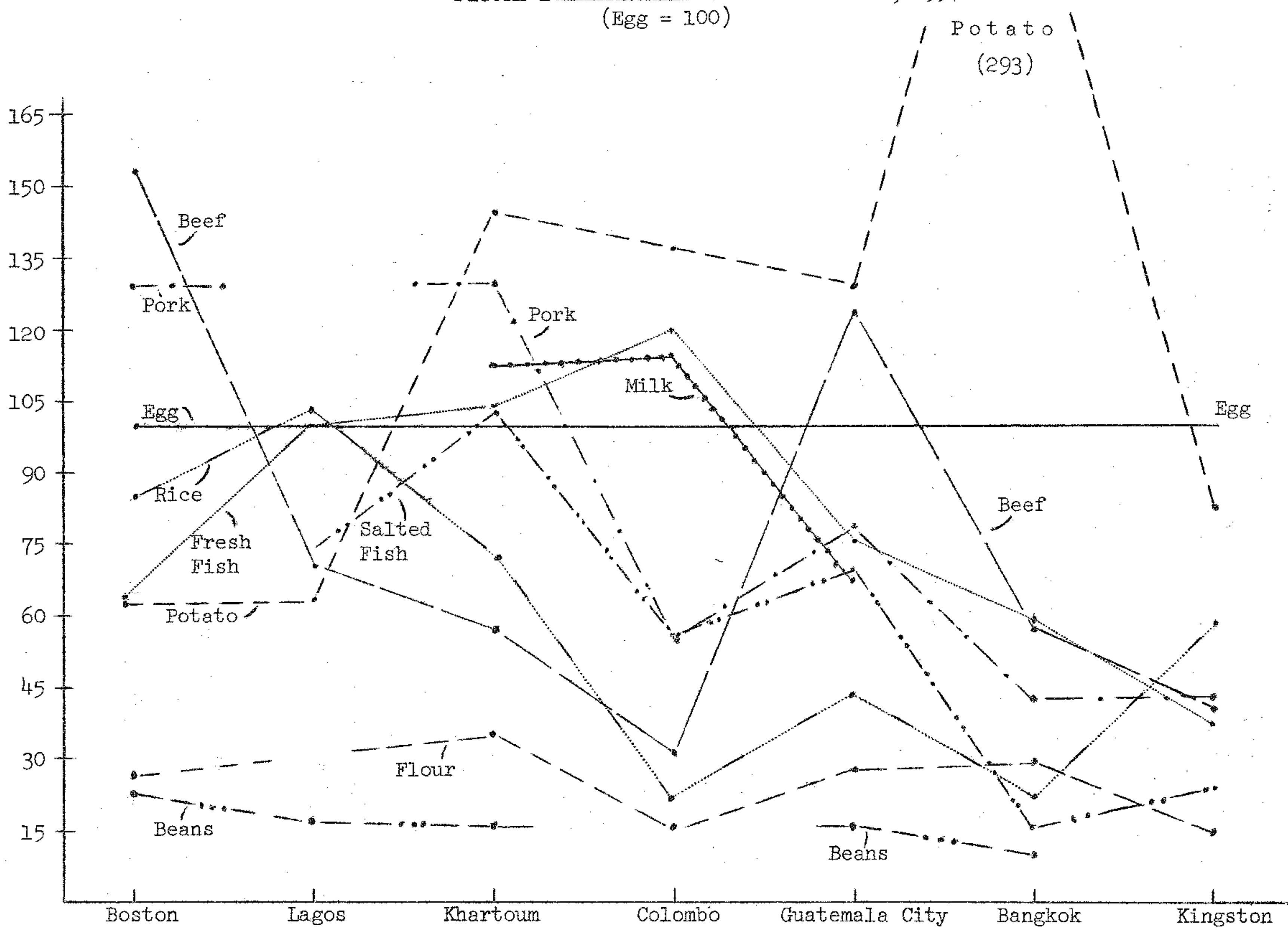
TABLE 12. PROTEX VALUES

	Boston	Lagos	Khar-toum	Colombo	Guatemala City	Bangkok	Kingston
Flour	1.5	-	16.8	27.9	22.8	43.0	8.7
Rice	4.7	64.3	35.0	38.4	35.8	31.4	32.4
Beef	8.6	44.6	27.4	53.5	100.9	81.4	23.3
Pork	7.4	-	62.6	87.9	63.8	61.6	24.9
Fresh fish	3.6	62.5	50.0	208.8	61.9	83.7	21.7
Salted fish	-	46.4	49.1	90.7	56.2	23.3	10.7
Milk	5.5	-	53.8	197.7	55.4	-	33.1
Eggs	5.6	62.5	48.2	173.9	81.4	141.9	56.7
Beans	1.3	10.7	7.9	-	13.3	13.9	-
Potatoes	3.6	39.3	70.0	196.5	104.8	415.1	46.2

TABLE 13. COST PER GRAM PROTEIN INDICES
(Eggs = 100)

	Boston	Lagos	Khar-toum	Colombo	Guatemala City	Bangkok	Kingston
Flour	27	-	35	16	28	30	15
Rice	84	103	73	22	44	22	57
Beef	153	71	57	31	124	57	41
Pork	130	-	130	51	78	43	44
Fresh fish	65	100	104	120	76	59	38
Salted fish	-	74	102	52	69	16	19
Milk	97	-	112	114	68	-	58
Eggs	100	100	100	100	100	100	100
Beans	23	17	16	-	16	10	-
Potatoes	63	63	145	113	129	293	82

FIGURE 1 HIERARCHIES OF PROTEIN COST, 1957
(Egg = 100)



Flour in general, supplies cheaper protein than rice. The exception in the tabulated data was Bangkok, a city in a rice exporting country. Since rice has less protein than wheat per unit weight, a lower protein cost for rice reflects a very low retail price. Flour in all but one case supplied cheaper protein than products of animal origin. The exception was again Bangkok where salted fish was cheaper.

Beef and pork in the U.S.A. were the most expensive protein sources, with beef the highest. Khartoum was interesting in that pork was much higher than egg protein, but beef much lower, a reflection doubtless of its Muslim character. Guatemala City represented an opposite situation where beef was more expensive than egg protein, but pork cheaper. Colombo, Bangkok and Kingston were locations where egg protein was generally twice as expensive as pork or beef.

Salted fish was a cheaper protein source than fresh fish in all cases, and in Bangkok and Kingston was very cheap compared to egg protein.

Potatoes fell within normal ranges in all locations except Bangkok. There it obviously was so scarce it does not represent something a bricklayer would have access to.

What can be drawn from this hierarchal arrangement? First, that beans were generally the cheapest protein source, with the location's main cereal staple, in this exercise rice or wheat flour, being next cheapest. Second, that animal products were generally most expensive, with salted fish in most locations being the cheapest animal protein source. The particular arrangement of animal products themselves was entirely a local phenomena.

"Effort Cost" of Protein

The value which is called "Protex" is simply a value which reflects the earning and purchasing power of a bricklayer, in this case relative to protein.

Summarized in Table 12, these values are helpful because they allow for comparisons to be made from location to location. An example would be between the "real cost" of beef in Guatemala City and Khartoum. One-hundred vs. 27 means that the effort needed to buy beef in Guatemala City was almost four times that in Khartoum. One-hundred vs. 9 in Boston, on the other hand, indicates that Boston's bricklayers can buy beef with one-tenth the effort a bricklayer in Guatemala City must expend.

Another and perhaps easier way to grasp these comparisons is to convert Protex values into minutes of labor required to purchase twenty-five grams protein. This is done in Table 14 and Figure 2.

Several things are apparent in Figure 2. Boston enjoyed a much lower effort cost for protein compared to the other locations. For most items the cost appears to be roughly ten times greater elsewhere. Beef is an exception, being on the order of three to six times more expensive elsewhere.

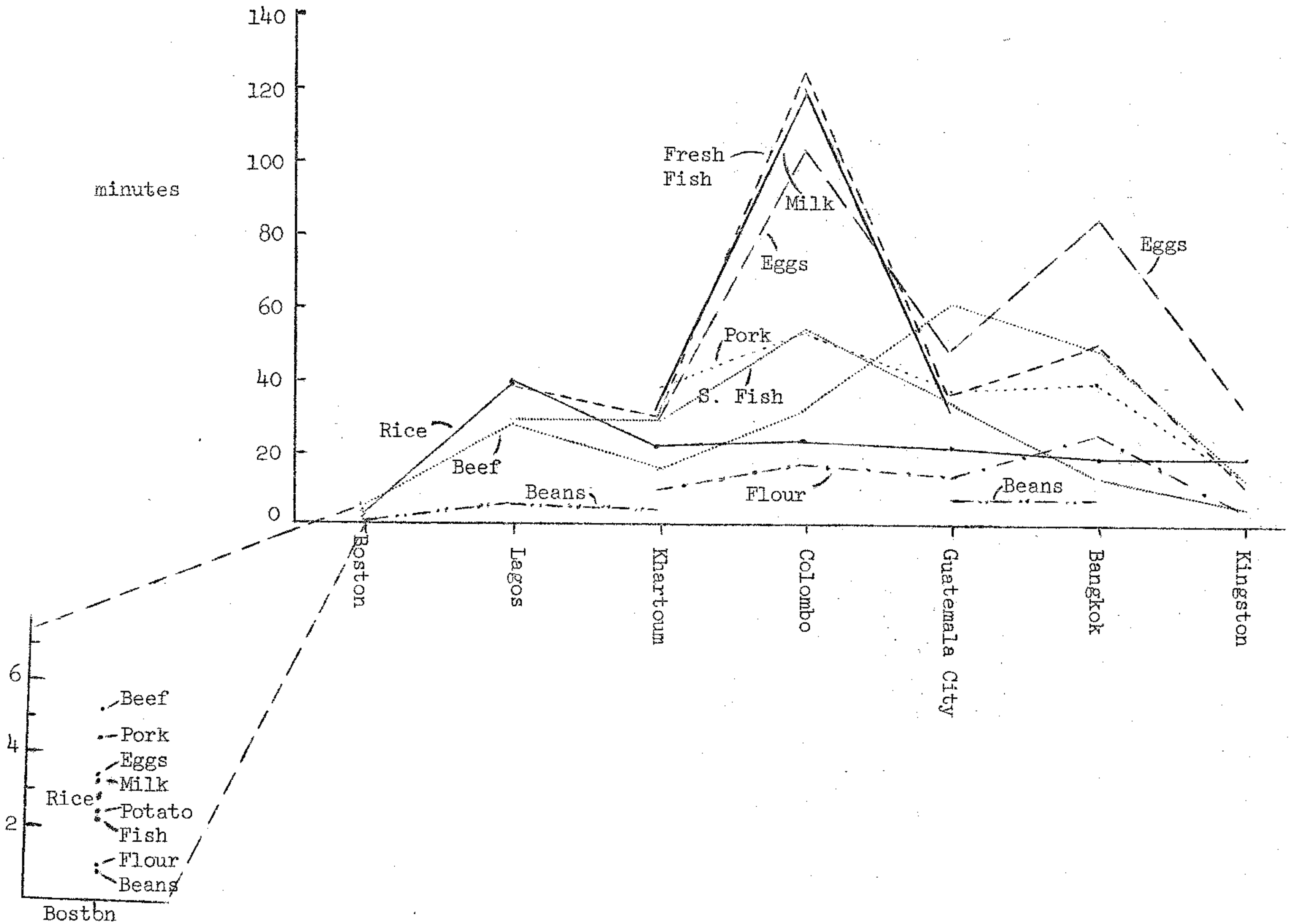
Rice in Khartoum, Colombo, Guatemala City, Bangkok, and Kingston appears to have cost just about the same amount, roughly seven times the number of minutes[1/] in Boston.

1/ The relationships illustrated in Figure 2 apply equally well if one is interested in speaking in terms of calories. This holds true as long as comparison is made between the same item from place to place. To illustrate, flour is used in an example. A bricklayer in Boston labored 0.9 minutes which enabled him to purchase twenty-five grams protein supplied in flour. His counterpart in Colombo spent seventeen minutes enabling him to purchase twenty-five grams protein from the same source, in this case the retail price of flour was controlled (Table 8). In addition to the twenty-five grams protein supplied, X amount of calories are included. Since the total amount of wheat flour in both cases is the same, the calories supplied are equal. Thus, the one to seventeen relation applies to calories as well as proteins.

TABLE 14. MINUTES OF WORK REQUIRED TO PURCHASE TWENTY-FIVE GRAMS PROTEIN FROM SELECTED FOODS

	Boston	Lagos	Khar-toum	Colombo	Guatemala City	Bangkok	Kingston
Flour	0.9	-	10	17	14	26	5
Rice	2.8	39	21	23	21	19	19
Beef	5.2	27	16	32	61	49	14
Pork	4.4	-	38	53	38	40	15
Fresh fish	2.2	38	30	125	37	50	13
Salted fish	-	29	29	54	34	14	6
Milk	3.3	-	32	119	33	-	20
Eggs	3.4	38	29	104	49	85	34
Beans	0.8	6	5	-	8	8	-
Potatoes	2.2	24	42	118	63	249	28

FIGURE 2. MINUTES OF WORK REQUIRED TO PURCHASE TWENTY-FIVE GRAMS PROTEIN FROM SELECTED FOODS, 1957



Concluding Applications

Although, because the price and wage data used were for 1957, the absolute results will not apply today, the relative ranking would probably be similar. Again, in the case of rice the effort cost in developing countries is doubtless still many-fold that in Boston.

Specific conclusions can be drawn concerning food protein costs. Leguminous and cereal products supply protein most cheaply, facts which conventional wisdom portray. Animal products are the most expensive protein suppliers, ranking themselves according to local conditions.

It is suggested that this approach has considerable currency. Planners increasingly recognize that few food problems are national in scope, but limited to certain "problem" foods and population groups. Protein deficiencies among the poor are the prime example. The methodology outlined here offers a convenient tool for zeroing in on this. The relative costs of specific portein sources are easily identified and the critical importance of income (and employment) to adequate intake highlighted.

GENERAL NOTES TO TABLES 5-11

1. Percent Protein Values from Composition of Foods, Agricultural Handbook No. 8, ARS, USDA, 1963.

2. Food Prices from Yearbook of Labour Statistics, International Labour Office, Geneva, 1957.

3. Hourly Wage Rates from Yearbook of Labour Statistics, International Labour Office, Geneva, 1957.

4. Conversion of Milk Price:
   Price quoted in litres. Conversion to kilogram price based on the specific gravity of cow's milk. A value of 1.031 was used. Taken from Documenta Geigy - Scientific Tables, New York, 1959, page 228.

5. Conversion of Egg Prices:
   Price quoted per egg. Average egg size taken to be 57 grams. This value taken from Egg Grading Manual, Agricultural Handbook No. 75, USDA, 1964, page 61.

6. $\text{Protex} = \dfrac{\text{Price/25 g. protein}}{\text{Hourly wage}} \times 100$

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1. The World Food Problem, Vol. II, The White House, 1967.

2. B. L. Oser, "An Integrated Essential Amino Acid Index for Predicting the Biological Value of Proteins," in A. A. Albanese (ed.), Protein and Amino Acid Nutrition, Academic Press, Inc., New York, 1959, Chapter 10.

3. M. L. Scott, Personal Communication, 1972.

4. H. J. Almquist, Proteins and Amino Acids in Animal Nutrition, Fifth Edition, 1972.

5. I. L. O, Yearbook of Labour Statistics, Geneva, 1957.

6. "Salaries and Hours of Work in Government Service: An International Comparison," International Labour Review, Vol. 68, Oct.-Nov. 1953, pp. 407-418.

APPENDIX ESSENTIAL AMINO ACID INDICES AND BIOLOGICAL VALUES OF FOOD PROTEINS

Item Number and Description[a]	EAA Index[b]	Biological Value Predicted[c]	Biological Value Observed
Milk			
1. Cow, whole, nonfat, evaporated, or dry	88	84	90
3. Human	87	83	
Milk products			
5. Buttermilk	88	84	
6. Casein	88	84	72
7. Cheese, cheddar, other ripened cheese,[d] and processed cheese foods	86	82	
8. Cottage	86	82	
9. Cream cheese	82	77	
10. Lactalbumin	89	85	84
11. Whey, dried	69	61	
Eggs, chicken			
12. Whole, raw or dried	(100)	97	96
13. Whites, raw or dried	95	92	93
14. Yolks, raw or dried	93	89	
Meat			
15. Beef cuts,[e] fresh or canned	84	80	76
16. Lamb cuts,[e] fresh or canned	84	78	
17. Pork cuts: fresh pork,[e] raw or canned	83	79	
20. Ham and other cured pork, raw, cooked, or canned	81	77	
22. Veal cuts, fresh or canned	83	79	
Poultry			
23. Chicken, muscle without skin	82	78	
24. Duck, muscle without skin	82	78	

(continued . . .)

APPENDIX (continued)

Fish and shellfish			
26. Fish, raw or canned	80	76	85
27. Shellfish, shrimp, including prawns, raw or canned	67	61	
28. Other shellfish	76	71	
29. Brains	85	81	
31. Fish flour	77	73	
32. Gelatin	25	16	25
33. Gizzard, chicken	75	70	
34. Heart	86	82	74
35. Kidney	86	82	77
36. Liver	89	85	77
41. Sausage containing liver	83	78	
42. Other sausage	77	72	
43. Tongue, fresh or smoked	82	77	
Legume seeds and their products			
Beans, includes kidney, navy, pinto, red, others			
45. Raw	80	75	
46. Baked with pork, canned	73	68	
47. Baked with tomato sauce, canned	65	60	
48. Black gram (*Phaseolus mungo*)	80	76	
49. Broad beans (*Vicia faba*)	70	65	
50. Chickpeas (*Cicer arietinum*)	77	72	
51. Cowpeas (*Vigna* spp.)	79	74	
53. Lentils (*Lens culinaris*)	71	65	
54. Lima beans (*Phaseolus lunatus*)	78	74	
57. Mung beans (*Phaseolus aureus*)	70	65	
58. Peanuts, flour, meal, peanut butter (*Arachis hypogaea*)	69	64	57
59. Peas (*Pisum sativum*)	81	77	
61. Soybeans and flour (*Glycine max*)	83	78	75
63. Soybean milk	86	82	

(continued . . .)

APPENDIX (continued)

Common nuts			
65. Almonds (Prunus amygdalus)	64	58	
66. Brazil nuts (Bertholletia excelsa)	69	64	
67. Cashews (Anacardium occidentale)	64	58	
68. Coconut and other palm family nuts and meals[f]	68	63	
69. Filberts (Corylus spp.)	68	62	
70. Pecans (Carya illinoensis)	76	71	
71. Walnuts, English or Persian (Juglans regia)	70	65	
Seeds and seed meals			
78. Cottonseed flour and meal (Gossypium spp.)	72	67	64
83. Sesame seed and seed meal (Sesamum indicum)	73	68	71
84. Sunflower seed meal (Helianthus annuus)	71	66	65
Grains and their products			
85. Barley (Hordeum vulgare)	66	60	
86. Bread: white made with refined wheat flour and 4% nonfat dry milk, flour basis	64	58	
88. Buckwheat flour (Fagopyrum esculentum)	73	68	
93. Corn, cornmeal, grits (Zea mays)	67	61	62
Corn products			
94. Flakes	60	54	
95. Germ	73	67	78
96. Gluten	63	57	
97. Hominy	68	62	
100. Tortilla	66	60	
101. Zein	31	22	
105. Pearl millet (Pennisetum glaucum)	75	70	
107. Oats, oatmeal, rolled oats (Avena sativa)	72	67	65

(continued . . .)

APPENDIX (continued)

109. Rice (*Oryza sativa*): brown, converted, white	73	68	70
112. Rye (*Secale cereale*), whole grain, and flours of different extractions	68	62	
113. Sorghum (*Sorghum vulgare*)	70	65	
115. Wheat (*Triticum aestivum*): whole grain and whole grain flour	64	58	67
117. White flour	61	54	52
Wheat products			
118. Bran	71	66	
122. Germ	74	69	75
123. Gluten	60	54	
124. Macaroni or spaghetti	55	48	
125. Noodles (contain egg solids)	67	61	
126. Shredded wheat	65	59	
Vegetables: immature seeds			
146. Corn (*Zea mays*)	72	66	
147. Cowpeas (*Vigna* spp.)	79	74	
148. Lima beans, large and small seeded varieties (*Phaseolus lunatus* including var. *macrocarpus*)	84	79	
149. Peas, raw or canned (*Pisum sativum*)	64	58	
Leafy vegetables			
152. Brussels sprouts (*Brassica oleracea* var. *gemmifera*)	64	58	
153. Cabbage (*Brassica oleracea* var. *capitata*)	56	49	
157. Kale (*Brassica oleracea* var. *acephala*)	61	54	
161. Spinach (*Spinacia oleracea*)	82	77	
162. Turnip greens (*Brassica rapa*)	76	71	

(continued . . .)

APPENDIX (continued)

Starchy roots and tubers			
165.	Cassava, root and flour (Manihot esculenta)	54	47
166.	Potatoes (Solanum tuberosum)	65	59
167.	Sweet potatoes (Ipomoea batatas)	82	78
168.	Taro (Colocasia spp.)	81	76
Other vegetables			
171.	Asparagus (Asparagus officinalis)	62	56
172.	Beans, snap (Phaseolus vulgaris)	66	60
173.	Beets (Beta vulgaris)	39	31
174.	Broccoli (Brassica oleracea var. botrytis)	66	60
175.	Carrots (Daucus carota)	59	52
176.	Cauliflower (Brassica oleracea var. botrytis)	73	68
182.	Eggplant (Solanum melongena)	57	50
186.	Okra (Hibiscus esculentus)	65	59
190.	Pumpkin (Cucurbita pepo)	54	47
195.	Tomatoes and cherry tomatoes (Lycopersicon esculentum and L. esculentum cerasiforme)	48	41
Miscellaneous food items			
199.	Yeast: Baker's	80	76
200.	Yeast: Brewer's, dried	83	79
201.	Yeast: Primary, dried (Saccharomyces cerevisiae)	82	77
202.	Torula yeast (Torulopsis utilis)	88	85

a/ As listed by Orr and Watt (1957).

b/ Computed from data of Orr and Watt (1957), cf. Table III, column (f).

c/ BV = 1.09 (EAA) - 11.73. See page 288.

(continued . . .)

APPENDIX (footnotes continued)

d/ Includes such kinds as Blue, Limburger, and Swiss.

e/ Based on data from many cuts.

f/ Including coconut (*Cocos nucifera*), babassu (*Orbignya speciosa*), palm cohune (*Orbignya cohune*), and palm nut (*Elaeis guineensis*).