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**Abstract**

*Agricultural producers and food marketers are increasingly responding to environmentally friendly cues from consumers even though privately appropriated values associated with a range of food products commonly rank above their public-good counterparts. Wine can be considered an ideal product to examine these issues given consumers' highly subjective sensory preferences towards wine, and a winegrape production process that is relatively intensive in chemical inputs for the control of disease and infection. Semi-dry Riesling wines made from field research trials following environmentally friendly canopy management practices were utilized in a lab experiment to better understand preferences for environmental attributes in wines. A combined sensory and monetary evaluation framework explicitly considered asymmetric order effects. Empirical results revealed that sensory effects dominate extrinsic environmental attributes. Once consumer willingness-to-pay (WTP) was conditioned on a wine's sensory attributes, the addition of environmentally friendly information did not affect their WTP; however, adding sensory information significantly influenced WTP initially based only on environmental attributes. The results confirm that promoting environmentally friendly winegrape production practices would increase demand and lead to higher premiums for the products, but are only sustainable if consumers' sensory expectations are met on quality.*

**Key words**: *environmentally friendly, lab experiment, sensory, wine, willingness to pay*

**JEL classifications**: C9, C24, M31, Q13

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## 1. Introduction

Food producers are responding to consumer perceptions of environmental sustainability and their growing awareness of the use of agricultural chemicals by creating new marketing opportunities for products grown with environmentally sound practices (Loureiro *et al*., 2002). The wine industry is no exception, where consumer demands are encouraging the investigation and adoption of alternative practices that can reduce the reliance on chemicals and promote more environmentally friendly products (Loureiro, 2003; Bazoche *et al*., 2008). Still, most studies have shown that privately appropriated values rank above public-good values for a range of food products (Lusk and Briggerman, 2009; Constanigro *et al*., 2011).

Private values, such as for intrinsic sensory attributes, have been shown to importantly affect consumers' perception of a product (e.g., Melton *et al*., 1996; Cardebat and Fiquet, 2004; Yang *et al*., 2009; Combris *et al*., 2009; Gustafson *et al*., 2011). However, some studies that combine objective and subjective cues do not find sensory characteristics to be significant (e.g., Combris *et al*., 1997; Lecocq and Visser, 2006), and that differential results may depend on the order information is received by consumers. Brennan and Kuri (2002) find that preferences for organic products are unlikely to change once first developed based on their sensory characteristics. In contrast, for wines, Lecocq *et al*. (2005) find that after tasting, information about the wines' characteristics and opinions from experts substantially affected consumers' willingness to pay (WTP), but that the reverse was not true; i.e., after receiving the same wine information initially, the taste of the wines did not have any additional impact on WTP.

Both sensory and economic factors matter to consumers and both are important for the development of informed food marketing strategies (Combris *et al*., 2009; Durham, 2010). We consider these inter-related factors by combining sensory and monetary valuations in the context of environmentally friendly wines. We use experimental auctions to elicit WTP bids from participants and explicitly estimate consumer premiums based on sensory (i.e., taste, smell, etc.) and objective (i.e., environmentally friendly production practices) characteristics. The data collected provide us with a unique opportunity to study the role and timing of sensory (an experience good attribute) and objective (a credence good attribute) information for wines that should contribute to a better understanding of beneficial marketing strategies.

Our experimental framework builds upon wine studies developed by Bazoche *et al*. (2008) and Gustafson *et al*. (2011) that consider multiple rounds of bidding with differences in information presented across rounds.[1] Bazoche *et al*. (2008) consider whether there is a consumer premium for environmentally friendly wines among French wine consumers and how the source of delivery of that information affects consumer values. Average WTP increased following blind sensory evaluation when label information on the wines' environmental characteristics was introduced, but the value depended on who conveyed that information (e.g., a public authority or

[1] Lecocq *et al*. (2005) estimate differential effects of taste and information by contrasting the distributions of bids across subjects assigned to different treatment groups based on the information received; i.e., product information only, tasting only, and product information and tasting. In all treatment groups, only one round of bidding was used following the exposure to information.

a collaborating retailer). Gustafson *et al*. (2011) incorporate objective and sensory valuations in a multiple (nine) round experimental setting and show that introduction of a wine's intrinsic sensory characteristics influences the valuation of a wine's previously known objective characteristics. In both studies, the order of the types of information received remained the same across experimental sessions. We contribute to the literature by explicitly considering asymmetric order effects of objective and subjective information.

This paper also contributes to the growing literature on consumer valuation of attributes for reducing environmental damages that focus on eco-labeling or eco-marketing strategies (e.g., Teisl *et al*., 1999; Blend and Van Ravenswaay, 1999; Wessells *et al*., 1999; Loureiro *et al*., 2001; Loureiro *et al*., 2002; Huffman *et al*., 2003; Costanigro *et al*., 2012). Eco-labels can provide easily interpretable information and elicit increased demand among some consumers for the products based on their perceived environmental benefits (Delmas and Grant, 2010). An increasing trend towards the use of eco-labels suggests that consumers can be induced to differentiate between products purely based on their production processes, even if they do not ultimately lead to any discernible physical differences between the final products (Foster and Mourato, 2000). However, the order and type of information received can result in asymmetric effects on environmental attribute valuations (Costanigro *et al*., 2012).

Generally, studies find that eco-labels increase consumers' WTP, but vary across types of products, consumer characteristics, and forms of marketing practices (McCluskey *et al*., 2009). For wine, Barber, *et al*. (2009) show that the level of a consumers' environmental knowledge influences their willingness to purchase more environmentally friendly products, while Molla-Bauza *et al*. (2005) find consumers with more healthy life styles will pay higher prices for organic products. In a survey of consumers in Colorado, Loureiro (2003) estimated that relative to regular Colorado wines, environmentally friendly wines receive a small premium, between 4 and 17 cents per bottle. Delmas and Grant (2010) find that eco-labeling has a negative impact on prices for organic California wines, although there is a price premium associated with eco-certification. Their findings support industry sentiment that consumers stigmatize (labeled) organic wine as an inferior product, and that eco-certification confers benefits more broadly (e.g., reputation effects and associations for the wineries themselves) that are not directly associated in the consumers' decision with specific environmental practices.

Finally, we contribute to the literature by considering these effects for new wines that are not currently commercially available. Predicting consumer demand for new food products is arguably incomplete without incorporating both sensory and monetary valuations (Melton, *et al*., 1996; Feldkamp, *et al*., 2005). While existing commercial wines may be more familiar to or accepted by consumers, examining new wine products provides necessary information to winegrape growers and vintners considering the adoption of alternative production practices and development of related product marketing strategies. This is particularly salient when the new products have characteristics that are multi-dimensional in nature; i.e., with inherent sensory quality (private) and environmental (public) characteristics.

As part of a larger project, we utilize wines made from actual vineyard production trials in New York State following alternative canopy management (CM) production treatments. The wet, cool climate growing conditions in New York make winegrapes particularly susceptible to the development of fungal diseases if not properly managed. Dense and shaded canopies often require multiple applications of fungicides throughout the growing season to inhibit infection. As a result, the field research is examining alternative CM practices to develop more open canopies that improve air circulation and sun light exposure, and reduce fungal pressures and fungicide use. The CM practices are considered more environmentally friendly relative to standard industry practices and are expected to increase wine quality. Through the experimental design, we are able to assess both the quality and environmental dimensions for these potentially new wine products.

Our focus in this paper is on three principal research questions. First, we examine how perceived differences in a wine's sensory attributes affect consumer preferences for Riesling wines. This more standard sensory exercise is useful in designing further field trials and in developing marketing promotions for consumers that appeal to particular attribute qualities. Second, we examine what WTP premia exist for new wines considering both quality (intrinsic sensory attributes) and production (extrinsic environmental attributes) information. Our baseline analysis provides marginal WTP estimates that do not distinguish between valuations of the wines' objective and subjective attributes, but rather provide pooled (or average) WTP estimates of the different production practices. Finally, we examine explicitly how the order and type of information received influences WTP premia by estimating a nested model with group and round interaction effects. The experimental design explicitly accounts for order effects by assigning subjects to two different types of experimental sessions where the order of information received varies. Given a two round bidding procedure with the varying order treatments, we exploit the panel nature of the data and identify individual premium components, and how the addition of new information affects initial WTP values.

We continue with a brief discussion of the study design and auction mechanism used. This is followed by a review of the data collected and the empirical modeling approach. A discussion of the sensory valuation results is then presented before describing the WTP model results. We close with some summary conclusions and directions for future research.

## 2. Study Design

In this section, we briefly describe the vineyard field trials where the winegrapes were grown and managed, as well as the experimental auction and sensory framework.

### *2.1 Field Treatments*

While there is no universal definition for 'environmentally friendly' wine, we delineate wines based on the underlying grape production practices followed. Specifically, we utilize four semi-dry Riesling wines made from actual vineyard trials that followed alternative CM protocols during the 2009 growing season. The four field treatments and, consequently, the four wines used in the experiment are described as:

1. Control, no canopy management (*CON*): recommended industry practices for premium quality grape and wine production are followed;
2. Level 1 canopy management - shoot thinning (*ST*): recommended industry practices for premium quality grape and wine production are followed, along with shoot thinning early in the growing season to five shoots per canopy foot;

3. Level II canopy management – leaf removal (*LR*) - recommended industry practices for premium quality grape and wine production are followed, along with leaf removal in the fruit zone late in the growing season; and
4. Level III canopy management - shoot thinning and leaf removal (*STLR*) - recommended industry practices for premium quality grape and wine production are followed, along with shoot thinning and leaf removal practices as described above.

The grapes were grown and managed by professional staff at an established private vineyard in the Finger Lakes region of New York State, and neither the grapes nor the wines produced from them were organic. Professional staff made the wines from the field treatments using standard industry winemaking practices. To control for dryness, juices were adjusted to 22 Brix (sugar level) prior to fermentation across treatments, and finished wines were back-sweetened to semi-dry industry standards.

For grapegrowers, the primary costs associated with the CM practices are labor (manual and/or mechanized) and lost yields. However, lost yields from thinned shoots may be partially offset by larger sized grape clusters on the shoots that remain. Reduced photosynthesis capacity is the primary determinant of yield losses from leaf removal. Quality improvements are expected from the improved canopy climate and, perhaps, from lower yield pressures. The belief that low yielding grapevines produce higher quality wines has a foothold among wine critics in the popular press (Preszler, 2012), and grapevine yield restrictions have long been codified by law in the quality appellations of some European countries (Johnson and Robinson 2001).

### *2.2 Experimental Setting*

Subjects were recruited in the fall of 2010 through advertisements posted on campus and through listserv notices maintained by experimental lab staff. Given the auctioning of alcohol and consumption of alcoholic beverages, alcohol permits were obtained from the New York State Liquor Authority. Participants were at least 21 years of age and self-identified as regular white wine consumers; i.e., consume white wine at least once per month.

Subjects were randomly assigned to seats at individual computer terminals with dividers between terminals to ensure privacy and to eliminate visual influences from other participants. Each station also included water and crackers for cleansing the palate between wine tastings, and an expectorate container (participants were not required to swallow the wine). A maximum of 24 computer terminals were available per session, and the sessions ranged from 19 to 23 subjects. At the end of the experiment, subjects completed a survey about themselves and their wine consumption habits.

For the sensory portion of the experiment, participants completed tasting sheets where they were invited to write down comments about each of the wines and rate them on their perceived level of acidity, sweetness, fruitiness, and overall likability. The perceived level for each attribute was measured on a four-inch line scale with anchors at zero for “not at all” and four for “extremely high.” Subjects were asked to mark a line along the scale to indicate their response, which was later measured and converted to a numerical rating.

A computerized sealed-bid first-price English auction was used to elicit maximum WTP for the alternative wines presented. Elyakime *et al*. (1994) showed that the sealed-bid first-price auction is an incentive compatible method of eliciting WTP, and that the equilibrium strategy for a participant is to choose a reservation price equal to their private value. An additional advantage of the English auction is that it is relatively easy for subjects to understand (Kagel, 1995; Lusk, 2003).

After signing a consent form, participants were asked to read the instructions for the first part of the experiment that described general information and how to submit bids on the computer terminals.[2] The experiment administrator then gave a brief introduction of the rules of the experiment, which included the amount of money they would earn. Participants received $30 for completing the experiment that could be kept or used to spend on a bottle of wine introduced to them in one of several computerized auctions.[3] Participants were informed that they should submit their maximum WTP for a 750 ml bottle for each of several wines presented to them in a series of auctions and that only one of the wine auctions would be binding at the end of the experiment. For the binding auction, selected randomly, the highest bidder would buy the selected bottle of wine from their $30 participation payment. Since each wine auction was equally likely to be chosen, subjects were informed that it was in their best interest to bid their maximum WTP for each of the wines.[4] After answering questions from participants about the general nature of the experiment, a non-binding practice round was conducted with a pen to familiarize subjects with the computerized auction mechanism.

*2.3 Order Treatments*

Subjects were presented with four wine samples (one wine from each CM treatment) simultaneously at the beginning of the experiment via 1-oz samples in number coded ISO tasting glasses covered with watch glasses. Serving orders of the wines by CM treatment were randomized across panelists. After the practice round, subjects were given general information (written and verbal) about the wines and the grapes from which they were made (e.g., varietal, location of vineyard, how and where processed).

A total of 8 sessions were conducted. Figure 1 shows how the order of the information presented differed across two types of groups. In one-half of the sessions, participants submitted their first set of bids for the wines based on their sensory characteristics alone (hereafter referred to as Sensory First (SF) groups). The wine samples were placed on a simple paper template with numbered codes matching those on the glasses to maintain the original order of the wines as presented. After giving written and verbal sensory instructions, subjects were allowed to smell and taste each wine. They could taste wines more than once, but were instructed to cleanse their palate between tastings. Subjects were given 15 minutes to conduct their sensory evaluation and complete the tasting sheet provided. Subjects then submitted their maximum WTP for each wine through four sequential computerized sealed-bid auctions. In each auction, a bid clock was used

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[2] A copy of the instructions and information provided are available upon request from the corresponding author.

[3] An endowment of $30 was selected based on a review a Riesling prices from numerous wineries in the Finger Lakes. Most Riesling wines sold for between $10 and $20 per bottle; however, some reserve or special vintages were priced around $30.

[4] In addition to cost considerations, limited quantities of wine from the field trials also precluded the sale of more than one bottle of wine per session.

starting at $0.00 per bottle and increased by $0.25 every second with a maximum bid of $30 per bottle. Participants were allowed to refer to their tasting sheets. The auctions proceeded from the subject's left to right for each of the wines presented. Since the wines were in random order across subjects, the computer program sorted the bids to determine the highest bid for each wine and round.

In the third part of the experiment for the SF groups, detailed grape production information and disease protection efforts in the Finger Lakes Region were presented (Figure 1). Pictures of winegrape canopies with excessive vigor and common fungal diseases (i.e., botrytis, powdery mildew) were highlighted to illustrate problems associated with dense and shaded canopies. Subjects were informed that university research indicates that disease management can be enhanced by using CM practices that include shoot thinning and leaf removal. It was noted that CM practices are considered more environmentally friendly since they decrease the duration of wetness events and improve the penetration and efficacy of chemical applications, which should reduce total fungicide use and improve fruit composition and quality. Pictures were also shown illustrating the CM practices. Subjects were subsequently informed that the wines tasted in the previous part of the experiment were made from Riesling grapes produced under the four alternative CM practices and that winegrape growers and vintners can promote the use of these practices through a variety of marketing mechanisms. An example illustrating this information was distributed to participants that resembled the original wine order (numbered) template, but now with detailed information on the CM practices employed. An example template is provided in Figure 2. After reviewing the additional information, a second round of (four) wine auctions were completed, but now considering both types of information received (sensory and production).[5]

In the other four sessions, participants submitted their first set of bids based on the detailed CM information alone (hereafter referred to as Information First (IF) groups) before doing the sensory evaluation. Subjects were first provided with the detailed production and disease management information as described above, along with wine templates that contained the detailed CM information for each wine sample (Figure 2). After presentation of the information (written and verbal), subjects submitted their bids for each wine through four sequential computerized auctions. The sensory portion of the experiment followed for the IF groups, where participants completed tasting sheets and submitted their WTP bids in the computerized auctions considering both sets of information (production and sensory).

After completing both sets of wine auctions, one participant in each session was randomly chosen to draw one of eight labeled balls from a bag; there was one ball for each wine type (4) and round of bidding (2). The person with the maximum bid for the selected wine and round combination purchased a bottle of that wine from their $30 payment. Participants received their compensation after completing a survey about themselves and their wine consumption habits.[6]

[5] Participants were not allowed to taste or smell the wines again in this part of the experiment.
[6] A copy of the participant survey is available upon request from the corresponding author.

## 3. Data

A total of 169 subjects participated in the experimental sessions and were included in the final dataset; the data includes 86 subjects from SF groups and 83 from IF groups.[7] With eight observations per subject (4 wines, 2 rounds), the full dataset includes 1,352 observations. Table 1 provides a summary of selected demographic characteristics. There was considerable variation in participant age (*AGE*) and income (*INCOME*) levels. About 40% of the participants were male (*MALE*), 50% were students (*STUDENT*, primarily graduate students), and 46% were married (*MARRIED*). The average participant has spent about 44% of his/her life living in New York State (*NYYEARSP*). About 45% of the participants were strongly concerned about environmental protection efforts and activities related to the production of agricultural products (*ENVIRONC*), and 85% drank white wine, on average, more than once per month (*FREQWWINE*).

Table 2 describes participants' wine drinking and spending patterns, differentiated by white wine type. For all of the white wine categories, the most common drinking frequency was one to three times per month. As expected, there is a clear shift in the distribution towards lower consumption frequencies as the wine category is narrowed to the Riesling category, and then to the New York State Riesling category. In fact, 4.1% and 8.9% of participants had never drunk Riesling or New York State Riesling wines, respectively.

The range of $10 to $15 was the most typical range for a 750 ml bottle of white wine among subjects (lower portion of Table 2). While there is some indication that a higher percentage of participants would pay more for Riesling wines, there were also higher percentages of participants that had never actually purchased those types of wines previously, including almost 15% for any Riesling and nearly 21% for Rieslings from New York State. Taking the midpoints of the spending categories and valuing the lowest (highest) categories at $5 ($35), would imply an average spending per bottle of $11.20, $11.50, and $10.00 for White, Riesling, and New York State Riesling, respectively.

Table 3 provides a summary of the sensory attribute evaluations across all participants; i.e., tasting sheet information from round 1 in the SF groups and round 2 in the IF groups. On average, subjects liked the CM wines more, and found them less acidic and more fruity than the control. Perceived levels of sweetness intensity showed lower levels of differences in means, but the result is not surprising given that sugar levels of the juices and wines across treatments were equalized before and after the fermentation process. Mean likability and WTP levels are similar in a relative sense for the *ST* and *STLR* wines compared to the control, but the *LR* wine was discounted more prominently on WTP. The comparison is not straightforward, however, as the likability assessments were to be based on only the wines' sensory characteristics, while the WTP data for the IF groups may also reflect the CM information.

Average WTP bids for the experimental wines were much lower (i.e., around six dollars per bottle, Table 3) than what participants said they typically spent on a bottle of Riesling (Table 2). The lower values of bids, on average, are likely the result of using new wines not available commercially or familiar to the subjects. While the wines were made using standard industry practices, "university-made" wines may exhibit a downward bias in value amongst participants

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[7] Three subjects were removed since their response to a survey question on frequency of white wine consumption was 'Never'.

relative to existing commercial wines. As we are interested in the relative prices across treatments and, in particular, in the CM wines relative to the control, we do not think this will influence the relative results across wines.

Differences in information order effects were examined initially by comparing differences in mean WTP by wine treatment and round number and distinguished by order group (Table 4). WTP values for the CM treatment wines are higher, on average, for the IF groups in both rounds. All CM wines averaged $6.54 per bottle in round one for the IF groups, relative to only $6.14 for the SF groups. Furthermore, CM wine bids were higher, on average, than the control (non CM) wine in the IF groups, but lower in the SF groups. Next, consider the changes in WTP in round two. Changes are higher (in absolute value), on average, for the IF groups. Specifically, round two bids drop $0.30 per bottle on average for the CM wines in the IF groups (added sensory), compared to a $0.02 drop, on average, for the SF groups (added CM information).

## 4. Empirical Models

### *4.1 Sensory Model*

Ordinary least squares (OLS) regression was used in the sensory models to examine consumer preferences for the wines based on their perceived levels of acidity, sweetness, and fruitiness. The regression models do not distinguish on the production type of wine, but rather on their explicit sensory characteristics as perceived by the subjects. Accordingly, individual subject rankings of ‘likability’ were regressed on the three sensory attributes, including quadratic and interaction terms to allow for nonlinear responses.[8] The sensory models can be expressed as:

$$LIKE_{ij} = \alpha + \sum_k \beta_k S_{ij,k} + \sum_k \gamma_k S_{ij,k}^2 + \sum_k \sum_l \delta_{k,l} S_{ij,k} S_{ij,l} + e_{ij} \quad (k \neq l)\ , \qquad (1)$$

where $LIKE_{ij}$ is the likability ranking of wine $j$ by subject $i$, $S_{ij,k}$ are the intensity rankings for sensory attribute $k$ (i.e., acidity, sweetness, or fruitiness) by subject $i$ for wine $j$, $S_{ij,k}^2$ are the squared rankings, $S_{ij,k}S_{ij,l}$ are interaction variables between the sensory attributes $k$ and $l$ ($k \neq l$), and $e_{ij}$ is a random disturbance term distributed N(0,σ).

### *4.2 WTP Models*

Two-limit Tobit models (i.e., at $0 and $30) were estimated for the WTP models. Tobit models are commonly adopted for estimating WTP when the dependent variable is not binary and has a large number of bids at the limit (Lusk *et al*., 2004). Furthermore, Tobit models have been widely used to study consumer response to new food products or labels (e.g., Drichoutis *et al*., 2009; Kanter *et al*., 2009). A random effects model framework was used to account for the panel nature of the data; i.e., each subject submitted multiple bids for different wines in multiple rounds. The Tobit model, incorporating random effects is:

$$\begin{aligned} WTP_{jtim}^* &= \alpha + \boldsymbol{\beta} W_j + \boldsymbol{\gamma} W_j G_m + \delta R_t + \theta R_t G_j + \boldsymbol{\varphi}\mathbf{X}_i + e_{jtim} + u_i \\ WTP_{jtim} &= max\left[0, WTP_{jtim}^*\right]\ , \end{aligned} \qquad (2)$$

[8] The dependent variable is, by definition, bounded on [0,4]; however, only 3% of the responses were given at either of the bounds. As such, OLS was deemed sufficient. Estimated Tobit models demonstrated very similar results.

where $WTP^{*}_{ktij}$ is the latent value of WTP for wine type *j* in round *t* for subject *i* in group *m*, expressed as a function of wine type $W_j$, group type $G_m$, round $R_t$, and demographic characteristics $\mathbf{X}_i$. The vector of parameters describing the effects for specific CM treatments (relative to the control wine) is $\boldsymbol{\beta}, \boldsymbol{\gamma}$ is a vector of parameters describing the interaction effects between wines and groups (relative to the control wine and the SF group), $\delta$ is a parameter describing the effect of round 2 (relative to round 1), $\theta$ is a parameter describing the interaction effect between round and group (relative to round 1 and the SF group), and $\boldsymbol{\varphi}$ is a vector of parameters describing the effect of demographic characteristics. The individual specific disturbance term for subject *i* is $u_i$ and $e_{jtim}$ is the overall error term distributed N(0, $\sigma_e$ ). Likelihood-ratio tests are completed to compare the random effects model with the standard (pooled) tobit model.

## 5. Empirical Results

### *5.1 Sensory Models*

Understanding consumer preferences for sensory attributes in wines is important to growers and vintners in managing varieties and developing wines that match consumer preferences for particular characteristics. Communicating the levels or predominance of important sensory attributes is common practice by marketers when promoting their wine products. The sensory portion of the experiment provided data to estimate these effects in the Riesling wines produced from field trials. Given that the timing of the sensory exercise varied across the SF and IF groups, sensory data were used from round one in the SF groups and round two in the IF groups. While the CM information presented to the IF groups in round 1 could influence the subject's likability of the wines in round two, subjects were instructed to complete the tasting sheet based only on their sensory evaluation of the alternative wines.

Table 5 shows the results of the OLS sensory model regressing subject likability of wines on their perceived sensory attributes.[9] The attributes used (i.e., acidity, sweetness, and fruitiness) would appear to be distinct in their interpretation given that none of the interaction effects were statistically different from zero. For example, preference for the level of a wine's fruitiness is not affected by the level of sweetness or acidity.

Estimates for *ACIDITY* were positive on the level term and negative on the quadratic term, implying higher levels of acidity were associated with higher likability, but at a decreasing rate. The relative magnitude of the parameters is used to determine the level of acidity where likability is maximized, holding all else constant. The estimated parameters indicate a maximum likability rating at a perceived acidity level of 1.6.[10] Given that the ranking scale was from zero to four, this would indicate that consumers in our sample prefer a relatively limited amount of acidity in semi-dry Riesling wines.

As expected, *SWEETNESS* was not significant. Recalling that the juices and wines were equalized on sugar content before and after fermentation, less variation in sweetness across

[9] For ease of exposition, including demographic variables identical to those in the WTP regressions was also considered in the sensory model; however, *F*-tests on the null hypothesis that all demographic variable effects were zero could not be rejected at any reasonable significance level.

[10] The maximum is found by taking the first derivative of the sensory equation with respect to *ACIDITY*, setting it equal to zero, and solving; i.e., $ACIDITY_{max}$ = 0.449/(2*.144). Insignificant interaction effects were ignored.

wines likely drove this result. The level term for *FRUITINESS* was positive and significant, but the quadratic term was not. This indicates a strong preference for fruity flavors and aromas in the Riesling wines.

*5.2 WTP Models*

While the sensory characteristic results provide useful information on consumer preferences for wine attributes, they do not provide a monetary valuation of the wine's overall sensory characteristics or allow for changes in valuation based on other attributes. The WTP models are used to assess this additional information (Table 6). Four alternative specifications were considered, each with the same set of demographic variables identified *a priori* as potentially important determinants of a subject's WTP for the Riesling wines. In all cases, likelihood ratio tests reject the standard tobit model ($\sigma_u = 0$) at the 1% significance level.[11] Models 1 and 2 include both order groups, while Models 3a and 3b are the non-nested versions of Model 2 when considering the different order groups in isolation.

Focusing on Models 1 and 2, most demographic effects were not significant; however males (*MALE*), subjects with a strong concern for environmental protection efforts in agriculture (*ENVIRONC*), and subjects that frequently drank white wine (*FREQWWINE*) tended to pay more for the Riesling wines offered, all else held constant. Price premiums ranged from $1.18 per bottle for *MALE* to $2.23 per bottle for *FREQWWINE*.

Model 1 nests both order groups and includes marginal WTP estimates of the CM treatment wines relative to the control wine with no group or round interaction terms. Information and round effects are implicitly controlled for in the experimental design and, thus, Model 1 provides average (or pooled) CM treatment effects. In this case, subjects valued only the *LR* wine differently from the control wine. The pooled estimate for the *LR* wine showed a negative WTP premium relative to the control of nearly 54 cents per bottle, or a reduction of 8.5% (i.e., 0.54/6.32). In the pooled model, the determinants of that average effect – whether sensory evaluation or CM information or both - are indistinguishable, but a strong monetary disincentive is evident overall in the *LR* wine.

In Model 2 we exploit the panel nature of the data by estimating a nested tobit model that includes group interaction effects to explicitly identify the initial monetary values of subjective sensory and the objective environmental attributes. Round effects are incorporated to assess how the addition of different types of information change the product valuations. Models 3a and 3b are included for completeness and represent the non-nested variants of Model 2, where only the SF and IF group data are considered, respectively.

The first three coefficient estimates in Model 2 (i.e., for *ST*, *LR*, and *STLR*) represent marginal WTP estimates for the CM treatment wines based only on their combined sensory characteristics relative to the control for round one (Table 6). The CM treatment wines all show negative marginal effects, although only for the *LR* wine is the estimate significantly different from zero. The negative $0.91 per bottle premium translates into a 14% reduction in price relative to the average control wine bid of $6.69 (Table 4). Results from the experiment do not show improved sensory characteristics from the CM wines for these wine consumers. Furthermore, the round

[11] Chi-square test statistics were 847.29, 856.69, 386.83, and 416.76, respectively, for Models 1, 2, 3a and 3b.

two effect (*ROUND2*) was not significantly different from zero, indicating that the addition of the environmentally friendly CM information about the wines did not affect their original valuations.

It is not the case, however, that subjects were unwilling to pay for environmentally friendly practices in winegrape production in general. Indeed, the CM treatment-group interaction effects indicate just the opposite. Positive and significant marginal WTP values were estimated for all three CM wines and ranged from $0.78 per bottle for the *LR* wine to $1.31 per bottle for the *STLR* wine (CM wine and *IF_GROUP* interaction effects, Table 6), relative to the SF group in round one. The total premium effects of the CM wines based on environmental attributes are computed by summing the CM treatment and respective CM treatment-group interaction terms in Model 2 (e.g., *ST* + *ST*IF_GROUP*). In this case, the total WTP premiums for the environmentally friendly attributes are $0.86 ($p$-value = 0.014), -$0.13 ($p$-value = 0.703), and $0.83 ($p$-value=0.019) per bottle for the *ST*, *LR*, and *STLR* wines, respectively. Based on the average control wine bid of $6.22 (Table 4), these initial premiums are substantial for the *ST* and *STLR* wines, approximately 13% to 14%. However, surprisingly, the *LR* wine value did not differ significantly from the control wines based on the environmental information alone. This may be due to subjects devaluing the environmental benefits from leaf removal given that it was done later in the growing season and presupposing less of an overall influence on fungal disease control. Recall that shoot thinning was done early in the growing season. The difference may also be due to reductions in yields and the commensurate impacts on wine quality, where shoot thinning was likely considered more substantial to reducing vine yields.

Negative sensory responses to CM wines were also apparent when sensory valuation follows information on their environmental attributes. In particular, the round two effect for the IF groups was -0.528, indicating the WTP bids dropped, on average, $0.53 per bottle after sensory valuation. The combined influence of the environmentally friendly information and sensory evaluation is similar to those in the sensory first grouping. Specifically, total premium effects for the IF ordering (relative to the control wine) are $0.32 ($p$-value = 0.321), -$0.68 ($p$-value = 0.112), and $0.29 ($p$-value=0.502) per bottle for the *ST*, *LR*, and *STLR* wines, respectively.[12] The significant positive premiums for the *ST* and *STLR* wines based on the environmental attributes are distinguished with the addition of (negative) sensory feedback.

## 6. Conclusions and Implications

Growing consumer demands for environmentally friendly products are increasingly influencing agricultural production and food marketing strategies; however, both privately and publicly appropriated values influence consumers' WTP. Wine can be considered an ideal product to examine these issues given consumers' highly subjective sensory preferences towards wine, and given that winegrape production processes are relatively intensive in the use of chemical inputs for the control of disease and infection. Semi-dry Riesling wines made from actual field research trials following prescribed CM practices were utilized in an experimental laboratory setting to better understand preferences for environmentally friendly attributes incorporating sensory cues. The order of information received by subjects (i.e., sensory evaluation and environmental

[12] Total effects for the IF groups were estimated by summing the coefficients on treatment, round, and group interaction effects. For example, the estimated final premium for *ST* was *ST* + *ST*IF_GROUP* + *R2* + *R2*IF_GROUP*.

product information) varied across experimental groups to explicitly consider asymmetric order effects. Understanding potential WTP premiums for new wine products is essential information to winegrape growers considering the adoption of environmentally friendly production practices that face higher costs of production, as well as to the development of appropriate marketing strategies considering intrinsic sensory and extrinsic environmental cues.

In a standard sensory assessment, we found that our sample of regular white wine consumers clearly delineated their preferences for semi-dry Riesling wines based on the wines perceived levels of acidity and fruitiness. Moderate levels of acidity and strong fruity flavors and aromas were associated with increased likability of the wines. These types of characteristics are commonly used when describing and marketing wines – the empirical results here support those practices.

Furthermore, results from our laboratory experiment show that environmental friendly attributes were important to consumers, but improvements in wine quality based on sensory attributes alone were not apparent in the wines produced from the differing field treatments. Consistent with much of the recent literature, sensory factor effects dominated environmental attribute effects. WTP premiums of 13% to 14% were estimated for CM wines made following shoot thinning (*ST*) and shoot thinning/leaf removal (*STLR*) based on their environmental attributes alone. However, the addition of the wine's (negative) sensory characteristics eliminated the environmental premium effects. Furthermore, the wines' sensory attributes were not favorable to consumers initially and the introduction of environmentally friendly product information did not affect WTP bids. In other words, once conditioned on (negative) sensory valuations, the addition of environmental friendly attributes does not affect consumer valuations.

The sensory results would be strengthened with additional data that considers alternative site locations and vintages to eliminate any potential spatial and weather influences. In addition, the positive WTP premiums associated with the CM wines' environmentally friendly attributes should be compared with expected changes in production costs to better understand the economic implications for growers considering the adoption of CM practices, conditional on maintaining or improving wine quality. A careful examination of these issues is a top priority for our continuing research.

Overall, the realization of a wine's positive premiums for environmental attributes is realized only if consumers' sensory expectations are satisfied. The marketing implications are straightforward. It is expected that including environmentally friendly product information on wine labels and other marketing practices would increase demand and lead to higher premiums for the products. However, these premiums are sustainable only in the face of repeat purchases, implying that, after the initial purchase, a consumer's sensory expectations are met. For wine at least, quality matters and sensory evaluation trumps other extrinsic environmental factors. There appears to exist an opportunity for new products to be promoted as environmentally friendly; however we find evidence that for wine, products produced and marketed as environmentally friendly also need to meet consumer demand in sensory qualities. As a result, marketing food and beverages as environmentally-friendly remains one way to differentiate products, but such strategies need to be especially mindful of product quality issues.

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Table 1. Descriptive statistics for selected demographic variables (N=169).

| Variable | Description | Mean | Std Dev | Min | Max |
|---|---|---|---|---|---|
| *AGE* | Age in years | 31.79 | 12.54 | 21.00 | 71.00 |
| *INCOME* | Monthly income ($000) | 4.04 | 2.42 | 1.25 | 8.33 |
| *NYYEARSP* | Proportion of life lived in New York | 0.44 | 0.40 | 0.00 | 1.00 |
| *MALE* | Gender Male = 1, else 0 | 0.39 | 0.49 | 0.00 | 1.00 |
| *STUDENT* | Student Yes = 1, else 0 | 0.49 | 0.50 | 0.00 | 1.00 |
| *MARRIED* | Married Yes = 1, else 0 | 0.46 | 0.50 | 0.00 | 1.00 |
| *CHILDREN* | Children Yes = 1, else 0 | 0.21 | 0.41 | 0.00 | 1.00 |
| *ENVIRONC* | Strong concern for environmental protection efforts in agriculture Yes = 1, else 0 | 0.45 | 0.50 | 0.00 | 1.00 |
| *ASIAN* | Race Asian = 1, else 0 | 0.27 | 0.44 | 0.00 | 1.00 |
| *ORGANIC* | Prefer to consume organic Yes, else 0 | 0.46 | 0.50 | 0.00 | 1.00 |
| *FREQWWINE* | Consume white wine more than once per month, on average | 0.85 | 0.36 | 0.00 | 1.00 |

Table 2. Distributions of wine consumption and spending patterns by participants (N=169).

| Category | White (any) | Riesling | New York Riesling |
|---|---|---|---|
| Frequency of wine consumption (% of respondents by category): | | | |
| Daily | 1.2 | 0.0 | 0.0 |
| More than 1x/week | 13.0 | 6.5 | 4.7 |
| 1x/week | 24.9 | 7.1 | 5.3 |
| 1-3x/month | 46.1 | 39.6 | 30.8 |
| Less than 1x/month | 10.1 | 24.9 | 27.8 |
| A couple times per year | 4.7 | 17.7 | 22.5 |
| Never | 0.0 | 4.1 | 8.9 |
| Typically spend on a 750 ml bottle of wine (% of respondents by category): | | | |
| Less than $10 | 22.5 | 14.8 | 12.4 |
| $10 - $15 | 62.1 | 55.0 | 51.5 |
| $16 - $20 | 11.8 | 4.1 | 13.6 |
| $21 - $25 | 3.0 | 0.6 | 1.2 |
| $26 - $30 | 0.0 | 10.1 | 0.0 |
| More than $30 | 0.6 | 0.6 | 0.6 |
| Don’t buy | 0.0 | 14.8 | 20.7 |

Table 3. Summary statistics for sensory attributes and WTP.[a]

| CM Treatment | N | Mean | Std Dev | Min | Max |
|---|---|---|---|---|---|
| Sensory attributes: Scale 0 (low) to 4 (high) | | | | | |
| Like: | | | | | |
| *CON* | 166 | 2.00 | 0.99 | 0.00 | 4.00 |
| *ST* | 166 | 2.15 | 0.90 | 0.00 | 4.00 |
| *LR* | 166 | 2.04 | 0.89 | 0.00 | 4.00 |
| *STLR* | 166 | 2.17 | 0.92 | 0.00 | 4.00 |
| Acidity Intensity: | | | | | |
| *CON* | 169 | 2.07 | 0.90 | 0.00 | 4.00 |
| *ST* | 169 | 1.89 | 0.88 | 0.00 | 3.75 |
| *LR* | 169 | 1.91 | 0.89 | 0.00 | 4.00 |
| *STLR* | 169 | 1.88 | 0.92 | 0.00 | 4.00 |
| Sweetness Intensity: | | | | | |
| *CON* | 169 | 1.61 | 0.85 | 0.00 | 4.00 |
| *ST* | 169 | 1.69 | 0.81 | 0.00 | 4.00 |
| *LR* | 169 | 1.65 | 0.82 | 0.00 | 3.69 |
| *STLR* | 169 | 1.63 | 0.81 | 0.00 | 3.31 |
| Fruitiness Intensity: | | | | | |
| *CON* | 166 | 1.78 | 0.88 | 0.00 | 4.00 |
| *ST* | 166 | 1.87 | 0.80 | 0.00 | 4.00 |
| *LR* | 166 | 1.81 | 0.81 | 0.00 | 3.94 |
| *STLR* | 166 | 1.90 | 0.86 | 0.00 | 4.00 |
| WTP ($/bottle)[c] | | | | | |
| *CON* | 338 | 6.32 | 5.06 | 0.00 | 26.00 |
| *ST* | 338 | 6.47 | 4.81 | 0.00 | 22.50 |
| *LR* | 338 | 5.84 | 4.60 | 0.00 | 22.00 |
| *STLR* | 338 | 6.46 | 4.98 | 0.00 | 30.00 |

[a] Canopy management (CM) treatments are CON = control, no CM, ST = shoot thinning CM, LR = leaf removal CM, and STLR = shoot thinning and leaf removal CM.

Table 4. Average WTP bids by information/sensory grouping and bidding round.[a]

| CM Treatment | N | Round 1 | Round 2 | Difference |
|---|---|---|---|---|
| Sensory First Groups: | | (Sensory) | (Sensory + Information) | |
| *CON* | 172 | 6.69 | 6.73 | + 0.04 |
| *ST* | 172 | 6.24 | 6.37 | + 0.14 |
| *LR* | 172 | 5.89 | 5.82 | - 0.07 |
| *STLR* | 172 | 6.29 | 6.18 | - 0.11 |
| All CM Wines | 516 | 6.14 | 6.12 | - 0.02 |
| Information First Groups: | | (Information) | (Information + Sensory) | |
| *CON* | 166 | 6.22 | 5.60 | - 0.63 |
| *ST* | 166 | 6.76 | 6.54 | - 0.22 |
| *LR* | 166 | 6.01 | 5.62 | - 0.40 |
| *STLR* | 166 | 6.85 | 6.55 | - 0.30 |
| All CM Wines | 498 | 6.54 | 6.24 | - 0.30 |

[a] Canopy Management (CM) treatments are CON = control, no CM, ST = shoot thinning CM, LR = leaf removal CM, and STLR = shoot thinning and leaf removal CM.

Table 5. Ordinary least squares regression of consumer likability on sensory attributes for semi-dry Riesling, Finger Lakes, NY.[a]

| Variable | Estimate | |
|---|---|---|
| *ACIDITY* | 0.449 | *** |
| | (0.155) | |
| *ACIDITY*$^2$ | -0.144 | *** |
| | (0.034) | |
| *SWEETNESS* | 0.193 | |
| | (0.188) | |
| *SWEETNESS*$^2$ | -0.013 | |
| | (0.048) | |
| *FRUITINESS* | 0.656 | *** |
| | (0.176) | |
| *FRUITINESS*$^2$ | -0.042 | |
| | (0.046) | |
| *ACIDITY*SWEETNESS* | 0.009 | |
| | (0.050) | |
| *ACIDITY*FRUITINESS* | -0.049 | |
| | (0.047) | |
| *SWEETNESS*FRUITINESS* | -0.018 | |
| | (0.062) | |
| *INTERCEPT* | 0.774 | *** |
| | (0.228) | |
| Adjusted $R^2$ | 0.272 | |
| N | 663 | |

[a] The dependent variable is the level of how much the subject liked the wine from 'not at all' (0) to 'extremely' (4). The sensory attributes of perceived level of acidity, sweetness, and fruitiness are similarly rated. The data are from the sensory portion of the experiment only; i.e., round 1 for the Sensory First groups and round two for the Information First groups.

Note: we use *, **, and *** to represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively. Standard errors in parentheses.

Table 6. Willingness to pay estimates with random effects tobit model, semi-dry Riesling, Finger Lakes, NY.

| Variable | Model 1 (no round or interaction terms) | | Model 2 (round and group interaction terms) | | Model 3a (SF groups only) | | Model 3b (IF groups only) | |
|---|---|---|---|---|---|---|---|---|
| *ST* | 0.214 | | -0.399 | | -0.523 | | 0.990 | *** |
| | (0.253) | | (0.342) | | (0.357) | | (0.354) | |
| *LR* | -0.538 | ** | -0.912 | *** | -1.037 | *** | -0.005 | |
| | (0.254) | | (0.344) | | (0.358) | | (0.356) | |
| *STLR* | 0.154 | | -0.480 | | -0.606 | * | 0.955 | *** |
| | (0.254) | | (0.343) | | (0.358) | | (0.356) | |
| *ROUND2* | | | -0.014 | | -0.076 | | -0.478 | ** |
| | | | (0.246) | | (0.253) | | (0.250) | |
| *ST*IF_GROUP* | | | 1.262 | *** | | | | |
| | | | (0.477) | | | | | |
| *LR*IF_GROUP* | | | 0.777 | * | | | | |
| | | | (0.479) | | | | | |
| *STLR*IF_GROUP* | | | 1.307 | *** | | | | |
| | | | (0.478) | | | | | |
| *ROUND2*IF_GROUP* | | | -0.528 | * | | | | |
| | | | (0.327) | | | | | |
| *AGE* | 0.024 | | 0.024 | | 0.005 | | 0.019 | |
| | (0.037) | | (0.037) | | (0.054) | | (0.050) | |
| *MALE* | 1.250 | * | 1.180 | * | 1.008 | | 1.626 | |
| | (0.724) | | (0.729) | | (1.021) | | (1.050) | |
| *INCOME* | -0.043 | | -0.041 | | -0.230 | | -0.267 | |
| | (0.155) | | (0.156) | | (0.193) | | (0.252) | |
| *STUDENT* | 0.719 | | 0.741 | | 0.891 | | 0.806 | |
| | (0.912) | | (0.917) | | (1.286) | | (1.323) | |
| *MARRIED* | 1.019 | | 1.061 | | 0.334 | | 1.598 | |
| | (0.734) | | (0.738) | | (1.016) | | (1.054) | |
| *CHILDREN* | -0.173 | | -0.099 | | -0.267 | | -0.988 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (0.905) | | (0.909) | | (1.193) | | (1.465) | |
| *NYYEARSP* | 0.780 | | 0.712 | | 0.619 | | 0.572 | |
| | (1.008) | | (1.013) | | (1.442) | | (1.409) | |
| *ENVIRONC* | 1.428 | * | 1.463 | * | 1.313 | | 1.344 | |
| | (0.755) | | (0.759) | | (0.992) | | (1.163) | |
| *FREQWWINE* | 2.234 | ** | 2.181 | ** | 3.564 | *** | -0.264 | |
| | (0.976) | | (0.981) | | (1.233) | | (1.5665) | |
| *ASIAN* | -0.749 | | -0.658 | | -0.416 | | -2.351 | * |
| | (0.879) | | (0.885) | | (1.137) | | (1.430) | |
| *ORGANIC* | -0.497 | | -0.583 | | 0.226 | | -1.419 | |
| | (0.739) | | (0.744) | | (1.011) | | (1.087) | |
| *INTERCEPT* | 1.586 | | 1.789 | | 2.644 | | 3.609 | |
| | (2.003) | | (2.041) | | (2.834) | | (2.967) | |
| $\sigma_u$ | 4.208 | *** | 4.233 | *** | 3.955 | *** | 4.122 | *** |
| | (0.252) | | (0.254) | | (0.333) | | (0.355) | |
| $\sigma_e$ | 3.209 | *** | 3.189 | *** | 3.242 | *** | 3.132 | *** |
| | (0.073) | | (0.072) | | (0.104) | | (0.101) | |
| Log Likelihood | -3366.510 | | -3359.610 | | -1717.415 | | -1634.050 | |
| N | 1352 | | 1352 | | 688 | | 664 | |

Note: We use *, **, and *** to represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively. Standard errors in parentheses.

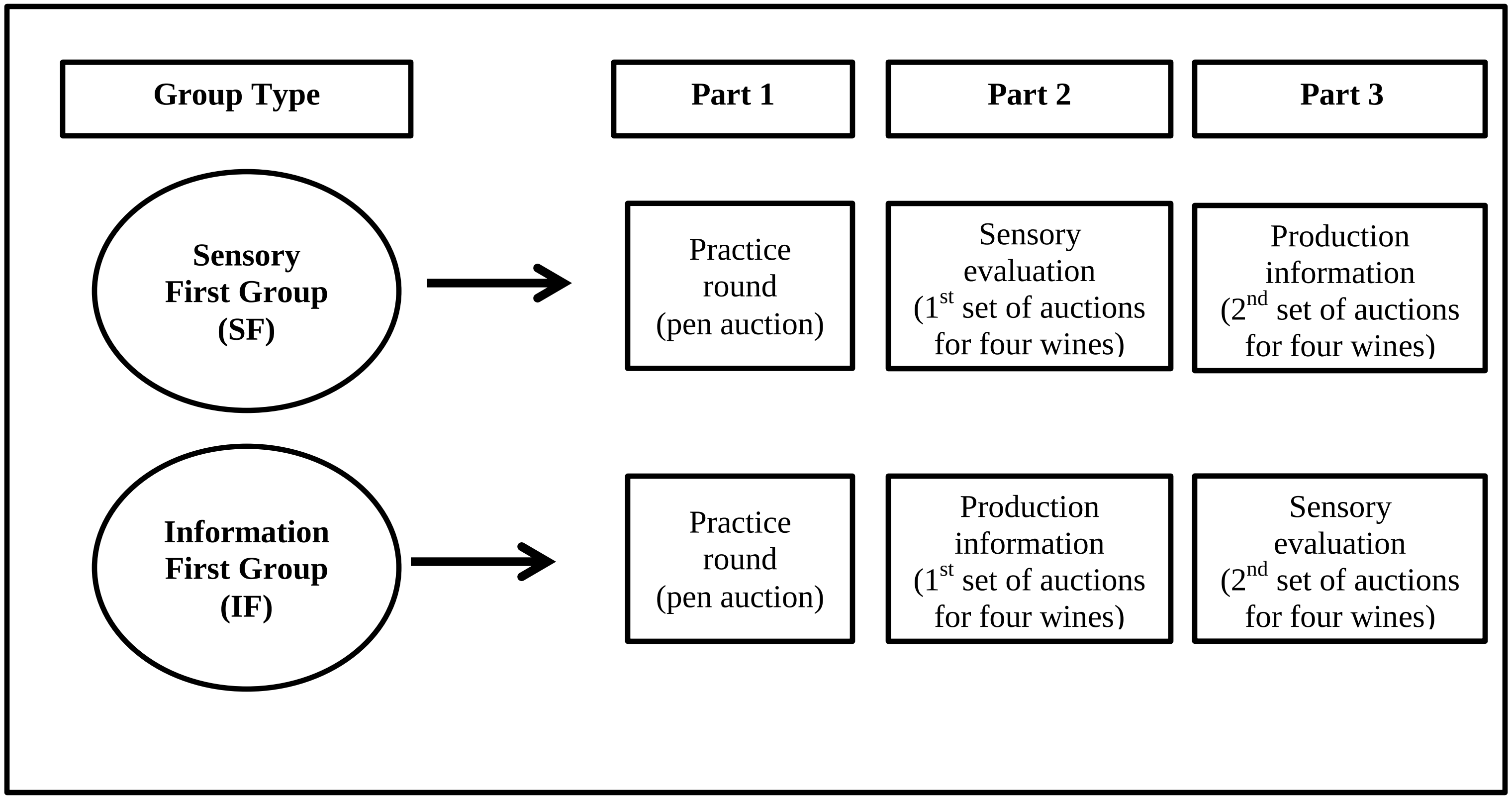


Figure 1. Experimental auctions and sensory evaluation order by information treatment and round

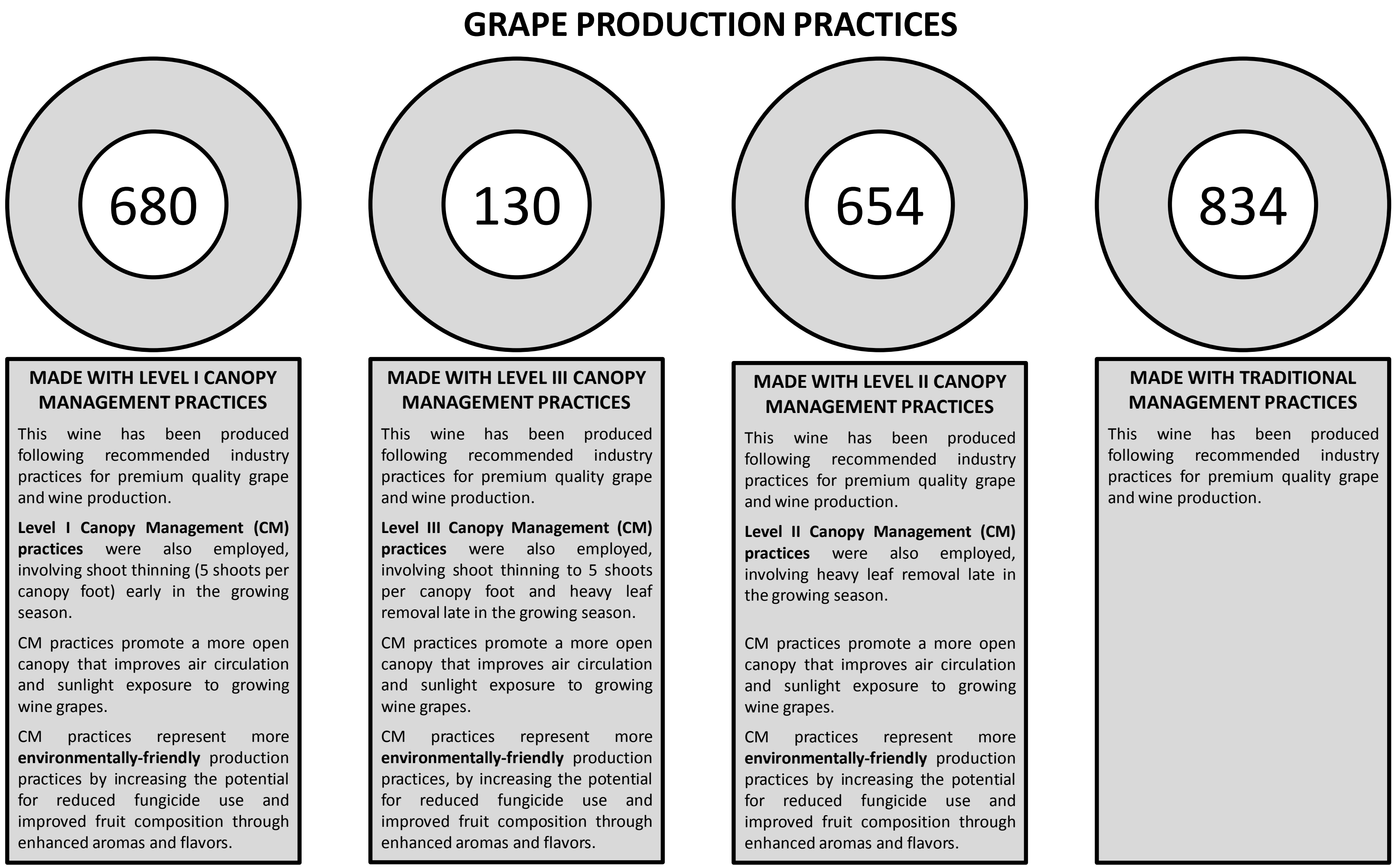


Figure 2. Example template describing canopy management practices used for alternative wine samples.

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