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The role of expert judgments in wine quality assessment: the mismatch between chemical, sensorial and extrinsic cues

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Abstract

Purpose – The complexity in determining the quality of a credence good like wine increases due to the lack of mandatory ingredient labeling. This has generated a significant information asymmetry in the wine market, leading consumers to delegate their purchase decisions to expert rankings and wine guides. This paper explores whether expert assessments reduce the information asymmetry caused by the absence of ingredient labeling in the wine market.

Design/methodology/approach – By employing analysis of variance (ANOVA) in a sample of 304 wines included in the Wine Guide of the Spanish Consumers Organization (OCU), this paper assesses the extent to which expert assessments based on sensory evaluations converge with the objective cues provided by laboratory analysis in wine quality evaluations.

Findings – Results reveal a mismatch between expert assessments and laboratory analyses. Chemical aspects such as SO_2 levels or volatile acidity, sensorial factors such as intensity and persistence, and extrinsic variables such as the region of origin or wine type play an important role in the quality ranking of wines.

Originality/value – These findings call for the inclusion of objective intrinsic cues in expert sensory assessments to provide consumers reliable information about wines and to resolve the apparent dissonances in wine quality assessments.

Keywords Wine quality, Sensory analysis, Informed purchase choices, Market asymmetries, Transparency of information

Paper type Research paper

1. Introduction

The organoleptic properties of wine are determined by a series of geographical and climatic characteristics, as well as vineyard and winery practices (Alonso González and Parga Dans, 2018). However, wine quality is difficult to define as it is a multifaceted product that lacks a generally accepted definition (Hopfer *et al.*, 2015). Added to this are different subjective perceptions of quality, socio-demographic context, wine involvement and consumption occasion, which lead to varied emotional responses to the wine experience (Sáenz-Navajas *et al.*, 2016a). This powerful subjective charge is demonstrated by authors such as Charters and Pettigrew (2007), who show that the perception of wine quality varies between different populations. Their approach incorporates the attributes that consumers employ when inferring wine quality, including extrinsic and intrinsic factors (Sáenz-Navajas *et al.*, 2014). Extrinsic cues refer to wine characteristics that are not physically connected with it, including

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labels, bottles, certificates, designation of origin (DO), brand, awards or aesthetics (Honoré-Chedozeau *et al.*, 2020; Oczkowski, 2016; Outreville and Le Fur, 2020). Intrinsic cues are directly related to the physical and chemical properties of wine and its sensory perception, including mouthfeel, flavor, aroma or color (Charters and Pettigrew, 2003; Jover *et al.*, 2004; Veale and Quester, 2009).

For wine consumers, however, the question remains of how to select a quality wine bottle on the market or how to make informed wine purchasing choices. In this sense, this article explores the extent to which the quality assessments of tasters are connected with consumer demands. Wine is a product that has shifted from being a nutritional food to a hedonic beverage in marketing and consumer representations (Faye and Le Fur, 2019; Lecat *et al.*, 2016), and quality judgments have been usually delegated to wine experts. The wine sector is dominated by critics from within the industry and experts (often enologists or professional tasters) who produce wine guides with varying degrees of influence (Maguire, 2016). Thus, the wine market is a paradigmatic case in which the power of experts is a key factor in purchasing decisions. Thach (2008) showed that consumers seek advice from wine experts to evaluate intrinsic properties and other reliable sources related to extrinsic properties. However, ratings of the same wines often differ widely among experts (Cardebat and Paroissien, 2015; Masset *et al.*, 2015; Stuen *et al.*, 2015). This suggests that no expert rating can be seen as a definitive measure of wine quality, but rather as a specific individual form of establishing sets of relationships between the attributes of specific wines (Perrouty *et al.*, 2006).

There is growing evidence that experts' criteria do not necessarily coincide with those of consumers (Hopfer and Heymann, 2014). Expert evaluations have more to do with their own intra-group knowledge than an ability to make a consumer-oriented evaluation (Lockshin *et al.*, 2006; Sáenz-Navajas *et al.*, 2013). Experts normally focus on the absence of wine faults or negative attributes and on whether the wine reveals its origin or terroir (Corduas *et al.*, 2013). However, several studies show that consumers may prefer wines with faults (Botha, 2010), or even containing illegal products such as flavorings (Saltman *et al.*, 2017).

The complexity of determining wine quality increases due to the lack of mandatory ingredient labeling of the more than 50 additives and processing aids permitted by the European Union (EU) and other organizations globally, which has generated significant information asymmetry in the market (Parga-Dans and Alonso González, 2017). The use and amount of these additives is known to the producer, but not to the consumer (van Amstel *et al.*, 2008). This is so despite the proliferation of legislative initiatives since the 2000s, when the EU developed its food safety policy attempting to put consumer interests before or at the level of those of producers (Halkier *et al.*, 2007). However, it is not enough to recognize consumers as key stakeholders making informed choices in the EU market. They should be included in discussions about food safety because consumers can only make informed purchasing choices when they have all the information about a product (European Commission, 2017). More recently, EU policies such as the Farm to Fork Strategy underline the need to develop a more transparent and sustainable food chain, aligning its aims with the growing concern of European citizens about food additives and residues (Alonso González *et al.*, 2021; EFSA, 2019).

There is a paradigm shift in the determination of wine quality whereby the consumer is claiming an active role in making informed purchasing decisions (Alonso González *et al.*, 2017). Consumers in developed countries have become more informed, critical and demanding in their food choices, with an expanding tendency to demand sustainable, organic and natural wines (Alonso González and Parga-Dans, 2020a; Grunert, 2005; Halkier *et al.*, 2007), and a growing willingness to pay for them (Costanigro *et al.*, 2014; Lanfranchi *et al.*, 2020; Saliba *et al.*, 2013). Research shows that consumers are increasingly committed to healthy eating habits and more willing to pay for wines that are healthy, sustainable, local, responsible, etc (Vecchio *et al.*, 2021). Similarly, producers are trying to differentiate themselves by introducing health considerations in wines through eco-labels or additional information in order to convey confidence to the consumer (Annunziata *et al.*, 2016; Bresciani *et al.*, 2016; Maguire, 2018). However, there is a research gap on the role tasters, critics, experts and opinion leaders play in this paradigm shift. Therefore, this article asks: To what extent are specialized tasters, critics, experts and opinion makers able to connect their subjective perceptions with the intrinsic qualities of wine in order to respond to current consumption demands?

To answer this question, we examine the 2020 edition of the yearly Spanish Wine Guide of the Organization of Consumers and Users (OCU). Similar to its Italian, Portuguese and Belgian counterparts within the so-called Euroconsumers consortium, OCU's guide is unique for annually offering a wine ranking based on expert judgments (sensory or subjective parameters) together with physico-chemical analyses (objective parameters) on a sample of 300 wines. As a wine guide produced by a consumer organization, it provides more reliable information to consumers by establishing correspondences between wines' intrinsic and extrinsic factors for the evaluation of their quality. The novelty of the latest 2020 edition is the inclusion of certified organic wines, in an attempt to connect wine choice with consumer demands for healthier wines. By employing analysis of variance (ANOVA), this paper explores the extent to which expert assessments and laboratory analyses converge in wine quality evaluations. It then explores the extent to which expert assessments reduce the asymmetry of information caused by inadequate ingredient labeling and the adverse selection problems this entails.

This article advances knowledge in wine consumption studies and sensory analysis. Despite some changes in the field of consumer perception of food quality and safety in recent decades (Grunert, 2005), most studies on the wine sector have focused on the development of new products and marketing strategies (Brentari *et al.*, 2015; Sáenz-Navajas *et al.*, 2016b). Similarly, among intrinsic cues, food control literature aimed at guaranteeing product quality tends to separate objective or physico-chemical variables, resulting from laboratory analysis, from subjective ratings derived from expert sensorial ratings (Hopfer *et al.*, 2015). The latter carry more weight in quality assessment, as they are considered to ensure a more comprehensive assessment of the product (Grunert, 2005). Therefore, there is a research gap regarding objective information on wine composition and ingredients for the consumer and its evaluation in relation to quality (Charters and Pettigrew, 2008). The specific contribution of this article is therefore to highlight the lack of congruence between the sensory analyses carried out by tasters and the chemical analyses that operate in the evaluation of wine quality. In this sense, the results of this study show how chemical analyses and consumer organizations' guides could reduce the information asymmetry and adverse selection problems that currently prevail in the wine sector.

This article is structured as follows. Data and methodological section includes an explanation of the research settings, a definition of variables and data analysis. Afterward, the results and discussion are presented, to finally explore the conclusions and implications of the study.

2. Research setting and data collection

EU wine legislation only requires the labeling of alcohol content in wines with or without DO. Wines with DO indications may also include on their labels information on region of origin, grape variety and harvest year. Wineries can offer alternative information in their technical sheets on a voluntary basis, which normally includes vineyard and winemaking details, and an organoleptic description. Moreover, wine can include descriptors of the viticulture and winemaking processes thorough certifications such as organic or biodynamic. However, ingredients and additives are not listed beyond those recognized as allergens (egg, casein, fish, etc.) or are exclusively labeled with no indication of amounts (e.g., "Contains sulfites"), despite the fact some of them are potentially harmful to certain consumer sectors and still others would prefer not to consume them (Annunziata *et al.*, 2016). Thus, consumers are hardly given any information about the winemaking process and enological practices, aside from general terms used to describe the wine itself (e.g., carbonic-macerated, oaked, etc.) (Parga-Dans and González, 2018). This lack of objective information leads consumers to resort to experts' evaluations in order to optimize purchase decisions based on subjective clues. This is the case of the OCU guide, the only one that combines sensory and objective parameters to inform consumers.

The influence of OCU's guide is considerable among its more than 300,000 subscribers (0.6% of the Spanish population and 1.6% of the total family units), but stretches beyond them to influence the national wine market. The OCU publishes an annual guide of wines ranked according to objective chemical analysis and subjective tastings by panels of experts on a wine sample available in supermarkets. The data set for this paper comprises a non-probabilistic sample of 304 wines included in the 2020 edition of OCU's wine guide. The novelty of the 2020 OCU guide is the inclusion of organic wines (20% of the total) adapting to the demands of consumers interested in healthier wines. We have selected only this edition and not previous ones for this reason. Although the selection of one year might bias the interpretation of the results, the introduction of the category of certified organic wines for the first time in the Wine Guide is of particular interest for the purposes of this research.

The OCU selects wines through a market study on the basis of their popularity and high sales. This guarantees the inclusion of a representation of Spanish wines that are accessible to the majority of the population, both in terms of purchase place and price. Wine prices range between 3 and 25€, although 65% are priced below 10€. Red wines comprise 57% of the sample, whites 29%, rosés 9% and sparkling 5%.

The Guide covers a technical data sheet for each wine. It contains: 1) Extrinsic or contextual information comprising brand, winery, vintage, variety, region of origin, average price, DO and organic certification, where applicable. 2) Intrinsic information includes a sensory perception analysis carried out by a panel of expert tasters that describes visual, olfactory and taste aspects of each wine as well as a specific numerical evaluation for this section. 3) A second area of intrinsic information includes the results of physico-chemical laboratory analysis about residual sugar, volatile acidity, total SO_2, alcohol content as well as a specific numerical assessment for this section. 4) A Global Quality Score (GQS) derived from intrinsic cues, i.e. the result of physico-chemical analysis and the tasting score.

2.1 Definition of variables

2.1.1 Dependent variables. All the scores in the guide, i.e. laboratory score, expert rating and GQS, are taken as dependent variables since wine quality is established accordingly. Firstly, the evaluation resulting from laboratory score reflects the physico-chemical quality of the wine. This is assigned 2 to 5 stars. For example, a wine that contains high levels of total SO_2, volatile acidity, alcohol or residual sugar will receive 2 stars and be classified as a bad wine. An acceptable wine will be categorized with 3 stars, a good wine 4, and very good, 5. Secondly, the expert rating is the average of numerical evaluations made by the expert panel during the tasting phase and reflects the sensory quality of the wine. This rating ranges from 10 to 100, where higher scores indicate better sensory quality. Thirdly, the GQS is an indicator of wine quality calculated from results of the laboratory score (which accounts for 45% of the total) and the expert rating (55% of the total). The GQS score ranges from 0 to 100, with higher scores indicating better wine quality.

2.1.2 Independent variables. The intrinsic (physico-chemical and sensory) and extrinsic variables are taken as independent variables. Firstly, the physico-chemical variables comprise volatile acidity, residual sugar, alcoholic strength and SO_2 content. All of them except alcohol are categorized in the Guide (see Table 1).

Table 1. Frequencies according to the chemical variables

Variables	Categorization			
Volatile acidity (g/L)	Bad	Acceptable	Good	Very good
	>0.8	0.8–0.6	0.5–0.3	<0.3
n	11	102	112	79
%	3.6	33.6	36.8	26.0
*Residual sugar (g/L)**	Dry	Semi-dry	Semi-sweet	Sweet
	<4	4–12	13–45	>45
n	274	12	0	2
%	95.1	4.2	0	0.7
Alcohol (g/L)	Low	Medium	High	
	<12.5°	12.6–13.5°	>13.6°	
n	45	91	168	
%	14.8	29.9	55.3	
Sulfur dioxide or SO_2 (mg/L)	Bad	Acceptable	Good	Very good
	>140	140–120	119–80	<80
n	7	30	82	185
%	2.3	9.9	27.0	60.8

Note(s): *To avoid the presence of categories with a low number of cases in the ANOVA, the following have been eliminated in this variable: the category of semi-sweet (13–45 g/L), with no cases; and the category of sweet (>45 g/L), with only 2 cases

Volatile acidity measures the amount of acetic acid found in wine. It lends organoleptic properties to wine, which at 0.8 g/L and above are considered a defect because they confer vinegar or acetone odors and sour flavors. High levels can indicate wine spoilage. Residual sugar is the amount of sugar that is not converted to alcohol during fermentation. It indicates wine sweetness and can be considered a defect, as fermentation may continue in the bottle or be a problem for the diabetic population. Alcohol content acts as a natural preservative against wine aging and oxidation, and consumption of high quantities can be harmful or even toxic (Fiore *et al.*, 2019). The alcohol content in wine usually ranges between 8 and 17% vol. Sulfur dioxide (SO_2) is an additive used in winemaking to stabilize wines, prevent oxidation and inhibit the development of undesirable micro-organisms. Excessive SO_2 content can lead to bitter tastes, unpleasant odors (rubber, mothballs or matches) and cause a dry itchy throat and health problems (D'Amico *et al.*, 2016; Puszka, 2020). The EU has set a legal limit for total SO_2 of 150 mg/L for red wines and 200 mg/L for whites.

Secondly, we categorized the sensory variables based on the descriptive sheet of the tasting phase. To carry out the coding, the most repeated words are selected in relation to the sensory attributes identified by the expert panel. The sensory characteristics considered are: aroma, intensity, bitterness, acidity, persistence and balance. We have coded each of these according to the categories "low", "medium" and "high", except in the dichotomous case of the persistence variable, which responds to the categories "yes" or "no", ensuring the parsimony of the tests and a less uneven case distribution (see Table 2).

The extrinsic cues include wine type, production region, average price, DO and organic certification. Wine type corresponds to the OCU categories white, red, rosé, sparkling, amusing, organic and single vineyard. Production region includes five categories, following the nomenclature of the statistical territorial units in Spain: Northwest (including the regions of Galicia, Bierzo, Asturias, Cantabria and the Basque Country), Central (Castilla y León, Castilla La Mancha, Extremadura and Madrid), Northeast (Aragón, Rioja and Navarra), East (Catalonia, Valencia and the Balearic Islands) and South (Andalucía, Murcia and the Canary Islands). DO includes three categories, DOC (protected designation of origin), DO and single-vineyard designation, followed by other lower designations (PGI–protected geographical indication and table wines, vintage wines and variety wines). Finally, the average price is a

Variables	Low	Categorization Medium	High
Aroma			
n	79	211	14
%	26.0	69.4	4.6
Intensity			
n	150	42	112
%	49.3	13.8	36.8
Bitterness			
n	184	93	27
%	60.5	30.6	8.9
Acidity			
n	95	86	123
%	31.2	28.3	40.5
Persistence			
n	131	82	91
%	43.1	27.0	29.9
Balance	Yes	No	
n	92	212	
%	30.3	69.7	

Table 2. Distribution of frequencies and percentages of wines according to sensory variables

scale variable categorized according to distribution quartiles: very low (<6.40 €), low (6.41–8.10 €), medium (8.11–10.70 €) and high (>10.71 €) (see Table 3).

3. Methodology

The statistical analysis is based on a one-factor ANOVA, because the dependent variables are metric variables (laboratory score, expert rating and GQS) whose means will be contrasted with respect to the categories of the independent variables, or qualitative factors including the intrinsic and extrinsic variables (Hair *et al.*, 2010). Different ANOVA models have been previously applied regarding the evaluation and characterization of wine quality, the most important of which are those of Guld *et al.* (2020), Budić-Leto *et al.* (2017),

Variables	Categorization						
Wine type	White	Red	Rosé	Sparkling	Amusing	Organic	Single-vineyard
n	46	104	14	16	60	48	16
%	15.1	34.2	4.6	5.3	19.7	15.8	5.3
Region	Northwest	Center	Northeast	East	South		
n	25	110	84	79	6		
%	8.2	36.2	27.6	26.0	2.0		
Price	Very low	Low	Medium	High			
n	78	77	74	75			
%	25.7	25.3	24.3	24.7			
Certification of origin	DOC and Single-vineyard	DO	Other (table wine and PGI)				
n	46	228	30				
%	15.1	75.0	9.9				

Table 3. Distribution of frequencies and percentages of the wines according to the exogenous variables

Ruiz-Moreno *et al.* (2017), Saénz-Navajas *et al.* (2016a) and Dall'Asta *et al.* (2011). By employing the F test in the single factor ANOVA, the statistical dependence or independence between the dependent and independent variables is assessed. The F statistic presented below reflects the degree of resemblance between the means of the categories being compared.

$$F = \frac{\hat{\sigma}_1^2}{\hat{\sigma}_2^2} = \frac{n\sigma_{\bar{Y}}^2}{\overline{S}_j^2}\ ;\ H = \frac{12}{n(n+1)}\sum_{j=1}^{J}\frac{R_j^2}{n_j} - 3(n+1)$$

F statistic* and Kruskal–Wallis test (H)**

*F value = variance of the group means $(\hat{\sigma}_1^2)\big/$mean of the within group variances $(\hat{\sigma}_2^2)$

**R_j = the sum of the ranks for group j

Thus, depending on the F value, the hypothesis of equality of means will be rejected under the condition $p < 0.01$ and, therefore, the dependence relationship between the dependent and independent variable will be demonstrated.

After a significance assessment using Levene's statistic, in case equality of variances can be assumed, a Tukey's HDS post-hoc test was performed to illustrate the direction of the differences I-J of the means. In the case equality of variances is ruled out, a Games–Howell post-hoc test is performed (Toothaker, 1993). Additionally, the assumption of normality tested through Kolmogorov–Smirnov or Shapiro–Wilk statistics is not met in several of the ANOVA proposed, especially when some of the variable categories have fewer than 30 cases. Rejection of the hypothesis of equality of means is then replicated by default through a Kruskal–Wallis or H test. This is a non-parametric technique that need not assume this premise and, consequently, is used as an alternative to ANOVA (Hecke, 2012; Kruskal and Wallis, 1952). Finally, a simple contrast of means was performed since it was not possible to carry out ANOVA when treating the independent dichotomous variables (sugar content and balance) to evaluate the level of significance associated with the F statistic.

Results show the relationship between explicative and independent variables with the scores received by the wines, revealing a mismatch between expert assessments and laboratory analysis in the ranking of wines. In addition, wine GQS show a significant statistical dependence on physico-chemical variables, especially SO_2 levels and volatile acidity. The mean contrasts of the physico-chemical variables with the dependent variables are presented first, followed by the sensory variables, and finally the extrinsic variables.

4. Results and discussion

4.1 Chemical variables and rating scores

Regarding physico-chemical variables (Table 4), laboratory scores reward those wines whose SO_2 content is considered "very good" (average score 4.56 over 5). In parallel, wines whose SO_2 content are considered "bad" (average 3.00 over 5) are penalized. Thus, the highest physical-chemical quality is associated with wines with SO_2 levels below 80 mg/L, which in turn obtain very good GQS (average score 75.14 over 100). On the other hand, the worst physical-chemical qualities are associated with wines with >140 mg/L of SO_2, which in turn obtain worse GQS (average score 61.00 over 100). Our results are consistent with recent research that reported a negative direct effect between high levels of SO_2 and GQS (Golia *et al.*, 2017) and which show a predisposition to pay extra prices on the part of consumers for wines labeled as sulfite-free because they associate headaches with sulfite consumption (Amato *et al.*, 2017). Thus, SO_2 content is a determining factor when evaluating the quality of wine for consumers and the OCU guide considers it to be so.

	SO$_2$-means				ANOVA		Difference in averages (I-J) (Sig. < 0.01)	
Contrast variable	Bad	Acceptable	Good	Very good	*F*	Sig		
Laboratory analysis	3.00	3.97	4.01	4.56	27.540	0.000*	Very good and bad[1]	1.562
Expert rating	76.43	78.20	78.06	77.69	2.759	0.042	*	*
GQS	61.00	71.70	73.91	75.14	15.498	0.000*	Very good and bad[2]	14.141

	Volatile acidity-Means				ANOVA		Difference in averages (I-J) (Sig. < 0.01)	
Contrast variable	Bad	Acceptable	Good	Very good	*F*	Sig		
Laboratory analysis	3.18	4.33	4.42	4.32	10.632	0.000*	Very good and bad[1]	1.135
Expert rating	77.45	77.99	77.66	77.84	0.757	0.519	*	*
GQS	63.00	75.08	74.88	73.44	15.256	0.000*	Very good and bad[2]	10.443

	Alcohol-means			ANOVA		Difference in averages (I-J) (Sig. < 0.01)	
Contrast variable	Low	Medium	High	*F*	Sig		
Laboratory analysis	4.53	4.14	4.36	4.989	0.007**	Medium and Low[1]	−0.39
Expert rating	77.98	77.78	77.78	0.234	0.791	*	*
GQS	74.84	71.93	75.15	8.643	0.000*	High and Medium[1]	3.221

	Sugar-means				
Contrast variable	Dry	Semi-dry	*F*	Sig	
Laboratory analysis	4.31	3.75	6.811	0.009*	*
Expert rating	77.75	77.83	0.027	0.871	
GQS	74.09	69.08	7.418	0.007*	

Note(s): *Kruskal–Wallis test (Sig. < 0.01)/**Kruskal–Wallis test (Sig. > 0.01)
1 = Games-Howell test / 2 = Tukey's HDS test

Table 4.
ANOVA, Kruskal–Wallis test and simple contrast of means (Dependent variables * Chemical variables)

Secondly, laboratory scores reward wines with volatile acidity considered "very good", "good" and "acceptable", i.e. with values ≤ 0.8, and penalize wines with "bad" volatile acidity or with values > 0.8 (average score 3.18 over 5). In addition, as was the case for SO$_2$ levels, volatile acidity significantly influences GQS. That is, wines with worse volatile acidity are penalized in the overall scores (average score 63.00 over 100). High volatile acidities in wines have been considered an organoleptic defect by experts, but not by consumers (Sáenz-Navajas *et al.*, 2015). However, our results show that the expert ratings do not present significant differences for this variable, and volatile acidity is only penalized at the physico-chemical level, although in a decisive way since it affects the GQS in a similar fashion to SO$_2$ levels.

Results of the ANOVA and Kruskal–Wallis test show that the difference between these means is highly significant (p < 0.01). Therefore, the physico-chemical variables strongly differentiate the evaluation of the GQS according to the amount of SO$_2$ and volatile acidity. Regarding sugar level, a simple contrast of means is significant. Dry wines with <4 g/L receive better laboratory scores (average score 4.31 over 5) than semi-dry wines (average score 3.75 over 5) as well as GQSs (average score 74.09 over 100 for dry wines and 69.08 over 100 for semi-dry wines). The issue of sugar is controversial in wine as there is no labeling of nutritional values. Thus, sugar levels are unknown to the consumer and also whether it is residual sugar resulting from the fermentation process or from chaptalization, i.e. the addition of sugar during fermentation to increase alcohol content, a practice authorized in several regions of Europe under unfavorable climatic conditions (Parga-Dans and Alonso González, 2017). Most consumers are unaware of the caloric intake of wine, although several studies show that a greater knowledge of the nutritional properties of wine is relevant to generate a better understanding of the relationship between wine and health (Annunziata *et al.*, 2016; Pabst *et al.*, 2019). For example, the absence of information in this regard can pose a risk to the diabetic population.

Finally, wines with lower alcohol content receive better scores in the laboratory evaluations (average score 4.53 over 5) than wines with medium and high alcohol content. However, there was no association in relation to GQS and the Kruskal–Wallis test, which does not corroborate a significant difference in means in this analysis. On this matter our results differ from those of Golia *et al.* (2017), who found a positive influence on overall wine rating as alcoholic strength increased. This indicates that the trend that dominated the 1990 and 2000s for very alcoholic wines, in the wake of Parker's wine guide (Hommerberg, 2011), does not hold sway among today's wine experts. Perceived healthiness is becoming a determinant driver among wine consumers, including the preference for wines with reduced alcohol content (Bucher *et al.*, 2018).

Another remarkable finding is the independence of the tasting notes in relation to wine's objective intrinsic qualities. This is confirmed by the non-significant difference of means in the ANOVA and Kruskal–Wallis tests. That is, the best score obtained by the tasting panel for the set of sensory variables lacks correspondence with the laboratory scores for those same variables. The highest average tasting scores are found in wines with acceptable SO_2 levels (average score 78.20 over 100) and acceptable volatile acidity levels (average score 77.99 over 100) as well as in semi-dry wines (average score 77.83 over 100). There is also no correspondence between tasting scores and GQSs for the chemical variables and no significant differences between means. This confirms that the sensory rating shows independence from the physico-chemical assessment of the wine. So, what are the variables that explain sensory scores?

4.2 Sensory variables and rating scores

The mean contrasts between sensory variables and expert ratings reflect a clear interdependence, all of them significant ($p < 0.01$) following ANOVA and Kruskal–Wallis tests (Table 5). Expert perceptions of aroma, intensity, acidity, persistence and bitterness show significant distances between the means I-J of their categories, for both low and high ratings. The more aromatic (average score 82.14 over 100), intense (78.74 over 100), acidic (78.30 over 100) or persistent (79.34 over 100) a wine is in the mouth, the higher the tasting score. The situation is reversed in the case of bitterness. A wine receives a better tasting score the lower the perception of this quality is in the mouth (average score 78.15 over 100). Finally, wines in which balance is perceived are better rated than those lacking this attribute (average score 78.75 over 100).

Sensory variables reveal a lower weight in the GQS than the physico-chemical variables. Nevertheless, there is a statistical dependent relationship between GQS and the variables intensity and persistence, as shown by the ANOVA and Kruskal–Wallis tests ($p < 0.01$). The higher the sensory intensity and persistence, the better the GQSs (average scores 75.75 and 75.77 over 100). The lower the intensity and persistence, the worse the overall scores (average scores 73.01 and 72.74 over 100). Previous research has associated quality as perceived by experts to the construction of common mental representations related to organoleptic qualities (visual, aromatic and gustatory) that depend more on the perceptual and cognitive information received during the tasting than on a collection of independent stimuli (Sáenz-Navajas *et al.*, 2016a). Olfactory stimuli show a greater relevance in the concept of overall

Contrast variable	Aroma-means Low intensity	Medium intensity	High intensity	ANOVA F	Sig	Examples	Difference in averages (I-J) (Sig. < 0.01)
Laboratory analysis	4.39	4.29	4.36	0.599	0.550	*	*
Expert rating	76.22	78.12	82.14	151.359	0.000*	High and Medium intensity[2]	5.928
GQS	73.25	74.18	78.57	4.451	0.012	*	*

Contrast variable	Intensity-means Low	Medium	High	ANOVA F	Sig	Examples	Difference in averages (I-J) (Sig. < 0.01)
Laboratory analysis	4.28	4.36	4.36	0.426	0.653	*	*
Expert rating	77.37	76.90	78.74	30.138	0.000*	High and Low[1]	1.374
GQS	73.01	73.90	75.75	6.452	0.002*	High and Low[1]	2.737

Contrast variable	Bitterness-means Low	Medium	High	ANOVA F	Sig	Examples	Difference in averages (I-J) (Sig. < 0.01)
Laboratory analysis	4.36	4.24	4.33	0.877	0.417	*	*
Expert rating	78.15	77.58	76.30	15.031	0.000*	High and Low[2]	−1.850*
GQS	74.93	72.90	73.04	3.826	0.023	*	*

Contrast variable	Acidity-means Low	Medium	High	ANOVA F	Sig	Examples	Difference in averages (I-J) (Sig. < 0.01)
Laboratory analysis	4.32	4.30	4.33	0.047	0.954	*	*
Expert rating	76.96	78.05	78.30	18.066	0.000*	High and Low[2]	1.343
GQS	73.15	74.74	74.50	1.822	0.163	*	*

Contrast variable	Persistence-means Low	Medium	High	ANOVA F	Sig	Examples	Difference in averages (I-J) (Sig. < 0.01)
Laboratory analysis	4.27	4.34	4.36	0.444	0.642	*	*
Expert rating	76.75	77.80	79.34	89.933	0.000*	High and Low[2]	2.593
GQS	72.74	74.59	75.77	6.891	0.001	High and Low[2]	3.029

Contrast variable	Balance-means No	Yes	F	Sig
Laboratory analysis	4.32	4.32	0.004	0.951
Expert rating	77.40	78.75	41.575	0.000*
GQS	73.65	75.29	4.542	0.034

Note(s): *Kruskal–Wallis test (Sig. < 0.01)
1 = Games-Howell test / 2 = Tukey's HDS test

Table 5. ANOVA, Kruskal–Wallis test and simple contrast of means (Dependent variables * sensory variables)

quality, especially with regard to the absence of aromatic defects related to animal or vegetable nuances (Sáenz-Navajas *et al.*, 2011). However, experts' scores show significant discrepancies in most attributes. This is especially true for the perception of taste quality, which highlights the need to develop other operational tools to describe a wider range of flavors (Gawel *et al.*, 2001). Inconsistencies in the perception of quality by tasting panels may be due to the fact that they are not trained to detect wine's intrinsic objective qualities such as their SO_2 levels, volatile acidity, sugar levels or alcohol content, despite some compounds being particularly important for consumers (D'Amico *et al.*, 2016). Some sensory experiments have already demonstrated that tasters can be trained to detect pesticide residues in wines (Douzelet and Séralini, 2018). This shows that doing so or not with other compounds present in wine depends on an epistemic decision by experts and not on practical impossibility.

Lack of coherence between the physico-chemical and sensorial assessments of wine quality is highly relevant in the case of OCU's guide, given that the information provided by tasting experts does not help to reduce the asymmetry of information in the wine market. Since the OCU contradictorily offers a low-quality chemical assessment of those wines that receive better scores in the sensory assessment, it is not guaranteeing independent neutral information to consumers. A more complete and constructive evaluation for consumers could be provided by expert tasters trained in the detection of SO_2 content and other wine additives, or by providing secondary side-information such as laboratory analysis to those same experts (Sader *et al.*, 2020). This would be essential for consumer organizations to reduce information asymmetries between producers and consumers.

4.3 Extrinsic variables and rating scores

Regarding extrinsic variables (Table 6), neither price nor type of certification of origin significantly differentiate the averages of the three dependent variables (physico-chemical rating, tasting score and GSQ).

A wine with a DOC or other DO does not obtain a better rating than a wine with a PGI or table wine. Nor does a wine obtain a better rating if its market price is higher. Thus, our results do not show a correlation between wine quality, price and certification of origin, as previous studies have suggested (Skuras and Vakrou, 2002). The value of theoretically value-added labels such as designations of origin is outweighed by other indicators, in line with the context of crisis and reformulation of the Spanish and international systems for the certification of origin (Alonso González and Parga Dans, 2018).

Examining regions of origin, the significant mean contrasts are located in the physico-chemical ratings and, consequently, in the GQS of the wines. In both contrasts, the Eastern region is best rated (average score 4.61 over 5 in laboratory scores and 75.73 over 100 in GQS) and the lowest rated is the North-Western (average score 3.80 over 5 in laboratory scores and 70.80 over 100 in GQS). In fact, the distance between the I-J means attributed to these two regions in the laboratory scores is highly significant. This makes sense since the eastern region oriented toward the Mediterranean enjoys better climatic conditions for obtaining healthy grapes, which require the use of fewer additives in the winery. This contrasts with the Atlantic-facing northwest, which is colder and rainier in general terms and has widely ranging plant health conditions. A striking conclusion in line with our argument is that the average expert tasting scores are inverted. The Northwest is considered the best rated region of origin, with no statistical significance in the mean contrasts.

As for wine types, sparkling wines obtain a better rating in both physico-chemical (average score 5.00 over 5) and tasting scores (average score 78.75 over 100), and therefore in their GQS (average score 78.50 over 100). The mean contrasts are significant for the three types of contrasts. The greatest distance between means I-J is found between sparkling and white wines both for laboratory scores (from 3.96 to 5) and GQS (from 70.22 to 78.50). Indeed, it would be interesting to delve deeper into the qualities of sparkling wines in relation to other types to understand their positive evaluations both at a physico-chemical and sensory level. They receive the highest GQS and whites the lowest. This is so despite whites obtain the second best tasting ratings (average score 78.74 over 100) only after sparkling wines (average

Table 6. ANOVA, Kruskal–Wallis test and simple contrast of means (Dependent variables * extrinsic variables)

Contrast variable	Wine type-Means White	Rosé	Red	Sparkling	Amusing	Organic	Single-vineyard	ANOVA F	Sig	Difference in averages (I-J) (Sig. < 0.01)	
Laboratory analysis	3.96	4.57	4.36	5.00	4.08	4.54	4.44	7.245	0.000*	Sparkling and White[1]	1.043
Expert rating	78.74	77.71	77.70	78.75	77.63	77.13	77.69	4.464	0.000*	Organic and Sparkling	−1.620
GQS	70.22	76.71	75.21	78.50	72.98	74.92	73.94	6.340	0.000*	Sparkling and White[1]	8.283

Contrast variable	Region-means Northwest	Center	Northeast	East	South	ANOVA F	Sig	Difference in averages (I-J) (Sig. < 0.01)	
Laboratory analysis	3.80	4.29	4.26	4.61	4.00	7.325	0.000*	East and Northwest[2]	0.808
Expert rating	78.76	77.86	77.79	77.56	76.50	3.088	0.016	*	*
GQS	70.80	74.13	73.86	75.73	71.50	3.519	0.008*	East and Northwest[1]	4.934

Contrast variable	Price-means Very low	Low	Medium	High	ANOVA F	Sig	Difference in averages (I-J) (Sig. < 0.01)	
Laboratory analysis	4.37	4.26	4.31	4.33	0.319	0.812	*	*
Expert rating	77.55	77.56	77.93	78.21	2.486	0.061	*	*
GQS	74.60	73.04	74.34	74.61	1.116	0.343	*	*

Contrast variable	Certification of origin-Means DOC and single vineyard	DO	Other (table wine and PGI)	ANOVA F	Sig	Difference in averages (I-J) (Sig. < 0.01)		
Laboratory analysis	4.15	4.34	4.40	1.519	0.221	*	*	*
Expert rating	77.52	77.89	77.63	0.978	0.377	*	*	*
GQS	73.11	74.35	74.17	0.761	0.468	*	*	*

Contrast variable	Organic wine-Means No	Yes	F	Sig	
Laboratory analysis	4.26	4.57	8.901	0.003	*
Expert rating	77.93	77.33	5.393	0.021	
GQS	73.93	75.03	1.525	0.218	

Note(s): *Kruskal–Wallis test (Sig. < 0.01)
1 = Games-Howell test / 2 = Tukey's HDS test

score 78.75 over 100), which can be explained by the fact that white wines often present higher levels of SO_2 and other additives.

Another significant result is that the lowest tasting scores are given to organic wines (average score 77.33 over 100). This differs from the study by Delmas *et al.* (2016), who show that organic certification is associated with a statistically significant increase in wine experts' quality ratings. Our results are in line with previous research about the confusion surrounding organic certification among consumers and tasters alike (Alonso González and Parga-Dans, 2020a, b; Migliore *et al.*, 2020). Evaluating organic certification as an extrinsic variable, independently of wine type, such wines receive better laboratory ratings (average score 4.57 over 5) and their average differs significantly from non-organic wines. However, expert tasters rate non-organic wine higher (average score 77.93 over 100), although the contrast of averages is not significant.

Owing to the weight of the physico-chemical analysis, the GQS for organic wine (average score 75.03 over 100) is higher than for conventional wine (average score 73.93 over 100), although the simple contrast of means is not significant. Thus, the results confirm that organic wines can offer quality advantages over conventional ones under objective measurements and in terms of health benefits (Yiridoe *et al.*, 2005). This is so despite experts giving organic wines lower rankings than conventional wines, although again the simple contrast of means is not significant. Definitely, expert intra-knowledge is not geared toward identifying sensory aspects exhibited by healthier wines in response to the demands of various consumer segments, although this would be possible through specific training. In fact, consumer research has pointed out that consumers generally consider a food product to be of higher quality if it has a lower number and variety of ingredients (Petrescu *et al.*, 2020). Wine guides issued by consumer organizations pave the way for the disclosure of wine additives. However, so far, the few existing studies on such guides have disregarded consumer demands and instead focused primarily on what wines winemakers should produce to attain good ratings (Brentari *et al.*, 2011; Golia *et al.*, 2017; Levaggi and Brentari, 2014).

5. Conclusions

Our examination successfully responded to the initial research aim, namely to address a research gap concerning the extent to which specialized wine tasters are able to connect their subjective perceptions with the intrinsic qualities of wine. By exploring the 2020 edition of the Spanish OCU wine guide, we conclude that subjective intrinsic factors or sensory perceptions differ from the objective intrinsic factors or laboratory analysis in the determination of wine quality. Findings show that wine GQS has a significant statistical dependence on physico-chemical variables, especially SO_2 levels and volatile acidity and on the sensory variables about intensity and persistence.

These results call for the use of additional or supplementary information in wine evaluation, to ensure providing better information to consumers and minimizing information asymmetries derived from the lack of ingredient labeling. In parallel, this article presents practical implications at the sectoral level. First, the role of consumer organizations could be very significant in reducing information asymmetries by providing information on substances perceived negatively by consumers such as additives, processing aids or toxic residues. Their guides could also incorporate information about other positively perceived compounds such as polyphenols, tannins or flavonoids. Thus, OCU's wine guide moves a step forward in mitigating the information asymmetry prevailing in the wine sector. Winemakers can also benefit from this research. According to our results, their wines must present low levels of added SO_2, sugar, alcohol and volatile acidity in order to attain better rankings in the guide. Wineries can look for the manifold technical alternatives to SO_2 for winemaking

(Hou *et al.*, 2020), and adapt their marketing strategies to offering SO_2-free or low-SO_2 wines that are in growing demand in different markets (D'Amico *et al.*, 2016; Jones and Grandjean, 2018). Finally, regulatory bodies and designations of origin could better connect with consumer demands for transparency and nutritional information by offering data on SO_2 levels or volatile acidity in labels, technical sheets or online platforms. This shows that consumer demands and purchase intentions can be the trigger for cause-related marketing strategies that are beneficial for companies, non-profit organizations and society as a whole (Ferraris *et al.*, 2019).

The main limitation of this study is the lack of longitudinal data. Our research draws upon the data set included in the 2020 OCU wine guide, the first to include organic wines, creating a potential bias in data analysis. Further research should examine future editions and compare them with international consumer wine guides. Another strand of research should focus on the gap found after the narrative-descriptive rhetoric that dominates wine assessment and critique is contrasted with objective wine parameters. Further research should explore the consequences of making the results of laboratory analysis available to expert tasters: would this side information change the tasting score received by the wines? More information should be offered about objective intrinsic wine parameters. This would certainly assuage the information asymmetry and diminish the adverse selection problems that currently pervade the wine sector.

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