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wine economics

AMERICAN ASSOCIATION OF WINE ECONOMISTS

AAWE WORKING PAPER
No. 117
Economics

MEASURING CONSUMER WILLINGNESS TO PAY FOR LOW-SULFITE WINE: A CONJOINT ANALYSIS

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August 2012
ISSN 2166-9112

www.wine-economics.org

Title: Measuring Consumer Willingness to Pay for Low-Sulfite Wine: A Conjoint Analysis

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Abstract: Using stated choice methods, a sample of 223 wine consumers participated in a conjoint experiment where 36 hypothetical wine labels were ranked based on organic and "no sulfites added" labeling, as well as varying price and quality levels. The results indicate that quality and price are the primary factors influencing wine choice, while "no sulfites added" labeling does not directly determine the purchasing decision. However, we find strong evidence that, at parity with price and quality, the average consumer is willing to pay $0.64 for no sulfites added in wine. Additionally, a substantial segment (34.08%) of the consumer population is willing to pay a greater premium of $1.23 for no sulfites added, indicating a potential niche market to which marketing promotions could be targeted.

Keywords: conjoint, wine, sulfite, sulfur dioxide, valuation, willingness to pay

Highlights:

- We quantify consumer preferences for wine differentiated by its sulfite content
- We find sulfites to be the primary ingredient in wine perceived to cause headaches
- Quality and price are the main triggers of purchase, but valuation for low sulfite wines is positive
- Consumers reporting headaches are particularly receptive to low-sulfite marketing
- Consumers are not willing to trade quality for low sulfite content

1. Introduction

The United States is the largest wine market by sales revenue in the world, representing nearly $32 billion in total retail value (Wine Institute, 2012). In the last 15 years, American wine production has increased 55%, and both total and per-capita wine consumption has expanded every year since 2001 (Wine Institute, 2011a; Wine Institute, 2011b). Though wine remains a highly diversified product, the growing popularity of wine has incentivized industry consolidation and a greater degree of uniform production practices. To counter this trend, some producers are increasingly focused on more natural and sustainable production practices, including the minimized use of chemical preservatives such as sulfites (Goode & Harrop, 2011).

Added in the form of sulfur dioxide (SO_2), sulfites serve as an antioxidant and antimicrobial agent and therefore help preserve the wine and enhance aging (Vine, Harkness, & Linton, 2002). All wines contain small amounts of sulfites naturally due to the presence of yeast during fermentation (Chengchu, Ruiying, & Yi-Cheng, 2006), and vintners commonly add around 30 to 90 parts per million (ppm) of additional sulfites to the wine throughout production (Burgstahler & Robinson, 1997). While historically uncommon, producing wine without adding sulfites is increasingly feasible due to better hygiene in the production process paired with the ability to produce wine in climate-controlled facilities (Goode & Harrop, 2011).

At higher levels, sulfites have led to reported incidences of negative health effects (Vally & Thompson, 2001), causing serious health problems including trouble breathing, skin rashes, and stomach pain (Grotheer, Marshall, & Simonne, 2005). Additionally, anecdotal evidence and articles in the popular press suggests that a share of the consumer population perceives that drinking even moderate amounts of wine which contains sulfites, particularly the red varieties, triggers less serious health effects including headaches and migraines (Robin, 2010; Gaiter & Brecher, 2000). Scientists have not reached a full consensus on whether sulfites do in fact cause the reported minor health effects (Gaiter & Brecher, 2000), but other ingredients in wine have also been identified as plausible causes (Mauskop & Sun-Edelson, 2009; Millichap & Yee, 2003). One explanation to the particularly negative consumer perceptions toward sulfites may relate to the U.S. labeling rules, which require that wine sold via interstate commerce include a warning statement if it contains more than 10 ppm of sulfites (Alcohol and Tobacco Tax and Trade Bureau, 2012).

Given the adverse reactions toward sulfites, a key aspect that would inform entrepreneurs is how valuable a minimized sulfite level in wine is to consumers, and what share of consumers would consider such a trait important in their buying decisions. Hence, our main objective is to understand the perceptions and quantify the value of wine produced without the use of sulfites to see if potential unexploited niche markets do in fact exist. Specifically, our objectives are 1) to assess the negative perceptions that consumers have toward sulfites; 2) to quantify willingness to pay (WTP) for reductions of sulfite levels in wine; and 3) to identify specific purchasing cohorts that are especially receptive to low-sulfite marketing campaigns. We apply a conjoint stated choice approach to address these objectives.

1.1 Motivating literature

Most wine studies utilizing stated choice methods have focused on variety and place-based factors such as viticultural areas, as well as the individual-specific characteristics that influence these attributes, rather than non-sensory attributes such as a wine's sulfite content. For example, Lockshin, Jarvis, d'Hauteville, & Perrouty (2006) conducted a market share simulation to see how brand size, region of production, price, and quality medals (all external attributes) influence consumer choice. Quality medals listed on the label for lower price points were found to significantly increase the market share, particularly with low-involvement consumers. High-involvement consumers, on the other hand, tended to prefer wine in the higher price categories and were less influenced by the award labeling. Mtimet & Albisu (2006) also segmented the preferences for wine attributes based on market involvement levels, but found that the wine's origin was important for occasional consumers, while the age of the wine had a relatively larger impact on utility for high-involved consumers. Market-involved consumers also expressed less preference for wines in the lower price ranges.

For consumers overall, Gil and Sánchez (1997) utilized weighted least squares (WLS) to vary price, age (labeled as "current year" or "old"), and origin of the wine in an orthogonally-designed choice experiment. The study found that product origin (an inherent quality cue) is the most important attribute in the purchasing decision for wine, and that price and vintage year were not significant in determining choice for the average consumer. Other wine marketing studies have looked at how specific labeling of the product attributes influences choice. For example, Jarvis, Mueller, & Chiong (2010) found that 18 to 30 year olds overall are significantly impacted by the label's image, followed by its slogan, advertised variety, and region of production.

Low-sulfite product marketing in the United States has predominantly been synonymous with organic production, likely due to organic winemakers foregoing the use of sulfites in addition to meeting a variety of other regulations (Alcohol and Tobacco Tax and Trade Bureau, 2012). Similarly, previous marketing literature has primarily focused on consumer preferences for organic wine, rather than alternative natural wine products, including "no sulfites added." This widely unexplored gap may have important marketing implications, particularly since consumers have difficulty explaining why they value organic wine over other varieties (e.g. Barreiro-Hurlé, Colombo, & Cantos-Villar, 2008).

Past literature has attempted to define the attractiveness of organic wine to consumers. One explanation includes the perception that organic wine is better for the environment which, in turn, elicits a higher valuation from environmentally-conscious consumers. The premium is justified by the consumer because it is viewed as a financial "self-sacrifice" in order to protect the environment (Olsen, Thach, & Hemphill, 2011). Wine, including the organic and natural varieties, are also widely perceived as being a health-promoting product (Barreiro-Hurlé, Colombo, & Cantos-Villar, 2008; Fotopoulos, Krystallis, & Ness, 2003), and health-conscious consumers are particularly receptive to marketing campaigns promoting natural (and organic) wines (Goode & Harrop, 2011). In fact, organic wine consumers associate the organic attribute more with its health benefits than a perceived connection to quality (Fotopoulos, Krystallis, & Ness, 2003), which encompasses a variety of sensory attributes.

Even for conventional wines, consumers are willing to pay a premium for wines perceived as being healthier than others. This is confirmed by Barreiro-Hurlé, Colombo, & Cantos-Villar (2008), finding that consumers are willing to pay a premium of €5.89 for resveratrol-enriched wine, a health-promoting ingredient that can be doubled without affecting main sensory attributes (color, acidity, taste). Given that low-sulfite wine may be an alternative niche to organic wine, significant price premiums may be available, particularly if low-sulfite wine is perceived as more natural and healthier than the conventional brands.

2. Methods

To study consumer perceptions toward low-sulfite wines, we used the conjoint stated choice approach to collect data using the Qualtrics survey software. The survey was conducted between March 8, 2012 and March 31, 2012[1] through a local wine retailer's email list, and it

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[1] The research was approved on January 20, 2012 by the IRB Coordinator of the Research Integrity & Compliance Review Office, Colorado State University. IRB ID: 131-12H.

comprised of preliminary questions followed by a main choice task. We first collected demographic information (age, income, level of education, and gender) (see Table 3). Since past wine literature has segmented the market between high-involvement and low-involvement consumers (Lockshin et al., 2006; Mtimet & Albisu, 2006), the survey included a series of questions about typical purchasing behavior. Given that at least some consumers perceive sulfites as causing headaches, we also asked participants about their subjective headache experiences, followed by their attitudes toward sulfites. Participants were compensated with a $20 wine voucher to the wine retailer, which incentivized participation and helped us gain access to the retailer's customer database[2]. The survey also included a cheap talk script immediately prior to the choice task intended to remind participants the importance of providing accurate choice responses, which has been shown to reduce the potential for bias (Carlsson, Frykblom, & Lagerkvist, 2005).

Several studies evaluating willingness to pay for wine attributes have used conjoint methods and stated preference surveys (e.g. Gil & Sánchez, 1997; Onozaka & Thilmany McFadden, 2011; Hu, Batte, Woods, & Erns, 2011; Mtimet & Albisu, 2006). While limited by its hypothetical nature, stated preference choice experiments allow for more exactness in the experimental design and better control for exogenous factors that may otherwise influence preferences (Kroes & Sheldon, 1988). The stated preference approach also allows for consumer valuation to be obtained for hypothetical products or products within an underdeveloped market segment.

The choices that participants make in a stated choice experiment inform the estimation of preferences among alternatives, but different survey structures may yield better results than

[2] The survey was designed based on an initial, shortened pilot survey intended to ensure that the experiment yielded reliable results, as well as to provide interested participants the chance to get a sense of the research.

others. Earlier choice literature has asked participants to rank a full list of products within a single choice set (Gil & Sánchez, 1997). More recent literature has utilized the panel fractional factorial setup where each individual ranks a set of alternatives in multiple choice sets. This is seen in Onozaka & Thilmany McFadden's (2011) study quantifying WTP for sustainable production claims on apples and tomatoes. The experiment utilized a panel design containing 8 choice sets, each with 2 alternatives. Hu et al. (2011) also designed an orthogonal survey where 3 choice sets were presented to respondents, each containing 2 alternatives to quantify consumer perceptions for local production labeling of blackberry jam.

A relatively new approach includes having participants rank the choices within each choice set, rather than only designating their "most preferred" choice (Scarpa, Notaro, Louviere, & Raffaelli, 2010). This best-worst design, originally developed by Louviere & Woodworth (1990) (cited in Potoglou et al., 2011), has been shown to decrease the number of required choice iterations by 2/3 while still maintaining the same standard errors compared to participants only selecting their "most preferred" alternative (Scarpa et al., 2010).

The main choice task utilized an optimal orthogonal in the differences (OOD) choice design developed with the Ngene software. This reduced the number of choices from 64 (2×2×4×4) hypothetical wines to 12 scenarios containing 3 alternatives each. Using the best-worst approach proposed in the literature, participants were asked to select their "most preferred" and "least preferred" wine label out of the three. Table 1 defines the attributes and levels used in the experiment. The four attributes chosen were price, quality, sulfites, and organic characteristics. To reduce the dimensionality of the design, we held the wine's variety constant throughout a given experiment but randomly assigned participants into a red wine or white wine category.

The quality levels were determined based on *Wine Spectator* ratings defined in Table 2, which was chosen as a basis for quality due to its extensive collection of wine reviews, as well as its use in previous wine marketing studies (e.g. Costanigro, McCluskey, & Mittelhammer, 2007). Defining multiple quality levels also enabled us to encompass what would otherwise represent a wide range of attributes, including origin, which consumers use as quality signals when deciphering between wines. Following the findings in Jarvis et al. (2010) indicating the importance of using pictures in wine labeling, an image of the actual "USDA Organic" seal and a fictitious "No Sulfites Added" proxy label were also included within the hypothetical wine labels. Any given wine could have one label, neither image, or both. Including both a sulfite and organic attribute allowed us to compare valuation for conventional low-sulfite wine versus full-organic production. In order to calculate willingness to pay in monetary units and detect structural differences across pricing categories, participants were also evenly and randomly assigned to one of three pricing groups: $10-$15; $20-$25; or $30-$35 (e.g. Costanigro, McCluskey, & Mittelhammer, 2007).

Many stated choice experiments include an opt-out option for each choice task, where participants can decide to not select any of the alternatives (e.g. Onozaka & Thilmany McFadden, 2011; Hu, Batte, Woods, & Erns, 2011; Barreiro-Hurlé, Colombo, & Cantos-Villar, 2008). In contrast, each of the twelve choice scenarios in our experiment contained a question asking if the participant would actually purchase the wine they selected as "most preferred." While still hypothetical in nature, this allowed us to maintain a suitable sample size while being able to decipher between attribute combinations that attract attention versus products that may actually trigger a purchase.

3. Theory/estimation procedure

A common application in analyzing stated preferences involves logistic estimation which is based on the random utility model (ARUM) (Koning and Ridder, 2003). Using multiple choice iterations for each respondent, it is specified as $U_{ijk} = V_{ijk} + \varepsilon_{ijk}$ where the utility of individual *i* choosing alternative *k* in choice set *j* is derived based on a vector set of attributes *V* plus a random error term. The vector set of attributes is linearly defined as a function of coefficients *β*, where each *β* represents the change in utility based on a change in the product attribute level, estimated via maximum likelihood (ML).

ML estimation incorporates a link function, which is also applied to predict the likelihood of a particular choice being made. For dichotomous logit models, with an outcome of either 1 for a positive selection or a 0 otherwise, the logit link function is specified as Prob $(Y_{ij} = k) = \exp(V_{ijk}) / \sum_{k=1}^{K} \exp(V_{ijk})$, where individual *i* is choosing alternative *k* within choice set *j*, and there are K=3 alternatives within each choice set (Hu et al., 2011; Punj & Staelin, 1978).

With ranked data, the link function can be "exploded" to predict the likelihood of a particular rank, rather than a single choice. With attribute-specific regressors, the rank-ordered model becomes an extension of conditional logit, and is specified as Prob_{ij} (rank A, B, C) $= \frac{\exp(V_{ijA})}{\sum_{k=A,B,C} \exp(V_{ijk})} \; \frac{\exp(V_{ijB})}{\sum_{k=B,C} \exp(V_{ijk})}$, where A, B, and C are specific *k* alternatives for individual *i* within choice set *j* (Train, 2009). Hence, the likelihood of person *i* ranking the three wines in the order of A, B, C within choice set *j* can be obtained by estimating the conditional logit probability of choosing alternative A from the list of A, B, C, multiplied by the conditional logit probability of choosing alternative B from the list of B and C (Chapman & Staelin, 1982). By eliciting multiple functions from a single respondent's choice set, the rank-ordered logit model provides a greater amount of information than the dichotomous choice models, which have been predominantly used in previous wine literature.

4. Results

4.1 Participant statistics

Table 3 summarizes the socio-demographic characteristics of the sample and Table 4 summarizes the reported market participation information. The large number of respondents owning 10 or more bottles at home (49.78%) indicates that many consumers may purchase wine for non-immediate consumption or for collection purposes, which could have direct implications for wine preservation methods. Overall, 34.08% of the sample reported experiencing headaches after moderate consumption of wine. Interestingly, 60.00% of participants purchasing zero bottles of wine in a typical month and 50.00% of consumers storing no bottles at home attributed headache experiences to wine consumption. As participants were recruited in a liquor store, it seems likely that some alcohol consumers may refrain from buying wine as a direct consequence of their headache experience.

While experiencing headaches is not necessarily indicative of having a negative perception toward sulfites, we find that 63.16% of headache sufferers perceive sulfites as triggering headaches, followed by dehydration (57.89%) and red wine (32.89%) (Table 5). To ensure that consumers did not confuse their post-consumption headache with the alcohol hangover headache (AHH), the questions were specifically framed to elicit subjective headache experiences only after moderate consumption.

4.2 Rank-ordered logit

The regression variable definitions are presented in Tables 6 and 7. Since the full ranking of data was obtained for each of the twelve choice scenarios, a rank-ordered logit model was estimated by aggregating the entire sample across the randomly assigned price and varietal categories. With 223 respondents each trading off 3 hypothetical wines across 12 choice scenarios, there were 8028 total observations available. However, to account and adjust for the within-subject dependency between an individual's responses through multiple choice groups, a clustered variance-covariance matrix was imposed on the model.

The rank-ordered logit estimates for all consumer groups combined produce small standard errors, and all estimated coefficient are significant at the 1% level. This suggests that the experimental design and sample size were adequate in deriving estimated consumer valuation. Since the dependent variable was coded as one for the most preferred wine and three for the least preferred in any given choice set, it follows that negative coefficients imply a decrease in ranking (e.g. from 2 to 1) or, equivalently, an increase in utility associated with the presence of an attribute. Results are presented in Table 8.

According to our estimates, consumers value a lack of sulfites in wine at $0.64, which is just over half the $1.22 value placed on organic wine[3]. While there are many possible explanations for this finding, our initial results suggest that consumers are aware of the fact that the organic production protocol prohibits, among other things, the use of added sulfites. A 4-point increase in the quality score induces a $2.84 increase in WTP, however, indicating that differences in quality influence wine valuation much more than organic or no added sulfite labels.

We do not find significant differences in WTP for consumers placed in higher pricing categories (Appendix Table A.1). Across the varietal groups, we initially expected increased valuation for "no sulfites added" in red wines since 11.21% of the total respondents ranked red wine as being a primary trigger of headaches, compared to 2.69% for white wine. By interacting

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[3] Willingness to pay is calculated as $-(\beta_a / \beta_{price})$, where *a* represents the attribute of interest, and *price* is the estimated price coefficient (Berreiro-Hurlé, Colombo, & Cantos-Villar, 2008). Since our pricing intervals were in $1.50 increments, the ratio was multiplied by 1.5 to obtain estimates in terms of $1 monetary increments. So, for example, sulfites are valued as $-(\beta_{sulfite} / \beta_{price}) \times 1.5 = -(-0.2748 / 0.6409) \times 1.5 = \$0.64$.

a variety dummy variable with the main coefficients, the results indicate that consumers value red wine with no added sulfites $0.01 more and quality $0.15 more than the white wine (Appendix Table A.2). However, Wald tests confirm that the estimates are not statistically different. These results point to the conclusion that attribute preferences can be aggregated across red and white variety groups, as well as across pricing cohorts.

A variety of other interaction models were also run to test for structural differences across demographic categories and purchasing behavior groups. There was some indication that income, belonging to a wine club, and wine purchases in a typical month was positively related to quality valuation. Given the triggering role that headache sufferers attribute to sulfites, we find the most significant structural difference in low-sulfite valuation to be between headache sufferers and non-sufferers. Our results indicate that individuals reporting headaches after moderate wine consumption have a willingness to pay of $1.23 for a lack of sulfites in wine, which is considerably higher than the $0.33 WTP from non-headache sufferers, and nearly double the overall population's valuation (Table 9). An interesting result that emerges from the model is that headache sufferers are actually willing to pay more for wine without added sulfites than for organic wine, which may indicate that, at least for this purchasing cohort, a clear "no sulfites added" designation is more important than organic labeling[4].

4.3 Population-averaged logit

Using the secondary part of the choice task that asked participants if they would actually be willing to purchase the wine selected as "most preferred," a dichotomous dependent variable was created and defined as 1 if the respondent said they would actually purchase the wine, and 0 otherwise. Using this setup, we estimated a population-averaged logit model which, when

[4] Post-estimation Wald tests confirm that the estimates for the organic and sulfite coefficients are in fact different between headache and non-headache sufferers. Likewise, the marginal WTP is statistically different for a "no added sulfites" claim between the two groups.

interpreted in terms of marginal effects, allowed us to directly observe how a change in the attribute level affected the probability of an affirmative purchase response. Since only the "most preferred" wine was analyzed, the number of observations was reduced by 2/3 to 2676 observations. For consumers overall, *ceteris paribus*, we find that an organic wine increases the probability of purchase by 1.86% (an effect that was not statistically significant at conventional levels), a wine without added sulfites increases the probability of purchase by 1.72% (also non-significant), a 4-point increase in the quality score increases the probability of purchase by 5.71%, and a $1.50 increase in price decreases the probability of purchase by 5.10% (Table 10).

By adding a price category dummy variable for the $20-$25 range as well as the $30-$35 range, we were able to directly observe the difference in purchase probability for higher-priced wine. Compared to the $10-$15 price range, being placed into a $20-$25 price ranged decreased the likelihood of an affirmative purchase response by 22%. Similarly, being in the $30-$35 range decreased affirmative response likelihood by 33% (Table 11). Compared to a marginal probability increase of 1.87% for low-sulfite and 1.89% for organic wine, the price coefficients indicate that being in a desired pricing category is of utmost importance to consumers.

Headache sufferers, like the consumer population overall, places the highest value on price and quality when determining a wine purchase. However, our results indicate that headache sufferers are the most important cohort when marketing the low-sulfite differentiation. In addition to the significantly higher willingness to pay that was observed from the rank-ordered logit results, headache sufferers are 3.41% more likely to purchase a wine made without added sulfites, whereas non-headache sufferers are only 0.97% more likely to make a purchase. Further confirming the importance of marketing to this group, the estimates for headache sufferers are statistically significant at 10%, while statistically insignificant for non-headache sufferers (Table 12).

5. Conclusions, future direction, and limitations

5.1 Conclusions

The objectives of the study were to assess whether consumers perceive sulfites negatively, especially concerning their perceived role in triggering headaches; quantify willingness to pay for wine produced without sulfites; and provide useful information to the wine industry that may infer the existence of niche market segments for low-sulfite wine. This initial work focused on consumer perceptions and potential interest in wines assuring such production practices that yield some interesting results for the industry.

Consumers perceive sulfites as being a main cause of headaches, and this is translated into a statistically significant willingness to pay for low-sulfite wine for consumers overall, particularly among headache sufferers. Throughout the analysis, however, we find quality and price to be considerably more important in determining a purchase decision, as a higher price range decreases the likelihood of an affirmative purchase response by up to 33%. Likewise, a 4-point increase in quality (on a 100 point scale) is over three times as important in determining a purchase as a lack of sulfites for consumers overall. Our results therefore reinforce the idea that "no added sulfites" labeling is useful to gain consumers' attention, but it is not sufficient, since poor quality would still discourage purchases. Nevertheless, we find that niche markets may be available for wine produced without added sulfites, especially when marketed toward headache sufferers.

In particular, producers may find low-sulfite niche markets beneficial to gain new customers or strengthen loyal and return buyers rather than securing a price premium. Or, at least, the amount of premium that can be secured must be evaluated in the context of where the wine is priced within current prevailing price ranges used by retailers. Implementing brand loyalty campaigns, such as promoting a wine club, may become an important and effective strategy to retain customers even if the wine is positioned to be attractive to certain groups, such as those who suspect sulfites affect their health.

Marketing low-sulfite wine as a natural and sustainable product could also potentially give it a place in the less crowded all-organic sections of wine retail stores, which may lead to less consumer distinction between organic and conventional sulfite-differentiated wines. As the empirical results indicate, there already exists some uncertainty over the difference between organic and low-sulfite wines, and although winemakers must remain ethical in only promising the assurances they can make (no added sulfites), if that claim is of paramount importance to consumers, it may allow them to mitigate the risks and production costs of a full organic transition.

Producers should remain cautious in foregoing to the use of sulfites, however, due to the higher risk of oxidation and spoilage of the wine. In fact, consumers may be actively deterred from purchasing a low-sulfite wine if they perceive that quality may suffer due to these risks. Offering a money-back guarantee would remove the barrier to making a purchase, but it would also shift the risk to the producer. A variety of production strategies have been shown to reduce the risks involved with low-sulfite production, though, including producing wine in smaller batches, using higher-quality grapes, and implementing gentler harvesting techniques (Goode & Harrop, 2011). This may imply particular benefits for wineries with an on-site supply chain and small batch processes to monitor, since imported grapes can experience stress and microbial contact during transport and may not be harvested at their optimal ripeness. Furthermore, emerging wine regions known for smaller-scale production may be able to better carve out a regional identity by exploiting the low-sulfite market.

5.2 Future direction

The research can be supplemented with two main areas of further study. The first is to better understand why a gap exists between consumer perceptions and the current scientific knowledge associating sulfites with headaches. An experiment that tests various labeling practices, such as including additional chemicals on an ingredients label and stating the actual amount of sulfite content in the wine, would prove useful in understanding the disparity and advocating for alternative labeling guidelines. Recommending changes to labeling policy may prove challenging, however, without more research related to the health outcomes associated with moderate wine consumption.

The second area warranting further research is to understand how consumers value the additional production practices for organic wine compared to wine differentiated only by its sulfite content. This would better inform producers whether the lack of added sulfites plays a significant role in a consumer's choice for organic wine, or if low-sulfite wine would more profitably be treated as an independent, rather than embedded, niche product.

5.3 Limitations

An inevitable difficulty in quantifying value for a low-sulfite niche market is that its growth will almost certainly lead to changed consumer perceptions. If consumers find that they continue to experience negative health effects after low-sulfite wine consumption, their attention may be diverted toward other products. If, on the other hand, low-sulfite wine continues to be integrated into the natural wine market, there could be considerable growth in demand, particularly among environmentally-conscious consumers. Given current interest in supporting local foods and smaller businesses, including small-batch or craft wineries as a product attribute in the choice design would shed light on why consumers actually value low-sulfite wine. Regardless, the suggested results may only imply marketing strategies for the short term, whereas long term strategies may need further analysis and refinement once actual consumer behavior is observed.

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Table 1
Attributes and levels used in the choice tasks

Attribute	**Level 0**	**Level 1**	**Level 2**	**Level 3**
"USDA-Certified Organic" Label	No	Yes	-	-
"No Sulfites Added" Label	No	Yes	-	-
Quality Score	80	84	88	92
Price (Participants randomly distributed to 1 of 3 price ranges)	\$10.49 \$20.49 \$30.49	\$11.99 \$21.99 \$31.99	\$13.49 \$23.49 \$33.49	\$14.99 \$24.99 \$34.99

Table 2

Wine Spectator quality scores (Wine Spectator, 2012)

Rating	Definition
95-100	Classic. A great wine.
90-94	Outstanding: A wine of superior character and style
85-89	Very good: A wine with special qualities
80-84	Good: A solid, well-made wine
75-59	Mediocre: A drinkable wine that may have minor flaws
50-74	Not recommended

Table 3
Socio-demographic summary statistics

Demographic	% of Sample (n=223)	% of Group Reporting Headache (Overall 34.08%)
Male	47.98%	32.71%
Female	52.02%	35.34%
Age 21 to 30	17.49%	28.21%
Age 31 to 40	19.73%	27.27%
Age 41 to 50	14.80%	45.45%
Age 51 to 60	33.18%	33.78%
Age 61 to 70	13.45%	40.00%
Age Over 70	1.35%	33.33%
Income Under $25,000	8.52%	36.84%
Income $26,000 to $50,000	19.73%	40.91%
Income $51,000 to $75,000	16.59%	45.95%
Income $76,000 to $100,000	23.77%	32.08%
Income $101,000 to $200,000	27.80%	25.81%
Income Above $200,000	3.59%	12.50%
Less than High School	0.00%	-
High School	1.35%	66.67%
Some College	15.70%	42.86%
Bachelor’s Degree	43.95%	34.69%
Master’s Degree	25.56%	33.33%
Doctorate/Professional Degree	13.45%	20.00%

Table 4
Market involvement summary statistics

Demographic	% of Sample (n=223)	% of Group Reporting Headache (Overall 34.08% of Sample)
Wine Club	12.55%	32.14%
Wine Magazine	10.76%	33.33%
0 bottles in typical month	2.24%	60.00%
1 to 3 bottles in typical month	27.80%	33.87%
4 to 6 bottles in typical month	32.29%	33.33%
7 to 9 bottles in typical month	17.49%	38.46%
10 or more bottles in typical month	20.18%	28.89%
0 bottles at home	2.69%	50.00%
1 to 3 bottles at home	24.22%	37.04%
4 to 6 bottles at home	14.35%	40.63%
7 to 9 bottles at home	8.97%	25.00%
10 or more bottles at home	49.78%	31.53%

Table 5
Summary of believed causes of wine headache

Cause	Percentage of Headache Respondents
Sulfites	63.16%
Dehydration	57.89%
Red Wine	32.89%
Tannins	19.74%
Other	14.47%
White Wine	7.89%
Tyramine	1.32%
Organic Wine	0.00%

Table 6
Definitions of the main-effect regression variables

Variable	Description
ORGANIC	1 if organic label, 0 otherwise
SULFITE	1 if "no added sulfites" label, 0 otherwise
QUALITY	*Wine Spectator* quality score
PRICE	Price

Table 7
Definition of the interacted regression variables

Variable	Description
WHITE	1 indicates white wine control group, 0 otherwise
RED	1 indicates red wine control group, 0 otherwise
HEAD	1 indicates headache after moderate wine consumption, 0 otherwise
NOHEAD	1 indicates no headaches after moderate wine consumption, 0 otherwise
10	1 indicates $10-$15 price group, 0 otherwise
20	1 indicates $20-$25 price group, 0 otherwise
30	1 indicates $30-$35 price group, 0 otherwise

Table 8
Rank-ordered logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANIC	-0.5196	0.0538	-9.65	0.000	-0.6252 to -0.4141
SULFITE	-0.2748	0.0578	-4.75	0.000	-0.3882 to -0.1614
QUALITY	-1.2139	0.0531	-22.86	0.000	-1.3180 to -1.1098
PRICE	0.6409	0.0344	18.65	0.000	0.5735 to 0.7083

Log pseudolikelihood = -2440.323, n=223 participants in 8028 observations

Table 9
Headache interaction model, rank-ordered logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
HEADORGANIC	-0.3991	0.0805	-4.96	0.000	-0.5569 to -0.2413
NOHEADORGANIC	-0.5934	0.0695	-8.54	0.000	-0.7297 to -0.4572
HEADSULFITE	-0.5016	0.1260	-3.98	0.000	-0.7487 to -0.2546
NOHEADSULFITE	-0.1465	0.0542	-2.70	0.007	-0.2527 to -0.0402
HEADQUALITY	-1.1563	0.0910	-12.71	0.000	-1.3347 to -0.9779
NOHEADQUALITY	-1.2537	0.0650	-19.30	0.000	-1.3810 to -1.1264
HEADPRICE	0.6121	0.0604	10.14	0.000	0.4938 to 0.7305
NOHEADPRICE	0.6631	0.0418	15.86	0.000	0.5812 to 0.7450

Log pseudolikelihood = -2429.724, n=223 participants in 8028 observations

Table 10
Marginal effects from the population-averaged logit, full sample

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	Sample Avg. (X)
ORGANIC	0.0186	0.0116	1.61	0.108	-0.0041 to 0.0414	0.6431
SULFITE	0.0172	0.0114	1.51	0.131	-0.0051 to 0.0394	0.5960
QUALITY	0.0571	0.0071	8.08	0.000	0.0432 to 0.0709	2.4563
PRICE	-0.0510	0.0052	-9.87	0.000	-0.0612 to -0.0409	0.9294

n=223 participants in 2676 observations

Table 11
Marginal effects from the population-averaged logit, price dummy

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	Sample Avg. (X)
ORGANIC	0.0189	0.0127	1.49	0.137	-0.0060 to 0.0438	0.6431
SULFITE	0.0187	0.0125	1.50	0.134	-0.0057 to 0.0431	0.5960
QUALITY	0.0635	0.0079	8.06	0.000	0.0481 to 0.0790	2.4563
PRICE	-0.0541	0.0057	-9.46	0.000	-0.0654 to -0.0429	0.9294
PRICE20	-0.2206	0.0676	-3.27	0.001	-0.3530 to -0.0882	0.3318
PRICE30	-0.3340	0.0648	-5.15	0.000	-0.4611 to -0.2070	0.3363

n=223 participants in 2676 observations

Table 12

Marginal effects from the population-averaged logit, headache interaction

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	X
HEADORG	0.0218	0.0193	1.13	0.257	-0.0159 to 0.0596	0.2160
NOHEADORG	0.0172	0.0139	1.24	0.217	-0.0101 to 0.0445	0.4271
HEADSULF	0.0341	0.0195	1.74	0.081	-0.0042 to 0.0724	0.2123
NOHEADSULF	0.0097	0.0135	0.72	0.472	-0.0168 to 0.0363	0.3838
HEADQLTY	0.0641	0.0117	5.48	0.000	0.0412 to 0.0870	0.8333
NOHEADQLTY	0.0542	0.0083	6.53	0.000	0.0380 to 0.0705	1.6229
HEADPRICE	-0.0555	0.0088	-6.35	0.000	-0.0726 to -0.0384	0.3236
NOHEADPRICE	-0.0490	0.0062	-7.86	0.000	-0.0612 to -0.0368	0.6058

n=223 participants in 2676 observations

Appendix

Table A.1
Price Interaction Model

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANIC10	-0.5921	0.0989	-5.99	0.000	-0.7860 to -0.3982
ORGANIC20	-0.5394	0.0943	-5.72	0.000	-0.7242 to -0.3546
ORGANIC30	-0.4368	0.0874	-5.00	0.000	-0.6081 to -0.2656
SULFITE10	-0.2545	0.0950	-2.68	0.007	-0.4406 to -0.0683
SULFITE20	-0.2412	0.0989	-2.44	0.015	-0.4351 to -0.0473
SULFITE30	-0.3327	0.1073	-3.10	0.002	-0.5430 to -0.1225
QUALITY10	-1.1634	0.0891	-13.05	0.000	-1.3381 to -0.9887
QUALITY20	-1.2118	0.0852	-14.22	0.000	-1.3789 to -1.0448
QUALITY30	-1.2824	0.1030	-12.44	0.000	-1.4844 to -1.0804
PRICEINT10	0.7304	0.0638	11.45	0.000	0.6054 to 0.8554
PRICEINT20	0.5556	0.0573	9.69	0.000	0.4432 to 0.6679
PRICEINT30	0.6449	0.0581	11.10	0.000	0.5310 to 0.7587

Log pseudolikelihood = -2429.945, n=223 participants in 8028 observations

Table A.2
Variety interaction model

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANICWHITE	-0.5663	0.0807	-7.02	0.000	-0.7244 to -0.4081
ORGANICRED	-0.4704	0.0699	-6.73	0.000	-0.6074 to -0.3334
SULFITEWHITE	-0.2681	0.0865	-3.10	0.002	-0.4377 to -0.0984
SULFITERED	-0.2857	0.0746	-3.83	0.000	-0.4319 to -0.1395
QUALITYWHITE	-1.1499	0.0707	-16.26	0.000	-1.2885 to -1.0113
QUALITYRED	-1.2843	0.0793	-16.19	0.000	-1.4397 to -1.1288
PRICEWHITE	0.6239	0.0455	13.72	0.000	0.5348 to 0.7131
PRICERED	0.6609	0.0519	12.74	0.000	0.5592 to 0.7626

Log Pseudolikelihood = -2436.419, n=223 participants in 8028 observations