Current Research Related to Wine Sensory Perception Since 2010

Jiyun Yang [1] and Jeehyun Lee [2],*

[1] Department of Food Science and Nutrition, Pusan National University, Busan 46241, Korea;
    jiyunyang@pusan.ac.kr
[2] Department of Food Science and Nutrition and Kimchi Research Institute, Pusan National University,
    Busan 46241, Korea
*   Correspondence: jeehyunlee@pusan.ac.kr; Tel.: +82-51-510-2784

Abstract: Due to socioeconomic changes, the demand for and interest in alcoholic beverages have recently been increasing. Among various alcoholic drinks, consumer preference for wine could be varied. It might be related with its complexity, as wine is known to have characteristics that are difficult to understand. Several factors, such as intrinsic or extrinsic factors interact to influence wine complexity and consumer perception. Many studies have been conducted to understand the complexity of wine, allowing deeper insight into its perception by consumers. Studies over the last decade on wine sensory perception using descriptive analysis and consumer tests were reviewed. Additionally, chemical analysis studies were included because flavor constituents information would contribute to a better understanding of sensory perception. Descriptive sensory analysis of wine was reviewed considering panels and flavor characterization for better understanding wine-related research. Several consumer studies regarding liking/preference, emotion, context, and extrinsic factors to understand consumer preference or perception were reviewed. Research on chemical constituents may affect consumer perception and is thus presented in this review. However, most of the research was focused on a narrow range of wine, thus is missing overall wine category evaluations. Furthermore, evaluations were mainly in wine-producing countries, resulting in limited understanding of an emergent market. This review will help guide wine researchers and industry by providing information on factors influencing consumer wine perception.

Keywords: wine; sensory evaluation; complexity; descriptive analysis; consumer; chemical analysis

---

1. Introduction

Wine is an alcoholic beverage made by fermenting wine grapes, particularly Vitis vinifera L. [1]. The top five wine producing countries are Italy, France, Spain, United States, and Argentina in 2013–2018 [2]. Recently, consumer preference for alcoholic beverages, especially wine, appears to be more affected by globalization, mixed cultures, or the open trade market rather than regional tradition [3–5]. In addition to globalization, economic change and the pursuit of pleasure may also have influenced regional drinking patterns [6,7]. These changes have occurred due to the blurring of the borders between nations and cultures [8]. In recent decades, the international wine trade has grown markedly [2]. Its growth was caused by increasing wine consumption in Northern Europe, North America (in the 1990s), and Asian countries [9,10].

Consumers have historically drunk wine for hedonic pleasure [11] and to experience the wide spectrum of sensations when drinking [12]. Perceived wine quality by consumers could be linked to their hedonic liking [13], while a preference for or liking of wine is quite different. In addition, the wine products range from economy to premium, ultra-premium, and artisan by economic value.

However, consumers have high expectations for good-quality wine products, regardless of the price [14]. Consumer research could provide meaningful information regarding factors that influence consumer preference, their purchase intent, and their opinion towards various styles of wine [15–18].

The sensory characteristics of wine, such as color, aroma, and mouthfeel, are closely linked to wine quality, which is hard to define because of its complexity and multidimensional aspects [11,19]. Furthermore, the quality of wine is difficult to pinpoint due to its quasi-aesthetic characteristics and relationship to personal taste [20]. Unlike the past generation, knowledgeable and empowered consumers with a sophisticated understanding of product value and the ability to discriminate quality expect that both intrinsic and extrinsic factors meet their liking [14]. Hofer and Heymann [19] mentioned that though wine quality has several dimensions, such as extrinsic and intrinsic factors, it is also highly variable itself. Several studies based on sensory evaluation such as descriptive analysis have been carried out to better understand wine quality and its characteristics. In some cases, volatile analysis was conducted to give additional information of wine perception.

Among the various characteristics of wine, many researchers consider "complexity" to be one of its most important aspects to understand wine itself and consumer perception [15,21,22]. Complexity appears to be linked with perception of quality and/or consumer liking [23,24]. Familiarity is a factor which can play an important role in the relationship between chemical and perceived complexity [25]. Analyzing wine complexity is a cognitive and multidimensional process, requiring detailed sensory analysis to separate the various aromatics, taste, and trigeminal stimulation components [11,21]. Complexity is therefore regarded as a positive aspect [21] and desirable characteristic of wine [26]. However, despite the fact that it is an indispensable element of wine, it is considered difficult for naïve consumers to understand.

Wine aroma is one of the main factors contributing to the quality and allows one to distinguish a variety of wines [27]. A multicomponent mixture aroma can be integrated and regarded as a single concept, described as "complex" [21].

Many studies have been conducted to understand the characteristics and complexity of wine. Additionally, many researchers seek to understand which characteristics influence the preference for and perception of wine by consumers. Research has also sought to determine whether consumers could differentiate attributes of wine, in addition to investigating how to find other factors that affect wine perception. Review papers relevant to consumer sensory science [28], combining consumer science and marketing [29], red wine astringency [30], cross-cultural studies [31], wine polyphenols [32], and mouthfeel perception [33] were published previously. These reviews covered specific topics and were very informative, but there is no comprehensive review that has dealt with studies related to sensory wine perception. Since wine is a complex alcoholic beverage, several factors were researched as to whether they affect consumers' perception. Reviewing what has been conducted can provide general consensus of the influence of each factor studied, and perhaps could show future research directions to improve consumers' acceptability of wine considering what other researchers considered important, and conducted studies recently are also an important part. Thus, the purpose of this review paper was to critically summarize the most recent 10 years' research progress on wine sensory studies and other studies which could help understand consumer perception of wine. To provide classified finding information, three subtopics were set as follows: descriptive sensory analysis (e.g., panels; flavor characterization), consumer studies (e.g., liking/preference; emotion; context; extrinsic factors), and chemical analysis. Rather than reviewing methodology, factors that might affect wine perception were categorized in each subtopic.

Since consumers' preference and demand keep changing, research conducted in recent years might provide more relevant information. Therefore, this paper reviewed wine sensory evaluation research focused on publications after 2010, including descriptive analyses and consumer studies. Several chemical analyses related to wine perception were also investigated as supplementary information. The literature was searched from Google Scholar (https://scholar.google.com/) using keywords which were "wine sensory perception", "wine descriptive analysis", "wine consumer

preference", "wine complexity", "wine sensory evaluation", "wine sensory volatile", and "wine sensory chemical". Among numerous studies, articles corresponding to each of subtopic were selected. This review will provide an overview of the sensory evaluation of wine, in addition to any related or useful academic insight into the wine industry and researchers.

2. Descriptive Sensory Analysis

2.1. Panels

Sensory analysis of wine should ideally be carried out by a trained panel to obtain accurate and reliable sensory data [34]. Sensory properties show the perceived differences amongst the samples and can be related to the hedonic responses of consumers [28]. Thus, a consumer-based trained panel has been advocated as best practice because they use consumer-relevant and non-technical-based language [35]. After a series of training and practice sessions including lexicon development, panelists evaluate and rate the attribute intensity of the samples [28] and are not asked to indicate liking or acceptability [36]. However, most wineries still rely on the judgement and opinion of wine experts [37] as opposed to general descriptive analysis conducted by a trained panel. It may be related to that novices find evaluating and detecting differences in wine quality difficult [38], but wine experts commonly screen wines and award a quality score to give a useful indication to consumers [19].

There are different perspectives on which panel would be more suitable for wine descriptive sensory analysis. Trained panels screened by their discriminative ability are specialized for descriptive analysis and typically participate in several training sessions to further develop their discrimination ability [39]. However, in some cases, wine experts were considered as having a better ability to describe and evaluate wine due to wine complexity [34,40,41]. In addition, experts enable to identify wine defects and evaluate how a wine typifies the variety, region, or style it represents [42]. Parr et al. [43] defined the term "experts" as including wine makers, wine-science researchers and teaching staff, professionals (e.g., wine master; wine judges; wine writers; wine retailers), graduate students who majored in viticulture and oenology, or individuals otherwise highly involved with wine. Maitre et al. [44] categorized panels by level of expertise, such as wine producers (working with the product), sensory assessors (tasting the products), a consumer group involving consumers (tasting for pleasure), and experienced consumers (looking for expertise).

Studies have been conducted to compare the discrimination and evaluation ability of trained panels. These aimed to determine their expertise regarding wine quality or characteristics, including complexity and astringency [19,34]. Hopfer and Heymann [19] compared the ability of experts and trained panelists to judge wine quality using 27 Cabernet Sauvignon wines based on the California Wine Competition awards. The evaluation process was different between the two judging groups. Descriptive analysis of the samples was conducted only by a trained panel, which developed terminology and evaluated the intensity of the characteristics. However, experts evaluated quality by dividing samples into five quality categories, ranging from the lowest to the highest quality. When comparing discriminative ability, the trained panel group showed a balanced profile with detectable differences between attributes, while the expert group had high inconsistency among wine judges. Vidal et al. [34] compared the assessment ability of trained assessors and experts based on astringency using six Tannat wines. In their study, both panels could discriminate samples, but trained assessors showed higher ability to discriminate sample astringency. The study mentioned that this may be linked to the training level of the panel and their familiarity with the evaluation process and attribute terms. Furthermore, when experts were asked to focus on only one characteristic, the halo-dumping effect may have occurred. The halo-dumping effect could occur when evaluating a sample that can evoke a mixture of sensations using only one intensity scale. Since the subject is forced to use only one question for two sensations, the second sensation is "dumped" onto the only available scale [45].

Unlike previous studies demonstrating that experts had greater ability to distinguish wine quality than novices [46–49], the aforementioned research showed that trained panels had better evaluation techniques. This may be explained by the fact that the studies did not just involve wine categorization, but also sensory evaluation involving developing sensory terms and rating intensities. Experts are known to evaluate wine based on their wine experience and knowledge [19,34,50], but this tendency may lead them to assess subjectively and inconsistently. To obtain reliable assessment by wine experts, it is crucial to advance their ability to objectively measure the sensory characteristics of wine [51]. To close the gap between the two types of panels, sensory training sessions will be needed to familiarize experts with descriptive analysis. Second, sufficient time and knowledge should be provided in the training session for descriptive panelists. A consumer-based trained panel has been recommended as the best option for enhancing validity, in addition to assessing relationships with consumer liking data [35].

Thus far, consensus has not been reached regarding whether trained panelists or wine experts are more appropriate for evaluating wine. A descriptive sensory study is conducted with a highly trained panel to objectively evaluate the attributes of the samples and their intensity. However, wine is considered as a very difficult beverage to evaluate due to its complex flavors, alcohol content, and the high knowledge requirements. Overall, the trained panel who were not wine experts had strengths in objectively evaluating samples, but lacked wine-related experience or knowledge. Conversely, experts appeared to have difficulty in objectively evaluating samples, but had abundant wine experience and knowledge. Although experts have some advantages and still participate in evaluation of the related field, the trained panel participating in traditional descriptive analysis would be more appropriate for evaluating wine. However, sufficient education and exposure to wine are required prior to evaluation in order to acquire knowledge and experience.

2.2. Flavor Characterization

Descriptive analysis is generally conducted for generating an attributes list of samples and then identifying the factors that most influence the sample characteristics, combined with consumer data. In most cases, panelists develop and evaluate overall characteristics. However, for wine, some specific attributes such as astringency, bitterness, or mouthfeel were evaluated because of their complexity. Different types of wines were evaluated for discrimination between samples, such as red wine [19], white wine [52,53], rosé wine [54], and sparkling white wine [15]. Other studies focusing on a specific attribute, such as astringency [34,55] or bitterness [56], were also conducted.

In those studies, different numbers of samples and ranges of attributes were evaluated. Except for sparkling white wine, most of those studies evaluated more aroma attributes than flavor or taste characteristics. This could potentially be because aroma is considered as an important factor of wine quality. In the study focusing on red wine [19], oak, sweet, and red/dark fruit aromas were positively correlated with quality, while brett, chemical, earthy, fresh/canned vegetable, and sulfur aromas showed a negative correlation with quality scores. In the white wine studies [52], different attributes were evaluated than those in the red wine studies. There were more fruity and floral attributes, and some different characteristics such as petrol and tropical fruit were included. Each sample was related to different attributes, and thus panelists could discriminate differences between samples despite their complexity. In a study comparing the mineral properties of white wine [53], mineral aroma was positively related with a chalky, reduced, and grassy aroma and bitter taste. However, it was negatively associated with ethanol taste and barrel, petrol, and fruit aromas. Rosé [54] and white sparkling wines [15] also had sensory differences in each sample. Interestingly, the characteristics of rosé wine were similar to those of both white and red wine, but white sparkling wine had more similarities to white wine attributes.

Astringency is a major contributor to the perceived quality and complexity of red wine and is regarded as one of the most complex mouthfeel sensations [30,34,57]. Astringency can be defined as a complex tactile sensation related to drying, puckering, and roughing of the mouth epithelia [58]. It is widely known that the phenolic compounds of red wine and their interaction with salivary proteins are closely related to astringent perception [59,60]. Moreover, other tastes such as bitterness, sourness, and even sweetness are able to modulate overall perception of astringency [61]. In a study made by Vidal et al. [34], wine astringency was evaluated by a time-intensity task, and check-all-that-apply (CATA) questions were assessed. Astringency was related to quality score and was highly associated with the complex and suede astringency subqualities. Rinaldi and Moio [55] analyzed the astringency intensities and subqualities of tannin-added wine. They mentioned that pucker, aggressive, adhesive, and dry attributes were negatively associated with astringency perception, whereas it was positively associated with the full-body, rich, and mouthcoat subqualities. Due to the use of different samples and the purpose of the studies differing, no consensus was achieved between the results of both studies. In further studies, it may be desirable to use the same terms for astringency subqualities.

Bitterness is also a major characteristic of wine, in addition to other properties such as sweetness or sourness [56]. Noticeable bitterness can be considered by consumers to be a negative property [56,62]. Sokolowsky and Fischer [56] conducted a study to compare methods for defining wine bitterness among descriptive analysis (DA), time–intensity (TI) analysis, and temporal dominance of sensation (TDS) analysis. Bitterness had a significant and positive correlation with the concentration of wine components, especially ethanol. DA was able to evaluate only the bitterness itself without being affected by other properties. TI could reflect the exact information of the properties related to time passing. However, as TI focused only on bitterness, a halo-dumping effect may have occurred. TDS demonstrated the average sequence of sensations, but as it does not measure intensity, it must be used in conjunction with other methods. It was recommended to combine all aforementioned methods and correlate with analytical measurements to facilitate a comprehensive understanding of bitterness which is a complex perception of wine. When this is not possible, a traditional descriptive sensory method, flavor profile, could be considered as it has "order of attributes perceived" and "aftertaste" aspects in addition to aroma and flavor-by-mouth [63].

Ethanol, the main component of alcohol in wine, is known to influence wine sensory profiles [64,65]. Ethanol concentration in wine is relevant to aroma, flavor, and mouthfeel [63–67]. In the study of Villamor et al. [66], an increased ethanol concentration in wine positively affected bitterness, burning sensation, and chemical/woody/spicy aroma and flavor. On the contrary, it negatively affected fruity, floral, and caramel aroma/flavor. Similarly, King and Heymann [68] showed a positive correlation between alcohol concentration and overall aroma intensity and hot mouthfeel. King et al. [65] also demonstrated the effect of alcohol concentration on the sensory perception using DA. In their study, alcohol had a positive relationship with bitterness, astringency, burning sensation, and mouthfeel sensation such as sharp and gritty, whereas a negative relation was shown between alcohol and fresh fruit and floral aromas. They also mentioned that tasting order by alcohol level may affect wine perception. Though the studies of King and Heymann [68] and King et al. [65] were about alcohol concentration, ethanol is expected to have a similar influence on other attributes of wine.

Studies carrying out descriptive analysis of wine were conducted focusing on specific attributes regarded as dominant aspects of wine, such as astringency, bitterness, or component (e.g., ethanol). The reason for this may be that these characteristics contribute to the complexity of wine and could affect consumer perception of wine as being difficult to understand. Though numerous descriptive sensory studies on some factors aforementioned in the text and mentioned in Table 1 were conducted in the past, more current DA studies paired with consumer acceptability would be helpful to understand present consumers because consumer preferences and wine market trends are dynamic.

Table 1. Study details and information of descriptive sensory analysis.

Category	Study Details—Sample, Methods	Other Information
Panel performance comparison	27 Cabernet Sauvignon wine from California [19]	15 trained panelists 27 experts
	6 Uruguayan Tannat wine [34]	9 trained panelists 27 professionals
Flavor evaluation/Lexicon development	27 Cabernet Sauvignon wine from California [19]	15 trained panelists 27 attributes
	5 Godello white wines manufactured [52]	7 trained panelists 12 attributes
	19 white wines [53] 4 Chardonnay, 3 Pinot gris, 5 Riesling 7 Sauvignon blanc	25 trained panelists 25 attributes
	26 Australia rosé wine [54]	12 trained panelists 25 attributes
	50 Australian sparkling white wines [15]	10 trained panelists 17 attributes
Astringency only evaluation	6 Uruguayan Tannat wine [34] Evaluate "astringency" using TI [1] task 24 red wine [55] 4 variety * (3 tannin * 2 concentration + 2 control)	9 trained panelists 16 subqualities 13 trained panelists 16 subqualities
Bitterness only evaluation	13 dry white wines [56] Evaluate "bitterness" using TI [1], TDS [2] task	18 trained panelists Intensity/persistency
Ethanol/alcohol effect on perception	36 samples [66] Combined levels of factor 11 Chardonnay wine [68] 1 original and 10 regulated alcohol concentration 24 wines [65] 14 Cabernet Sauvignon and 10 blended	12 trained panelists 12 attributes 12 trained panelists 18 attributes 34 trained panelists (2 groups) 34 attributes

[1] TI means time–intensity. [2] TDS means temporal dominance of sensation.

Different descriptive panels with different cultural backgrounds may use different terms to describe the characteristics of wine because of their languages, food culture, or experiences. In the cross-cultural DA studies of wine, there were differences between panels on verbalization by cultural background of French and Spanish [69], or perception of minerality by the different wine histories and production styles of France and New Zealand [70]. To elucidate general information regarding wine, more studies with considerations such as evaluating new products or panels from emerging markets in Eastern countries are required because the previous studies were focused on Western countries.

3. Consumer Studies

Consumers can be divided into subgroups by familiarity with wine, such as familiar and unfamiliar consumers [71,72]. The authors defined unfamiliar consumers as individuals "without any formal training or much exposure to product" and familiar consumers as those "without any formal training but with regular exposure to product" [72]. The common feature of these groups is that each individual has their own preference for consumer products, including wine. Consumer tests to measure the degree to which they like and dislike products are conducted with naïve consumers [39]. As diverse factors such as emotion, context, or extrinsic cues can affect consumer liking or perception, research was conducted considering the following factors: elicited emotion during consumption of wine, context effect of place, lighting, and music, and extrinsic factors such as price, label, brand, cultivar, and origin, among others. Furthermore, wine with different characteristics can influence both consumer liking and the emotion elicited [73,74]. The intention of this consumer studies part is to summarize and organize various consumer studies of wine from these aforementioned perspectives. The brief information of those studies is shown in Table 2.

Table 2. Study details and information of consumer tests.

Category	Study Details Sample and/or Methods	Consumer Information	Factors
Consumer Liking/Preference	6 Australian sparkling white wines [15]	150 consumers in Australia 4 subgroups	
	27 Cabernet Sauvignon wine from California [19]	174 consumers in US 4 subgroups	
	2 white wines from Portugal [75] Temporal liking	80 consumers in Portugal	
Emotion elicited from wine consumption	12 Australian Shiraz wine [73] (3 different set of 4 wines)	360 consumers in Australia evoked emotion using 19 terms	
	4 treated wines [76] (2 astringency level × 2 body level)	112 consumers in Australia evoked emotion using 10 terms	
	2 white wines from Portugal [75] Temporal dominance of emotion (TDE)	80 consumers in Portugal evoked emotion using 10 terms	
	6 commercial wines [8] (2 white, 1 rosé, 3 red)	208 consumers in Spain evoked emotion using 26 terms	
Influence of evaluation context	12 Australian Shiraz wine [73] (3 different set of 4 wines)	360 Australian consumers	3 places (lab/restaurant/home)
	A glass of red wine [77]	1580 consumers (Exp.1) in UK 1309 consumers (Exp.2) in UK	Controlled lighting and music
	4 wines (2 white/2 red) [78]	24 consumers (Exp.1) in UK 26 consumers (Exp.2) in UK	Differed on background music
Influence of extrinsic factors	21 commercial Australian Shiraz wine [79]	426 consumers in Australia	Price
	16 combination (back label) [80]	910 US consumers	Back label information
	11 attributes [81] (10 statements + price)	331 consumers in Australia	Back label information
	4 wines [82] (1 for blind)	521 German consumers	Brand, cultivar, packaging, region
	16 wine labels [83]	304 consumers in Australia	Price, region
	275 wines [84] (used bottle weight information only)	150 consumers in Spain (collect demographic and quality perception)	Price, bottle weight
	24 Chardonnay wines [85]	48 consumers in France	Origin, label, bottling, awards

3.1. Liking/Preference

Consumer liking or preference represents the interaction between humans and foods [86] and is closely linked with intent to purchase products. General consumer tests are conducted to analyze and compare the liking score between sample sets. For wine studies, consumer evaluations from various perspectives have also been conducted such as studies considering consumer subgroups, clusters, or demographic data, or time-related studies. Many factors must be considered due to the complexity of wine, with the involvement of sensory attributes including intrinsic/extrinsic factors and others such as target consumers and methods.

For understanding consumer opinions, cluster analysis was performed to identify consumer subgroups with different preferences [87–89]. Culbert et al. [15] investigated consumer acceptance of Australian sparkling white wine and determined subgroups showing different preferences. The younger consumer group preferred fruit-forward style wines, while the older group preferred those with more complexity. In a study by Hopfer and Heymann [19], consumers were divided by their tendency for liking Cabernet Sauvignon wine. Consumers had different preferences by subgroup but could not classify wines with similar qualities. Both studies obtained the demographic information of each subgroup to understand differences between clusters. However, the later study did not indicate liking and only showed consumer clusters in internal preference mapping. This may be because obtaining this liking data was not the main aim of their investigation.

Silva et al. [75] emphasized that because eating and drinking are dynamic processes, temporal evaluation is required. Indeed, evaluation at a single point provided only limited information of a continuous process. They measured liking at several points throughout the tasting period, namely temporal liking (TL), and the liking score was different per sip. The authors mentioned the importance of the multi-sip approach, as liking can be increased with an additional sip of wine. This is related to hedonic escalation, which is likely to occur in palatable food and beverages with complex flavor combinations, and typically occurs according to the number of sips [90]. It would be very critical to control the evaluation process to be consistent in measuring the acceptability of the same sample repeatedly such as when and how many times to ask liking. Repeated measure analysis of variance

could be considered within the same sample evaluation and compared to the first sip of wine [91], but between-sample evaluation throughout the repeated liking measure would be difficult.

In general, little research has been conducted in recent years simply comparing consumer acceptance between samples. This has instead been used as an additional means to identify any factors affecting consumer perception, in addition to comparing or proving methods in the field of sensory science. To understand consumer perception of wine beyond liking and/or preference, simple and quick ways such as check-all-that-apply (CATA) and rate-all-that-apply (RATA) methodologies were used in recent sensory studies [92–94]. Comparison studies of wine between DA and CATA [92] or RATA [93] showed that consumer-based approaches had similar discriminability as well as DA. Perception of extrinsic factors [95], cultural differences [94,96], and wine defect [97] using CATA or RATA also showed significant results. Though increasing consumer preference research through various approaches may be considered positive, wine evaluation should be conducted with a careful and critical attitude and from various angles, even in the general consumer test. One of the most important reasons for this is that wine is an alcoholic beverage with complexity, and some sensory attributes such as bitterness or astringency may easily cause palate fatigue [98]. This may have a greater impact on the naïve consumer than on wine experts or trained panels. Further research on familiarity with wine utilizing different wine types, such as red, white, or sparkling, may be helpful for understanding how consumers perceive wine attributes differently by their degree of familiarity. Producers or marketers should also be able to refer to this to set marketing strategies in meeting consumer expectations.

3.2. Emotion

The sensory properties of wine can vary markedly and trigger different responses in consumers. When consuming food products, one of the aspects eliciting consumer responses is an emotional response [8]. Emotion research may provide deeper insight into consumer perception. This is different to consumer acceptance measured by the hedonic scale [99], as this could distinguish products of similar price, quality, and other factors in a competitive product space [100,101]. Emotion research was conducted alongside wine consumption or was related to other factors such as context or temporal dominance [8,73,75,76].

Danner et al. [73] pointed out that perception of quality by naïve consumers was highly associated with emotion. High-quality wines were more liked and elicited more positive emotions in consumers than low-quality wines. They also observed that the emotions evoked were highly correlated with willingness to pay. In another emotion study associated with mouthfeel [76], changes in emotions were observed. Adding a mouthfeel agent (e.g., grape seed extract) led to a decrease in liking score and positive emotions such as calm and relaxed, while negative emotions such as irritated increased. This indicates that liking is closely linked to emotions, wherein higher liking of wine is associated with positive emotions, and disliking is associated with negative emotions [73,74]. In a temporal emotion study [75], the three dominant emotions while consuming wine were pleased, comforted, and relaxed. When Mora et al. [8] analyzed the emotion evoked by commercial wine, different emotions were influenced according to the demographic information of consumers, such as sex and age. For joyful and hedonic, only female participants showed significant differences among samples. Overall, males gave higher ratings than females for emotion. Besides, older adults reported higher scores for active, enthusiastic, good natured, joyful, loving, mild, nostalgic, pleasant, satisfied, understanding, warm, and curious than the young and middle-aged groups. Furthermore, the attributes of white wine were associated with more positive emotions than those of aged wine, which were associated with negative emotions in their study.

All wine emotion studies generally adhere to the perspective that liking and emotion are positively associated. Additionally, drinking wine may be considered to generally arouse positive emotions. However, some factors related to disliking or low quality could induce negative emotions during consumption. Assessing emotion research regarding wine tasting has mostly been conducted in assorted contexts over the course of relevant studies. As context alone could influence the emotions

of consumers, detailed attention is required to determine how the quality or characteristics of wine itself affect consumer perception. Unlike the research conducted by Mora et al. [8], Ashton et al. [102] showed that consumers generally feel tired and relaxed when consuming red wine. This was not the case for white wine, which did not evoke strong emotional responses. These results show that carrying out an emotion study of wine characteristics also requires careful preparation and attention to detail. Moreover, prudent interpretation is needed when analyzing results related to consumer demographic data such as age and gender to avoid generalization.

3.3. Context

In addition to emotion, context also affects consumer perception. Many researchers have considered that environmental context could affect how accurately one can predict real-life consumer behavior and observe interactions between product choice and evaluation [73,103–106]. Food served in different dining settings, such as a restaurant versus a cafeteria, could affect consumer acceptance, perhaps due to consumer expectations [106]. Music or sound also changes consumer perception while consuming wine [107–110]. Though there are only a few contextual studies of wine evaluation, it is clear that context leads to differences in consumer perception.

Danner et al. [73] investigated the relationship between context and liking, emotions, and moods while consuming wine. In their study, the three contexts of a sensory laboratory, restaurant, and home environment were utilized. Presentation, social conditions, and environmental conditions were compared across the three contexts. Unlike previous context studies [105,106,111], there were no significant contextual effects on liking. However, context had a significant impact on several emotions and moods. Spence et al. [77] demonstrated the effect of light colors and background sound on the perception of wine by consumers. The liking and flavor intensity scores were significantly different with differing environmental contexts. Another study conducted by Spence et al. [78] revealed the effect of background music. Participants rated higher for enjoyment when they tasted wine while listening to music compared with consuming in silence. These studies compared how different contexts affect the perception of wine by consumers.

All of the aforementioned studies were well controlled for comparing context, but some limitations may be considered when conducting future research. Familiarity, expectations, and other factors could affect the association between context and acceptability. It is therefore believed that sufficient consideration is required for sample selection. The study conducted by Spence et al. [78] had very limited consumers (n = 26) participating. For a more general conclusion, it may be better to target a larger number of consumers. Though detailed results were only obtained for the wines used in the study, general differences between the three different contexts could be applied to other context studies.

3.4. Extrinsic Factors

As consumers often cannot taste wine at the moment of purchase, they make their selection based on product information such as the brand, price, and label [84,112,113]. This information is called extrinsic cues, which combine with intrinsic cues to constitute a product [114]. Compared with other commercial food products, wine has many more extrinsic factors that can affect consumer perception, such as information on origin, variety, wine ageing, awards, bottle shape or weight, and back label [85,115]. Factors such as origin, variety, or wine ageing influence intrinsic characteristics, however, information transforms them into extrinsic factors, as awards, bottle shape or weight, and back label information are. For example, consumers consider expert assessments of wine quality and attributes to be valuable information for their purchase decisions [34]. When regular wine consumers purchase wine, they frequently rely on recommendations from wine experts and other trusted sources [19,42].

Among the numerous studies on the extrinsic factors of wine, research conducted since 2010 includes the following: brand or price [79]; label/back label information [80,81]; label and brand [82]; grape variety/price/region/awards and others [83]; bottle weight [84]; and overall extrinsic cues [85]. Mueller et al. [79] determined that price was a strong positive driver for the liking and tasting

experience of consumers, and strongly affected repurchase intent. Kelly et al. [80] mentioned that back label information, especially regarding food–wine pairing, appeals to consumers and may influence their purchase decisions. Similarly, Mueller et al. [81] stated that wine back label information discussing food pairing and taste descriptors was found to have a positive effect on consumer choice. In a study by Muller and Szolnoki [82], the degree of wine experience affected perceived extrinsic cues such as packaging, label, or brand. Chrea et al. [83] showed that price and region were the most important factors for consumers, followed by grape variety, awards, and vintage. Piqueras-Fiszman and Spence [84] mentioned that there was a positive correlation between wine price and quality and the weight of the wine bottle. However, they also stated that further research would be required to reveal the actual perception of consumers. A study carried out by Sáenz-Navajas et al. [85] determined that there was a correlation between quality perception and extrinsic cues such as origin, label design, bottling, awards, and vintage.

In these studies, extrinsic factors were associated with consumer perception and wine purchasing behavior. Extrinsic factors such as brand, label information, including origin and variety, and others may be associated with the wine knowledge of consumers or their familiarity with wine. However, these factors may be less influential to consumers in emerging markets and other factors may be more important such as product price compared to price willing to pay, and sensory properties communicated. More studies like choice experiments [116,117], conjoint analysis [80,95], fine wine instrument [118], or wine product involvement [119,120] paired with intrinsic evaluations will enable to investigate the relationship between extrinsic and intrinsic factors that influence consumer acceptability or selection behavior. Further, studying consumers from emergent markets, or finding consumer segmentation from existing markets, thus differing the influence of these factors, would be beneficial so that the wine industry could respond to meet consumers' expectations.

4. Chemical Analysis

The perception of wine flavor and aroma is the result of multi-interactions between the vast chemical components and sensory receptor of humans [52,121]. Wine aroma is necessary for identifying the factors involved in consumer preferences for all wine styles [54]. Additionally, other factors such as color, flavor, and mouthfeel could affect consumer perception. Astringency is regarded as one of the most important characteristics of wine. While mouthfeel is described as dryness and roughness rather than a taste [122,123], bitterness is a taste caused by a variety of molecules [124]. Sound knowledge is needed to understand the specific chemical compounds that impart the desirable sensory characteristics of wine [125]. Many researchers analyzed which components affect wine perception associated with aroma, mouthfeel, or other attributes [52,54,124,126,127].

Chemical analysis of wine was generally accompanied by sensory evaluation, such as descriptive analysis and/or consumer tests. This is likely because the purpose of chemical analysis is not just to determine constituents, but also to investigate which components interact with consumer perception of wine such as studies mentioned in Table 3. Gas chromatography (GC), liquid chromatography (LC), high-performance liquid chromatography (HPLC), mass spectrometry (MS), and other physicochemical assessments provided quantitative data on volatile and non-volatile composition [52,128]. Electronic nose (e-nose), electronic tongue (e-tongue), and gas chromatography-olfactometry (GC-O) are also used for characterization and classification [129,130]. Ebeler [131] already reviewed the analytical tools of wine about targeted/non-targeted analysis. However, when evaluated individually, the precise volatile compounds of the "sniffed aroma" of wine provide inadequate information regarding the flavor of the whole system as perceived by the human senses [52,132]. To understand the relationship between complex mixtures of compounds and sensory properties, multivariate statistical methods such as principal component analysis (PCA) and partial least square regression (PLS) are usually conducted [131].

Table 3. Study details and information of chemical analysis accompanied with descriptive sensory analysis.

Sample	DA Information	Chemical [1]	Descriptor	Relation	Chemical Compounds [2]
5 Godello wine [52]	12 aromas 8 panels	37 volatiles by GC/MS	Apple, Melon, tropical	positive	Isovaleric acid, octanoic acid, isoamyl acetate
			Apricot, floral, pear	positive	Isoamyl acetate, ethyl butyrate, hexanoate
			Citrus, herbaceous	negative	Isovaleric acid, octanoic acid
				negative	isovalerix acetate, ethyl hexanoate
			Pineapple	positive	Isoamyl acetate, ethyl hexanoate
				negative	Isovaleric acid, octanoic acid, methionel
16 Chardonnay wine [126]	30 attributes (1 appearance + 16 aroma + 13 palate) 11 panels	4 thiols by HPLC-MS/MS 71 volatile by GC/MS/MS, SPME-GC/MS, GC/MS	Passionfruit	positive	3-Mercaptohexan-1-ol, 3-MHA, ethyl hexanoate
				negative	Monoterpenes nerol, geraniol, acetic acid, butanol
			Box hedge aroma	positive	3-MH, 3-MHA, hexanoate, BM, 4-MMP
			flint	positive	BM
			Pineapple, confection	positive	Linalool, nerol, geraniol, 2-methylbutyl, 3-methylbutyl acetate, 2-methylpropanal, furfuryl aldehde
26 Australian rosé wines [54]	25 attributes (13aroma + 12 flavor) 12 panel	35 volatiles by (HS-SPME)-GC-MS 5 thiols by HPLC-MS/MS	Floral	negative	α-terpineol, β-citronellol BM
			Red/dark fruit	positive	Acetate esters
			Confectionery aroma	positive	Ethyl esters, acetate esters
			Stone fruit	positive	3-methylbutyl acetate, 3-MHA

[1] GC: gas chromatography, MS: mass spectrometry, HPLC: high-performance liquid chromatography, SPME: solid-phase microextraction, HS-SPME: headspace-solid-phase microextraction. [2] 3-MH: 3-Mercapto-1-hexanol, 3-MHA: 3-mercaptohexyl acetate, 4-MMP: 4-mercapto-4-methylpentan-2-one, BM: benzyl mercaptan.

To determine how chemical compounds affect the aroma and sensory properties of wine, volatile compound analysis was conducted. In a study by Álvarez et al. [52], 37 volatile compounds were identified and quantified, including terpenes, alcohols, acetates, ethyl esters, volatile phenols, volatile fatty acids, lactones, aldehydes, and sulfur compounds. Various compounds affect aroma perception, among which are ethyl ester/acetates, fatty acids, and terpenes. These markedly contribute to the flavor of Godello wine. Thiols are widely present in fruits and vegetables and were studied in Chardonnay wine by Capone et al. [126]. A total of 71 volatile aroma compounds were quantified, including thiols, esters, acids, acetate, C6 compounds, aliphatic γ-lactones, norisoprenoids, monoterpenes, ethyl cinnamate, and oxidation-related compounds. Highly potent thiols related to tropical fruit aroma and flavor, such as 3-mercaptohexan-1-ol (3-MH), could be major contributors to Chardonnay wine. In Australian rosé wines, a total of 51 chemical compounds were identified, including 47 volatile compounds (ethyl esters, acetate esters, other esters, alcohols, isoprenoids, acids, carbonyls, and other) and four thiols [54]. In this study, esters were a prominent aroma based on their odor activity value. Other chemical components such as β-damascenone, 3-methylbutyl acetate, ethyl hexanoate, and 3-mercaptohexyl acetate (3-MHA) were also regarded as important. Sauvignon blanc [133] and Malbec [134] wines were also investigated on the relationship between chemical and sensory properties depending on the different origin. Over and above, reviews of wine chemistry and flavor/aroma published before 2011 provide more information about wine perception-relevant flavor/aroma chemical components [121,135,136].

Chemical analysis can be conducted to understand taste and mouthfeel, such as bitterness and astringency, respectively. Chira et al. [124] investigated phenolic compounds, tannin composition, and other chemical components to compare Bordeaux wine (Cabernet Sauvignon and Merlot) with ageing. The correlation between astringency and chemical factors differed based on the variety. However, the study also suggested that chemical components such as tannin and phenolic compounds may regulate wine perception involved with astringency or bitterness.

When chemical analysis studies are accompanied with descriptive sensory analyses, relationships between chemical constituents and sensory perception by human senses can be analyzed. Gawel [30]

reviewed the non-volatile chemical contents of wine associated with red wine astringency for a better understanding of the effect of the wine polyphenol–salivary protein interaction. To improve wine quality, Garrido and Borges [32] reviewed wine and grape polyphenols to obtain insight into wine characteristics and knowledge. More chemical and sensory studies considering wine with various cultivars, regions, winemaking techniques, processing methods, and other factors affecting wine quality might be helpful to researchers and the wine industry for developing high-quality wine.

5. Concluding Remarks

In this review, sensory studies on wine published over the past 10 years were broadly reviewed. These studies included descriptive sensory analysis, consumer evaluation, and chemical analysis. As aforementioned, wine is one of the most difficult beverages to evaluate because of its complex characteristics. The studies provided information regarding the attributes of wine and consumer behaviors for academics and the wine industry. Among the numerous sensory studies of wine, some limitations existed. Firstly, most wine sensory studies conducted in the last decade evaluated only a narrow range of wines as samples, such as the origin and cultivar, and aimed to compare wine-making methods, processing, or other treatments. However, the wine origin or grape cultivar are factors that directly affect the characteristics of wine, therefore, studies comparing different kinds of wine are required to better comprehend consumers' wine perception. Additionally, most wine studies were conducted in Western countries, which are generally where wine is produced. For example, European countries with a long tradition of winemaking such as France, Italy, Spain, and Germany, and more recently in other countries such as the United States, Argentina, Chile, Australia, New Zealand, and South Africa. This may be because of the availability of winemakers and academic training in viticulture and oenology, in addition to the high frequency of wine consumption in these countries. Wine sensory studies conducted in minor wine consumption regions where the wine market is currently expanding may provide a wider and deeper insight into the perception of wine by novice consumers. To obtain deeper insight into consumers, the sensory evaluation of wine has previously been reviewed [28,29]. This review also recommended that more studies should be conducted to understand the attitude of consumers towards wine. Evaluating this in natural situations (e.g., context, food pairing) would also be beneficial. This general review of studies related to wine perception would provide helpful information to the wine industry for understanding consumers and researchers, allowing further evaluation using various categories of wine. In addition, further evaluation to achieve insight into consumers and the relationship between wine quality and actual consumer perception is essential. The knowledge gained could be utilized to meet consumers' hedonic expectations and results satisfaction from wine consumption.

Author Contributions: J.Y. wrote this article, and J.L. conceived, guided, and revised this article. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Puckette, M.; Hammack, J. *Wine Folly: The Essential Guide to Wine*, 1st ed.; Penguin: New York, NY, USA, 2015; p. 4.
2. The International Organisation of Vine and Wine (OIV). State of the Vitiviniculture World Market, State of the Sector in 2018, Published on April 2019. Available online: http://www.oiv.int/en/normes-et-documents-techniques/analyses-statistiques/analyse-conjoncturelle (accessed on 8 April 2020).
3. Holmes, A.J.; Anderson, K. Convergence in national alcohol consumption patterns: New global indicators. *J. Wine Econ.* **2017**, *12*, 117–148. [CrossRef]

4. Bentzen, J.; Smith, V. Developments in the structure of alcohol consumption in OECD countries. In Proceedings of the workshop on The World's Wine Markets by 2030: Terroir, Climate Change, R&D and Globalization, Adelaide Convention Centre, Adelaide, Australia, 7–9 February 2010.

5. Campbell, G.; Guibert, N. Introduction: Old World strategies against New World competition in a globalising wine industry. *Br. Food J.* **2006**, *108*, 233–242. [CrossRef]

6. Villanueva, E.C.; Castillo-Valero, J.S.; García-Cortijo, M.C. Wine consumer profiles from producing and importing countries in Europe are different. *Ciência e Técnica Vitivinícola* **2017**, *32*, 115–125. [CrossRef]

7. Smith, D.E.; Mitry, D.J. Cultural convergence: Consumer behavioral changes in the European wine market. *J. Wine Res.* **2007**, *18*, 107–112. [CrossRef]

8. Mora, M.; Urdaneta, E.; Chaya, C. Emotional response to wine: Sensory properties, age and gender as drivers of consumers' preferences. *Food Qual. Prefer.* **2018**, *66*, 19–28. [CrossRef]

9. García-Cortijo, M.C.; Villanueva, E.C.; Castillo-Valero, J.S.; Li, Y. Wine consumption in China: Profiling the 21st Century Chinese wine consumer. *Ciência e Técnica Vitivinícola* **2019**, *34*, 71–83. [CrossRef]

10. Mariani, A.; Pomarici, E.; Boatto, V. The international wine trade: Recent trends and critical issues. *Wine Econ. Policy* **2012**, *1*, 24–40. [CrossRef]

11. Charters, S.; Pettigrew, S. The dimensions of wine quality. *Food Qual. Prefer.* **2007**, *18*, 997–1007. [CrossRef]

12. Jackson, R.S. *Wine Science: Principles and Applications*, 4th ed.; Academic press: San Diego, CA, USA, 2014; p. 831.

13. Lawless, H.; Liu, Y.F.; Goldwyn, C. Evaluation of wine quality using a small-panel hedonic scaling method. *J. Sens. Stud.* **1997**, *12*, 317–332. [CrossRef]

14. Bisson, L.F.; Waterhouse, A.L.; Ebeler, S.E.; Walker, M.A.; Lapsley, J.T. The present and future of the international wine industry. *Nature* **2002**, *418*, 696. [CrossRef]

15. Culbert, J.A.; Ristic, R.; Ovington, L.A.; Saliba, A.J.; Wilkinson, K.L. Influence of production method on the sensory profile and consumer acceptance of Australian sparkling white wine styles. *Aust. J. Grape Wine Res.* **2017**, *23*, 170–178. [CrossRef]

16. Saliba, A.J.; Bruwer, J.; MacDonald, J.B. Consumption metrics of Chardonnay wine consumers in Australia. *Int. J. Wine Res.* **2015**, *7*, 1–11.

17. Lesschaeve, I.; Bowen, A.; Bruwer, J. Determining the impact of consumer characteristics to project sensory preferences in commercial white wines. *Am. J. Enol. Vitic.* **2012**, *63*, 487–493. [CrossRef]

18. Bruwer, J.; Jiranek, V.; Halstead, L.; Saliba, A. Lower alcohol wines in the UK market: Some baseline consumer behaviour metrics. *Br. Food J.* **2014**, *116*, 1143–1161. [CrossRef]

19. Hopfer, H.; Heymann, H. Judging wine quality: Do we need experts, consumers or trained panelists? *Food Qual. Prefer.* **2014**, *32*, 221–233. [CrossRef]

20. Charters, S.; Pettigrew, S. Is wine consumption an aesthetic experience? *J. Wine Res.* **2005**, *16*, 121–136. [CrossRef]

21. Parr, W.V.; Mouret, M.; Blackmore, S.; Pelquest-Hunt, T.; Urdapilleta, I. Representation of complexity in wine: Influence of expertise. *Food Qual. Prefer.* **2011**, *22*, 647–660. [CrossRef]

22. Wang, Q.J.; Spence, C. Wine complexity: An empirical investigation. *Food Qual. Prefer.* **2018**, *68*, 238–244. [CrossRef]

23. Pierguidi, L.; Spinelli, S.; Dinnella, C.; Prescott, J.; Monteleone, E. Individual differences in perceived complexity are associated with different affective responses to alcoholic cocktails. *Food Qual. Prefer.* **2019**, *76*, 47–59. [CrossRef]

24. Olabi, A.; Neuhaus, T.; Bustos, R.; Cook-Camacho, M.; Corvi, T.; Abdouni, L. An investigation of flavor complexity and food neophobia. *Food Qual. Prefer.* **2015**, *42*, 123–129. [CrossRef]

25. Wang, Q.J.; Spence, C. Is complexity worth paying for? Investigating the perception of wine complexity for single varietal and blended wines in consumers and experts. *Aust. J. Grape Wine Res.* **2019**, *25*, 243–251. [CrossRef]

26. Kennedy, J. Tannins and polysaccharites in textural quality of wine. *N. Z. Winegrower* **2009**, *12*, 71–73.

27. Rodríguez-Nogales, J.M.; Fernández-Fernández, E.; Vila-Crespo, J. Characterisation and classification of Spanish Verdejo young white wines by volatile and sensory analysis with chemometric tools. *J. Sci. Food Agric.* **2009**, *89*, 1927–1935. [CrossRef]

28. Francis, I.L.; Williamson, P.O. Application of consumer sensory science in wine research. *Aust. J. Grape Wine Res.* **2015**, *21*, 554–567. [CrossRef]

29. Lesschaeve, I. Sensory evaluation of wine and commercial realities: Review of current practices and perspectives. *Am. J. Enol. Vitic.* **2007**, *58*, 252–258.

30. Gawel, R. Red wine astringency: A review. *Aust. J. Grape Wine Res.* **1998**, *4*, 74–95. [CrossRef]

31. Rodrigues, H.; Parr, W.V. Contribution of cross-cultural studies to understanding wine appreciation: A review. *Food Res. Int.* **2019**, *115*, 251–258. [CrossRef]

32. Garrido, J.; Borges, F. Wine and grape polyphenols—A chemical perspective. *Food Res. Int.* **2013**, *54*, 1844–1858. [CrossRef]

33. Laguna, L.; Bartolomé, B.; Moreno-Arribas, M.V. Mouthfeel perception of wine: Oral physiology, components and instrumental characterization. *Trends Food Sci. Technol.* **2017**, *59*, 49–59. [CrossRef]

34. Vidal, L.; Antúnez, L.; Giménez, A.; Medina, K.; Boido, E.; Ares, G. Astringency evaluation of Tannat wines: Comparison of assessments from trained assessors and experts. *J. Sens. Stud.* **2018**, *33*, e12330. [CrossRef]

35. Stone, H.; Bleibaum, R.N.; Thomas, H.A. *Sensory Evaluation Practices*, 4th ed.; Academic press: San Diego, CA, USA, 2012; pp. 233–289.

36. American Journal of Enology and Viticulture. Available online: https://www.ajevonline.org/ (accessed on 12 April 2020).

37. Lesschaeve, I.; Noble, A.C. Sensory analysis of wine. In *Managing Wine Quality*; Reynolds, A., Ed.; Woodhead Publishing Limited: Cambridge, UK, 2010; pp. 189–217.

38. D'Alessandro, S.; Pecotich, A. Evaluation of wine by expert and novice consumers in the presence of variations in quality, brand and country of origin cues. *Food Qual. Prefer.* **2013**, *28*, 287–303. [CrossRef]

39. Lawless, H.T.; Heymann, H. Introduction. In *Sensory Evaluation of Food: Principles and Practices*, 2nd ed.; Lawless, H.T., Heymann, H., Eds.; Springer Science and Business Media: New York, NY, USA, 2010; pp. 1–2. ISBN 978-1-4419-6487-8.

40. Gawel, R. The use of language by trained and untrained experienced wine tasters. *J. Sens. Stud.* **1997**, *12*, 267–284. [CrossRef]

41. Lawless, H.T. Flavor description of white wine by "expert" and nonexpert wine consumers. *J. Food Sci.* **1984**, *49*, 120–123. [CrossRef]

42. Gawel, R.; Godden, P.W. Evaluation of the consistency of wine quality assessments from expert wine tasters. *Aus. J. Grape Wine Res.* **2008**, *14*, 1–8. [CrossRef]

43. Parr, W.V.; Heatherbell, D.; White, K.G. Demystifying wine expertise: Olfactory threshold, perceptual skill and semantic memory in expert and novice wine judges. *Chem. Senses* **2002**, *27*, 747–755. [CrossRef]

44. Maitre, I.; Symoneaux, R.; Jourjon, F.; Mehinagic, E. Sensory typicality of wines: How scientists have recently dealt with this subject. *Food Qual. Prefer.* **2010**, *21*, 726–731. [CrossRef]

45. Clark, C.C.; Lawless, H.T. Limiting response alternatives in time-intensity scaling: An examination of the halo-dumping effect. *Chem. Senses* **1994**, *19*, 583–594. [CrossRef]

46. Llobodanin, L.G.; Barroso, L.P.; Castro, I.A. Sensory characterization of young South American red wines classified by varietal and origin. *J. Food Sci.* **2014**, *79*, S1595–S1603. [CrossRef]

47. Ballester, J.; Patris, B.; Symoneaux, R.; Valentin, D. Conceptual vs. perceptual wine spaces: Does expertise matter? *Food Qual. Prefer.* **2008**, *19*, 267–276. [CrossRef]

48. Parr, W.V.; Green, J.A.; White, K.G.; Sherlock, R.R. The distinctive flavour of New Zealand Sauvignon blanc: Sensory characterisation by wine professionals. *Food Qual. Prefer.* **2007**, *18*, 849–861. [CrossRef]

49. Solomon, G.E. Conceptual change and wine expertise. *J. Learn. Sci.* **1997**, *6*, 41–60. [CrossRef]

50. Zamora, M.C.; Guirao, M. Performance comparison between trained assessors and wine experts using specific sensory attributes. *J. Sens. Stud.* **2004**, *19*, 530–545. [CrossRef]

51. Sáenz-Navajas, M.P.; Avizcuri, J.M.; Echávarri, J.F.; Ferreira, V.; Fernández-Zurbano, P.; Valentin, D. Understanding quality judgements of red wines by experts: Effect of evaluation condition. *Food Qual. Prefer.* **2016**, *48*, 216–227. [CrossRef]

52. Álvarez, M.G.; González-Barreiro, C.; Cancho-Grande, B.; Simal-Gándara, J. Relationships between Godello white wine sensory properties and its aromatic fingerprinting obtained by GC–MS. *Food Chem.* **2011**, *129*, 890–898. [CrossRef]

53. Heymann, H.; Hopfer, H.; Bershaw, D. An exploration of the perception of minerality in white wines by projective mapping and descriptive analysis. *J. Sens. Stud.* **2014**, *29*, 1–13. [CrossRef]

54. Wang, J.; Capone, D.L.; Wilkinson, K.L.; Jeffery, D.W. Chemical and sensory profiles of rosé wines from Australia. *Food Chem.* **2016**, *196*, 682–693. [CrossRef]

55. Rinaldi, A.; Moio, L. Effect of enological tannin addition on astringency subqualities and phenolic content of red wines. *J. Sens. Stud.* **2018**, *33*, e12325. [CrossRef]

56. Sokolowsky, M.; Fischer, U. Evaluation of bitterness in white wine applying descriptive analysis, time-intensity analysis, and temporal dominance of sensations analysis. *Anal. Chim. Acta* **2012**, *732*, 46–52. [CrossRef]

57. Cheynier, V.; Sarni-Manchado, P. Wine taste and mouthfeel. In *Managing Wine Quality*; Reynolds, A., Ed.; Woodhead Publishing Limited: Cambridge, UK, 2010; pp. 29–72.

58. American Society for Testing and Materials. *Standard Definitions of Terms Relating to Sensory Evaluation of Materials and Products*; Annual book of ASTM standards: Philadelphia, PA, USA, 2004; pp. 5–15.

59. Ma, W.; Guo, A.; Zhang, Y.; Wang, H.; Liu, Y.; Li, H. A review on astringency and bitterness perception of tannins in wine. *Trends Food Sci. Technol.* **2014**, *40*, 6–19. [CrossRef]

60. McRae, J.M.; Kennedy, J.A. Wine and grape tannin interactions with salivary proteins and their impact on astringency: A review of current research. *Molecules* **2011**, *16*, 2348–2364. [CrossRef]

61. Fleming, E.E.; Ziegler, G.R.; Hayes, J.E. Salivary protein levels as a predictor of perceived astringency in model systems and solid foods. *Physiol. Behav.* **2016**, *163*, 56–63. [CrossRef] [PubMed]

62. Lattey, K.A.; Bramley, B.R.; Francis, I.L. Consumer acceptability, sensory properties and expert quality judgements of Australian Cabernet Sauvignon and Shiraz wines. *Aust. J. Grape Wine Res.* **2010**, *16*, 189–202. [CrossRef]

63. Caul, J.F. The profile method of flavor analysis. *Adv. Food Res.* **1957**, *7*, 1–40.

64. Sherman, E.; Greenwood, D.R.; Villas-Boâs, S.G.; Heymann, H.; Harbertson, J.F. Impact of grape maturity and ethanol concentration on sensory properties of Washington State Merlot wines. *Am. J. Enol. Vitic.* **2017**, *68*, 344–356. [CrossRef]

65. King, E.S.; Dunn, R.L.; Heymann, H. The influence of alcohol on the sensory perception of red wines. *Food Qual. Prefer.* **2013**, *28*, 235–243. [CrossRef]

66. Villamor, R.R.; Evans, M.A.; Mattinson, D.S.; Ross, C.F. Effects of ethanol, tannin and fructose on the headspace concentration and potential sensory significance of odorants in a model wine. *Food Res. Int.* **2013**, *50*, 38–45. [CrossRef]

67. Gawel, R.; Sluyter, S.V.; Waters, E.J. The effects of ethanol and glycerol on the body and other sensory characteristics of Riesling wines. *Aust. J. Grape Wine Res.* **2007**, *13*, 38–45. [CrossRef]

68. King, E.S.; Heymann, H. The effect of reduced alcohol on the sensory profiles and consumer preferences of white wine. *J. Sens. Stud.* **2014**, *29*, 33–42. [CrossRef]

69. Sáenz-Navajas, M.P.; Ballester, J.; Pêcher, C.; Peyron, D.; Valentin, D. Sensory drivers of intrinsic quality of red wines: Effect of culture and level of expertise. *Food Res. Int.* **2013**, *54*, 1506–1518. [CrossRef]

70. Parr, W.V.; Ballester, J.; Peyron, D.; Grose, C.; Valentin, D. Perceived minerality in Sauvignon wines: Influence of culture and perception mode. *Food Qual. Prefer.* **2015**, *41*, 121–132. [CrossRef]

71. Honoré-Chedozeau, C.; Chollet, S.; Lelièvre-Desmas, M.; Ballester, J.; Valentin, D. From perceptual to conceptual categorization of wines: What is the effect of expertise? *Food Qual. Prefer.* **2020**, *80*, 103806. [CrossRef]

72. Honoré-Chedozeau, C.; Lelièvre-Desmas, M.; Ballester, J.; Chollet, S.; Valentin, D. Knowledge representation among assessors through free hierarchical sorting and a semi-directed interview: Exploring Beaujolais wines. *Food Qual. Prefer.* **2017**, *57*, 17–31. [CrossRef]

73. Danner, L.; Ristic, R.; Johnson, T.E.; Meiselman, H.L.; Hoek, A.C.; Jeffery, D.W.; Bastian, S.E. Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines. *Food Res. Int.* **2016**, *89*, 254–265. [CrossRef] [PubMed]

74. Jiang, W.; Niimi, J.; Ristic, R.; Bastian, S.E.P. Effects of immersive context and wine flavor on consumer wine flavor perception and elicited emotions. *Am. J. Enol. Vitic.* **2017**, *68*, 1–10. [CrossRef]

75. Silva, A.P.; Voss, H.P.; van Zyl, H.; Hogg, T.; de Graaf, C.; Pintado, M.; Jager, G. Temporal dominance of sensations, emotions, and temporal liking measured in a bar for two similar wines using a multi-sip approach. *J. Sens. Stud.* **2018**, *33*, e12459. [CrossRef]

76. Niimi, J.; Danner, L.; Li, L.; Bossan, H.; Bastian, S.E. Wine consumers' subjective responses to wine mouthfeel and understanding of wine body. *Food Res. Int.* **2017**, *99*, 115–122. [CrossRef]

77. Spence, C.; Velasco, C.; Knoeferle, K. A large sample study on the influence of the multisensory environment on the wine drinking experience. *Flavour* **2014**, *3*, 8. [CrossRef]

78. Spence, C.; Richards, L.; Kjellin, E.; Huhnt, A.M.; Daskal, V.; Scheybeler, A.; Velasco, C.; Deroy, O. Looking for crossmodal correspondences between classical music and fine wine. *Flavour* **2013**, *2*, 29. [CrossRef]

79. Mueller, S.; Osidacz, P.; Francis, I.L.; Lockshin, L. Combining discrete choice and informed sensory testing in a two-stage process: Can it predict wine market share? *Food Qual. Prefer.* **2010**, *21*, 741–754. [CrossRef]

80. Kelley, K.; Hyde, J.; Bruwer, J. US wine consumer preferences for bottle characteristics, back label extrinsic cues and wine composition: A conjoint analysis. *Asia Pac. J. Mark. Logist.* **2015**, *27*, 516–534. [CrossRef]

81. Mueller, S.; Lockshin, L.; Saltman, Y.; Blanford, J. Message on a bottle: The relative influence of wine back label information on wine choice. *Food Qual. Prefer.* **2010**, *21*, 22–32. [CrossRef]

82. Mueller, S.; Szolnoki, G. The relative influence of packaging, labelling, branding and sensory attributes on liking and purchase intent: Consumers differ in their responsiveness. *Food Qual. Prefer.* **2010**, *21*, 774–783. [CrossRef]

83. Chrea, C.; Melo, L.; Evans, G.; Forde, C.; Delahunty, C.; Cox, D.N. An investigation using three approaches to understand the influence of extrinsic product cues on consumer behavior: An example of Australian wines. *J. Sens. Stud.* **2011**, *26*, 13–24. [CrossRef]

84. Piqueras-Fiszman, B.; Spence, C. The weight of the bottle as a possible extrinsic cue with which to estimate the price (and quality) of the wine? Observed correlations. *Food Qual. Prefer.* **2012**, *25*, 41–45. [CrossRef]

85. Sáenz-Navajas, M.P.; Campo, E.; Sutan, A.; Ballester, J.; Valentin, D. Perception of wine quality according to extrinsic cues: The case of Burgundy wine consumers. *Food Qual. Prefer.* **2013**, *27*, 44–53. [CrossRef]

86. Villagas, B.; Carbonell, I.; Costell, E. Acceptability of milk and soymilk vanilla beverages: Demographics consumption frequency and sensory aspects. *Food Sci. Technol. Int.* **2009**, *15*, 203–210. [CrossRef]

87. Yang, J.; Lee, J. Korean consumers' acceptability of commercial food products and usage of the 9-point hedonic scale. *J. Sens. Stud.* **2018**, *33*, e12467. [CrossRef]

88. Wu, G.; Ross, C.F.; Morris, C.F.; Murphy, K.M. Lexicon development, consumer acceptance, and drivers of liking of quinoa varieties. *J. Food Sci.* **2017**, *82*, 993–1005. [CrossRef]

89. Lee, J.; Chambers IV, E.; Chambers, D.H.; Chun, S.S.; Oupadissakoon, C.; Johnson, D.E. Consumer acceptability for green tea by consumers in the United States, Korea and Thailand. *J. Sens. Stud.* **2010**, *25*, 109–132.

90. Crolic, C.; Janiszewski, C. Hedonic escalation: When food just tastes better and better. *J. Consum. Res.* **2016**, *43*, 388–406. [CrossRef]

91. Lee, J.; Chambers, D.; Chambers, E., IV. Sensory and instrumental flavor changes in green tea brewed multiple times. *Foods* **2013**, *2*, 554–571. [CrossRef] [PubMed]

92. Alencar, N.M.M.; Ribeiro, T.G.; Barone, B.; Barros, A.P.A.; Marques, A.T.B.; Behrens, J.H. Sensory profile and check-all-that-apply (cata) as tools for evaluating and characterizing syrah wines aged with oak chips. *Food Res. Int.* **2019**, *124*, 156–164. [CrossRef] [PubMed]

93. Danner, L.; Crump, A.M.; Croker, A.; Gambetta, J.M.; Johnson, T.E.; Bastian, S.E. Comparison of rate-all-that-apply and descriptive analysis for the sensory profiling of wine. *Am. J. Enol. Vitic.* **2018**, *69*, 12–21. [CrossRef]

94. Lockshin, L.; Corsi, A.M.; Cohen, J.; Lee, R.; Williamson, P. West versus East: Measuring the development of Chinese wine preferences. *Food Qual. Prefer.* **2017**, *56*, 256–265. [CrossRef]

95. Puyares, V.; Ares, G.; Carrau, F. Searching a specific bottle for Tannat wine using a check-all-that apply question and conjoint analysis. *Food Qual. Prefer.* **2010**, *21*, 684–691. [CrossRef]

96. Corsi, A.M.; Cohen, J.; Lockshin, L.; Williamson, P. Testing lexical equivalences for wine flavours in emerging markets: Do hawthorns taste like blackberries? *Food Qual. Prefer.* **2017**, *62*, 296–306. [CrossRef]

97. Franco-Luesma, E.; Sáenz-Navajas, M.P.; Valentin, D.; Ballester, J.; Rodrigues, H.; Ferreira, V. Study of the effect of H2S, MeSH and DMS on the sensory profile of wine model solutions by Rate-All-That-Apply (RATA). *Food Res. Int.* **2016**, *87*, 152–160. [CrossRef]

98. Noble, A.C. Astringency and bitterness of flavonoid phenols. In *Chemistry of Taste: Mechanisms, Behaviors and Mimics*; Given, P., Paredes, D., Eds.; ACS Symp. Ser. 825; American Chemical Society: Washington, DC, USA, 2002; pp. 192–199.

99. Köster, E.P. Diversity in the determinants of food choice: A psychological perspective. *Food Qual. Prefer.* **2009**, *20*, 70–82. [CrossRef]

100. Schifferstein, H.N.; Fenko, A.; Desmet, P.M.; Labbe, D.; Martin, N. Influence of package design on the dynamics of multisensory and emotional food experience. *Food Qual. Prefer.* **2013**, *27*, 18–25. [CrossRef]

101. Churchill, A.; Behan, J. Comparison of methods used to study consumer emotions associated with fragrance. *Food Qual. Prefer.* **2010**, *21*, 1108–1113. [CrossRef]

102. Ashton, K.; Bellis, M.A.; Davies, A.R.; Hughes, K.; Winstock, A. Do emotions related to alcohol consumption differ by alcohol type? An international cross-sectional survey of emotions associated with alcohol consumption and influence on drink choice in different settings. *BMJ Open* **2017**, *7*, e016089. [CrossRef] [PubMed]

103. Porcherot, C.; Petit, E.; Giboreau, A.; Gaudreau, N.; Cayeux, I. Measurement of self-reported affective feelings when an aperitif is consumed in an ecological setting. *Food Qual. Prefer.* **2015**, *39*, 277–284. [CrossRef]

104. Edwards, J.S.; Hartwell, H.J.; Brown, L. The relationship between emotions, food consumption and meal acceptability when eating out of the home. *Food Qual. Prefer.* **2013**, *30*, 22–32. [CrossRef]

105. King, S.C.; Meiselman, H.L.; Hottenstein, A.W.; Work, T.M.; Cronk, V. The effects of contextual variables on food acceptability: A confirmatory study. *Food Qual. Prefer.* **2007**, *18*, 58–65. [CrossRef]

106. Meiselman, H.L.; Johnson, J.L.; Reeve, W.; Crouch, J.E. Demonstrations of the influence of the eating environment on food acceptance. *Appetite* **2000**, *35*, 231–237. [CrossRef]

107. Spence, C.; Wang, Q.J. Wine and music (II): Can you taste the music? Modulating the experience of wine through music and sound. *Flavour* **2015**, *4*, 33. [CrossRef]

108. Yan, K.S.; Dando, R. A crossmodal role for audition in taste perception. *J. Exp. Psychol. Hum. Percept. Perform.* **2015**, *41*, 590. [CrossRef]

109. Stafford, L.D.; Fernandes, M.; Agobiani, E. Effects of noise and distraction on alcohol perception. *Food Qual. Prefer.* **2012**, *24*, 218–224. [CrossRef]

110. Stafford, L.D.; Agobiani, E.; Fernandes, M. Perception of alcohol strength impaired by low and high volume distraction. *Food Qual. Prefer.* **2013**, *28*, 470–474. [CrossRef]

111. De Graaf, C.; Cardello, A.V.; Kramer, F.M.; Lesher, L.L.; Meiselman, H.L.; Schutz, H.G. A comparison between liking ratings obtained under laboratory and field conditions: The role of choice. *Appetite* **2005**, *44*, 15–22. [CrossRef] [PubMed]

112. Choi, Y.; Lee, J. The effect of extrinsic cues on consumer perception: A study using milk tea products. *Food Qual. Prefer.* **2019**, *71*, 343–353. [CrossRef]

113. Lockshin, L.; Jarvis, W.; d'Hauteville, F.; Perrouty, J.P. Using simulations from discrete choice experiments to measure consumer sensitivity to brand, region, price, and awards in wine choice. *Food Qual. Prefer.* **2006**, *17*, 166–178. [CrossRef]

114. Jover, A.J.V.; Montes, F.J.L.; Fuentes, M.D.M.F. Measuring perceptions of quality in food products: The case of red wine. *Food Qual. Prefer.* **2004**, *15*, 453–469. [CrossRef]

115. Sáenz-Navajas, M.P.; Ballester, J.; Peyron, D.; Valentin, D. Extrinsic attributes responsible for red wine quality perception: A cross-cultural study between France and Spain. *Food Qual. Prefer.* **2014**, *35*, 70–85. [CrossRef]

116. Roselli, L.; Clodoveo, M.L.; Corbo, F.; De Gennaro, B. Are health claims a useful tool to segment the category of extra-virgin olive oil? Threats and opportunities for the Italian olive oil supply chain. *Trends Food Sci. Technol.* **2017**, *68*, 176–181. [CrossRef]

117. Kallas, Z.; Escobar, C.; Gil, J.M. Analysis of consumers' preferences for a special-occasion red wine: A dual response choice experiment approach. *Food Qual. Prefer.* **2013**, *30*, 156–168. [CrossRef]

118. Johnson, T.E.; Bastian, S.E. A fine wine instrument—An alternative for segmenting the Australian wine market. *Int. J. Wine Bus. Res.* **2015**, *27*, 182–202. [CrossRef]

119. Bruwer, J.; Buller, C. Product involvement, brand loyalty, and country-of-origin brand preferences of Japanese wine consumers. *J. Wine Res.* **2013**, *24*, 38–58. [CrossRef]

120. Bruwer, J.; Huang, J. Wine product involvement and consumers' BYOB behaviour in the South Australian on-premise market. *Asia-Pac. J. Mark. Logist.* **2012**, *24*, 461–481. [CrossRef]

121. Styger, G.; Prior, B.; Bauer, F.F. Wine flavor and aroma. *J. Ind. Microbiol. Biot.* **2011**, *38*, 1145–1159. [CrossRef]

122. Lea, A.G.; Arnold, G.M. The phenolics of ciders: Bitterness and astringency. *J. Sci. Food Agric.* **1978**, *29*, 478–483. [CrossRef]

123. Guinard, J.X.; Pangborn, R.M.; Lewis, M.J. Preliminary studies on acidity-astringency interactions in model solutions and wines. *J. Sci. Food Agric.* **1986**, *37*, 811–817. [CrossRef]

124. Chira, K.; Pacella, N.; Jourdes, M.; Teissedre, P.L. Chemical and sensory evaluation of Bordeaux wines (Cabernet-Sauvignon and Merlot) and correlation with wine age. *Food Chem.* **2011**, *126*, 1971–1977. [CrossRef] [PubMed]

125. Francis, I.L.; Newton, J.L. Determining wine aroma from compositional data. *Aust. J. Grape Wine Res.* **2005**, *11*, 114–126. [CrossRef]

126. Capone, D.L.; Barker, A.; Williamson, P.O.; Francis, I.L. The role of potent thiols in Chardonnay wine aroma. *Aust. J. Grape Wine Res.* **2018**, *24*, 38–50. [CrossRef]

127. Ballester, J.; Magne, M.; Julien, P.; Noret, L.; Nikolantonaki, M.; Coelho, C.; Gougeon, R. Sensory impact of polyphenolic composition on the oxidative notes of chardonnay wines. *Beverages* **2018**, *4*, 19. [CrossRef]

128. Noguerol-Pato, R.; González-Barreiro, C.; Cancho-Grande, B.; Simal-Gándara, J. Quantitative determination and characterisation of the main odourants of Mencía monovarietal red wines. *Food Chem.* **2009**, *117*, 473–484. [CrossRef]

129. Genovese, A.; Gambuti, A.; Piombino, P.; Moio, L. Sensory properties and aroma compounds of sweet Fiano wine. *Food Chem.* **2007**, *103*, 1228–1236. [CrossRef]

130. Buratti, S.; Benedetti, S.; Scampicchio, M.; Pangerod, E.C. Characterization and classification of Italian Barbera wines by using an electronic nose and an amperometric electronic tongue. *Anal. Chim. Acta* **2004**, *525*, 133–139. [CrossRef]

131. Ebeler, S.E. Analysis of Grapes and Wines: An Overview of New Approaches and Analytical Tools. In *Advances in Wine Research*; American Chemical Society: Washington, DC, USA, 2015; pp. 3–12.

132. Noble, A.C.; Ebeler, S.E. Use of multivariate statistics in understanding wine flavor. *Food Rev. Int.* **2002**, *18*, 1–20. [CrossRef]

133. Green, J.A.; Parr, W.V.; Breitmeyer, J.; Valentin, D.; Sherlock, R. Sensory and chemical characterisation of Sauvignon blanc wine: Influence of source of origin. *Food Res. Int.* **2011**, *44*, 2788–2797. [CrossRef]

134. King, E.S.; Stoumen, M.; Buscema, F.; Hjelmeland, A.K.; Ebeler, S.E.; Heymann, H.; Boulton, R.B. Regional sensory and chemical characteristics of Malbec wines from Mendoza and California. *Food Chem.* **2014**, *143*, 256–267. [CrossRef] [PubMed]

135. Ebeler, S.E.; Thorngate, J.H. Wine chemistry and flavor: Looking into the crystal glass. *J. Agric. Food Chem.* **2009**, *57*, 8098–8108. [CrossRef] [PubMed]

136. Polášková, P.; Herszage, J.; Ebeler, S.E. Wine flavor: Chemistry in a glass. *Chem. Soc. Rev.* **2008**, *37*, 2478–2489. [CrossRef] [PubMed]