

## The role of acidity, sweetness, tannin and consumer knowledge on wine and food match perceptions

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The purposes of this study were to (1) explore significant differences in perception of match for a variety of food and wine styles; (2) evaluate the impacts of wine sweetness level, wine acidity level, and wine tannin level on perception of match; and (3) investigate the impact of food and wine expertise on perceived level of match. The highest perceived wine matches for each food item were: Sauvignon Blanc and chèvre, Chardonnay and brie, Cabernet Sauvignon and spicy Italian salami, and Port and milk chocolate. Wine sweetness, acidity, and tannin levels all significantly impacted the level of match with certain food items. Food and wine expertise also significantly impacted the level of match, indicating differences between the more expert and novice participants in the role wine sweetness, acidity, and tannin had on level of match.

**Keywords:** food and wine match; expert vs novice consumers; acidity; sweetness; tannin

### Introduction

People have been enjoying and experimenting with food and wine combinations for years, and research has shown that consuming the two together can increase satisfaction of both the food and the wine (Bastian, Collins, & Johnson, 2010; Harrington & Hammond, 2005). As consumers are becoming more adventurous, they are seeking more knowledge of food and drink combinations in order to reap the full benefits of gastronomy (Van Westering, 1996). From a business standpoint, earlier studies suggest that matching food and wine can significantly impact restaurant sales and, for the contemporary restaurant, an understanding of this process is among the most critical responsibilities (Lockshin, Cohen, & Zhou, 2011).

While research on wine and gastronomy has been substantial, very little has been published assessing particular empirical relationships between a variety of foods paired with wines and an assessment of drivers of match perceptions. The perceived level of match refers to how well an individual believes the food and wine pair together (Harrington, 2008; Rosengarten & Wesson, 1989).

Therefore, the overall goal of this research was to evaluate a variety of sensory relationships in the interaction of wine and food. Differences in perceived level of match were explored to evaluate a variety of food and wine style combinations. Additionally, the effects of certain wine

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characteristics (component and texture elements) are examined to determine their impact on perceived level of match, and the impact food–wine pairing expertise has on the perceived level of match was explored.

Hence, the following research questions were addressed to explore these food and wine pairing issues: Are there significant differences in perceived level of match for a variety of different food and wine styles? Do certain wine characteristics impact the perceived level of food and wine match? Does food and wine pairing expertise level impact the perceived level of food and wine match? Are there significant differences in perception of match between experts and novices for selected food and wine combinations?

## Background

Experts have generated several ‘rules’ to act as guidelines when pairing wine and food. These rules have expanded upon the old suggestion of ‘red wine with meat, white wine with fish’ to take into consideration the many factors influencing a food and wine match such as gastronomy and the important elements of food and wine components, textures, and flavors (Harrington, 2008; Immer, 2002). Authors and experts disagree on which elements are most important in determining the success of a food and wine pairing, but they agree that these are important elements to consider when pairing food and wine (Harrington, 2008; Immer, 2002; Rosengarten & Wesson, 1989; Simon, 1996).

Components are often measurable and correspond to the basic sense perceptions of sweet, salty, bitter, and sour on the tongue. Textures are perceived in every corner of the mouth and correspond to touch and temperature sensations. Flavors are experienced through an interaction of the nose and palate, and they give food and wine their distinct aromas and retro-nasal characteristics. For this study, the focus was on wine sweetness, acidity, and tannin as they are thought to be important elements in determining the perception of match between wines and foods (e.g. Harrington, 2008; Rosengarten & Wesson, 1989).

Sweetness, or ‘dryness’ in wine-tasting terminology, comes from residual sugars left after fermentation, and levels vary depending on grape variety and other factors. High sugar levels can create a sense of body and can also diminish acidic, bitter, and astringent aspects of wine (Clarke & Bakker, 2004; Jackson, 2002). The perception of sourness comes from acidity levels in wine and foods. Acidity gives wine refreshing, crisp, and fresh qualities. Acids originate in the grape (tartaric and malic) and are generated during fermentation (lactic and succinic). Since different grape varieties have different acidity levels, the finished wines vary in their acid taste. The growing region’s climate also plays a role in the amount of acid a wine will have. Cooler climate growing regions usually produce wines that are crisper and tarter. Wines made in warmer climates can often be flat and bland (Clarke & Bakker, 2004; Grainger & Tattersall, 2005).

Astringency is the sensation most synonymous with tannins. Increasing with ripeness, tannin comes from the grape skins, stems, and seeds; and wines made from grapes with thick skins usually have the most tannin. Often confused with bitterness, tannins create a rough, drying, and puckering sensation in the mouth (Gawel, Oberholster, & Francis, 2000; Turner & Roycroft, 1979).

## Food and wine research

While food and wine pairing ‘rules’ and suggestions are abundant in popular literature, only a small amount of empirical studies have been published in peer-reviewed journals on the subject of food and wine pairing (Harrington, McCarthy, & Gozzi, 2010; Pettigrew & Charters,

2006). A slightly larger number of wine and cheese pairing studies have been conducted (Bastian, Payne, Perrenoud, Joscelyne, & Johnson, 2009; Bastian et al., 2010; Madrigal-Galan & Heymann, 2006).

Nygren, Gustafsson, Haglund, Johansson, and Noble (2001) and Nygren, Gustafsson, and Johansson (2002, 2003a, 2003b) explored the change in flavor produced by food and wine combinations by measuring interactions as well as sequential or mixed tasting approaches. Overall, the Nygren, Gustafsson, and Johansson (2003b) study indicated that using a mixed approach in wine and cheese research would be most appropriate, as this technique resembles how people normally eat.

King and Cliff (2005) evaluated wine and cheese pairings with the use of a scale to measure ideal matches. The study found that between white, red, and specialty wines, white wines paired best with the cheeses. It was also noted that stronger flavored cheeses tended to be better matched with stronger flavored wines. Because there was a relatively high deviation for each cheese across all wines, this indicated that even experts vary due to personal preferences and individual differences in tastes on perception of match.

Harrington and Hammond (2005) also found a substantial amount of variation in perceived level of match across a trained panel. Sweetness level in wine was a strong predictor of perceived level of match with two out of the four cheeses used in the study, and overall wine body was a significant predictor of match with one of the cheeses. No support was found for the role of acidity, spiciness, saltiness, bitterness, or the importance of wine or food flavor intensity as predictors of level of match. In 2006, Harrington and Hammond studied the impact of body or texture elements on perception of food and wine match. Through the use of sequential evaluations of foods and wines, it was shown that perceived level of match can be predicted. The study found that body matches (as well as food fattiness to tannin matches) impact the success of pairings.

Madrigal-Galan and Heymann (2006) studied how red wine impacted flavor perceptions of certain cheeses. The overall finding was that the tasting of cheese prior to the evaluation of wine decreased the perception of certain wine attributes, such as astringency, oak, berry flavor, and aroma; but the perception of butter did not decrease. This research aligned with the Nygren, Gustafsson, Haglund, et al.'s (2001) research, indicating the mixture effects cause not only some attributes to be suppressed but others enhanced too.

Bastian et al. (2009) studied consumers' evaluations of ideal food and wine pairings recommended by experts. Using a mixed tasting method, it was found that the majority of pairs suggested by experts were also rated highly by the consumers. Red table wines proved to be better accompaniments to cheeses than white wines as they were more versatile. Bastian et al. (2010) explored preferences for pairing of different red wines with the same cheddar cheese. This research found that eating cheddar cheese before drinking Shiraz reduced some of the negative characteristics of the wine and enhanced the preference for the wine. This indicates that consuming food and wine together can minimize some of the less desirable flavors of both.

Harrington et al. (2010) considered the addition of specific food items to wine and cheese pairings to increase the overall match sensation. The study found substantial differences in perceptions across participants; but, overall, the addition of other food items increased the overall sensation of the wine and cheese match and indicated an enhancement in the overall experience for the consumer.

A review of the small number of food and wine studies reveals that regardless of the tasting method (mixed, sequential, or both) the combination of wine and food can bring about not only attribute suppression but also enhancement. Also, there appeared to be a level of variance in food elements, wine elements, and perceived level of match among participants in all studies which highlights the role of individual differences such as between subject taste preferences and food and wine expertise.

### ***Impact of wine and food experience***

While sensory research has highlighted some performance differences between experts and novices, the majority of food and wine studies conducted used expert or trained sensory panels (Harrington & Hammond, 2005, 2006; Harrington et al., 2010; King & Cliff, 2005; Madrigal-Galan & Heymann, 2006; Nygren, Gustafsson, Haglund, et al., 2001; Nygren, Gustafsson, & Johansson, 2002, 2003a, 2003b) and few studies used novices to study preferences for food and wine combinations (Bastian et al., 2009, 2010).

The literature revealed that a main difference between experts and novice consumers was the quality of the vocabulary used to describe food and wine elements (Chollet & Valentin, 2001; Gawel, 1997). In addition to superior and consistent vocabulary, experts possessed greater conceptual knowledge about wines and their expertise was developed on the basis of experience with wine-related compounds rather than superior sensory ability. Experts are able to identify major attributes of wines (Lehrer, 1975) and should be skilled enough to produce consistent descriptions for the same wine in terms of detectable elements (Hughson & Boakes, 2001).

Taylor, Dodd, and Barber (2008) completed an exploratory study on the impact of wine education on developing wine knowledge and preferences. The study found that, while objective knowledge increased, subjective knowledge levels ('what participants believe they know') did not change (p. 193). While an anticipated change in participants' preferences for particular wine styles did not change significantly (i.e. preferences for white, red, or blush wines), the participants' rankings of the wine changed significantly; specifically, the participants' perception of wine samples' overall quality decreased with a more educated wine palate.

For the purposes of this study, experts are defined as individuals who possess explicit knowledge of wine and food, grape varieties, and wine production, and enjoy wine on a regular basis. Novices are defined as individuals who drink wine infrequently, know very little about it or its production, and have limited experience with pairing wine with food (Hughson & Boakes, 2001).

### **Hypotheses**

The literature on food and wine implies numerous potential interactions based on taste components, texture elements, and flavors in food and wine products, and studies have found that certain wines pair better with certain foods (Bastian et al., 2009; Harrington et al., 2010; King & Cliff, 2005). Authors in popular literature also propose food and wine combinations that they suggest will be successful based on personal experience and age-old adages (Immer, 2002; Rosengarten & Wesson, 1989; Simon, 1996). The exploration into food and wine match level indicates that certain foods and wines are simply better than others. For the first hypothesis, we suggest that the perceived level of match between certain food and wine combinations will be significantly greater than others. Formally stated:

**H1:** Certain food and wine combinations will be perceived as significantly better than others.

Certain key wine characteristics potentially determine the level of match with certain foods. According to the relevant literature, only sweetness level and tannin level have been identified empirically to be significant predictors of ideal food and wine match. To date, no support has been found for acidity level as a significant predictor of level of match. Harrington and Hammond (2005) found that sweetness significantly impacted the level of match with two out of four cheeses used in the study, and in 2006, Harrington and Hammond found that a match of food fattiness and wine tannin levels strongly impacted the level of perceived food and wine match. While no empirical studies have found acidity levels in wine to have a significant

impact on level of match, authors do speculate that acidity levels can have a great impact on food and wine combinations (Harrington, 2008; Immer, 2002). Based on the findings of empirical studies and suggestions made in food and wine pairing literature, the following relationships are predicted:

**H2a:** Wine sweetness level will significantly impact perceived level of food and wine match.

**H2b:** Wine acidity level will significantly impact perceived level of food and wine match.

**H2c:** Wine tannin level will significantly impact perceived level of food and wine match.

The food and wine relationship appears to be further complicated by individual differences, experience levels, and other factors (Amerine & Roessler, 1976; Gilbert, 2005). The majority of the literature exploring differences between experts and novices or experience levels is centered on performance differences in sensory study environments and does not compare differences in perceptions of match in food and wine. Only two food and wine pairing studies exploring perception of match have been conducted using novice consumers. Bastian et al. (2009) had consumers rank eight different wine and cheese pairs suggested by four industry experts. Overall, the consumers agreed with the experts on six of the eight matches. Bastian et al. (2010) found that consumers had similar wine preferences to the experts when tasting 10 Shiraz wines with the same cheddar cheese. In contrast, Taylor et al. (2008) found that wine quality rankings significantly changed with greater objective wine knowledge and experience.

Therefore, there appear to be mixed findings leading to predictions on the role and impact experience level on perceptions of food and wine matches. Based on this, it is predicted that experience level in food and wine pairing is likely to significantly impact the perceived food and wine match as well as potential drivers of match. Formally stated:

**H3:** Food and wine expertise will significantly affect the perceived level of food and wine match.

## Methods

Numerous publications exist in the mainstream press exploring food and wine pairing combinations, but the views projected are mainly subjective and merely offer guidelines to follow to achieve successful food and wine matches instead of providing definite rules for pairing (Harrington, 2008). Also, previously published articles in scholarly publications researching food and wine pairing generally used a small sample size with the largest sample size being 76 participants (Bastian et al., 2010), and most of these studies used trained or expert panelists. Additionally, the food selections in earlier studies have been limited mostly to cheeses. Therefore, these studies have neglected to explore different component, texture, and flavor elements that a larger variety of foods could provide, because the cheeses used in previous research share similar characteristics in regard to acidity, fat, and salt levels (Bastian et al., 2009, 2010; Harrington & Hammond, 2005, 2006; Harrington et al., 2010; King & Cliff, 2005; Madrigal-Galan & Heymann, 2006; Nygren, Gustafsson, Haglund, et al., 2001; Nygren, Gustafsson, & Johansson, 2002, 2003a, 2003b).

This study assessed which food and wine combinations result in the perception of an ideal match using a larger sample size ( $N=248$ ) consisting of individuals ranging from novices to experts in food and wine pairing as well as adding other types of foods in addition to cheeses. A criticism of previous food and wine studies is that the majority of experiments conducted used small groups of experts or trained panelists in labs. While a highly controlled and artificial environment in laboratory settings provides greater control over a variety of procedural aspects, this results in a less accurate reflection of the general population when the intent is to determine

parameter estimates of a population (Dobbins, Lane, & Steiner, 1988). The current study design used a broader range of expertise by participants and a field setting to assess relationships. This approach increased the external validity of the findings beyond expert populations, and the findings provide a better estimate of population parameters to aid restaurateurs, service staff, and wine sellers in improving the overall customer experience through pairing suggestions.

### *Sample and procedures*

As Meilgaard, Civille, and Carr (2007) point out there is an enormous range shown by earlier research for thresholds for different compounds and substantial differences across individuals. Therefore, this study utilized a larger sample to increase the validity of its findings for the general population. The convenience sample of culinary students and trade professionals participated in the study during a semester-long wine and food course at a large North American college. Participants ranged in expertise levels and in industry experience; the resulting sample consisted of 248 participants (91 females and 157 males). The data collection procedures included a one-time sensory training and evaluation session lasting approximately 60 minutes in duration.

The testing instrument was adapted from previous food and drink research (Bastian et al., 2009; Harrington et al., 2010). Because this study used a previously developed scale with slight modifications, the content for the wine attributes, level of match, and food and wine expertise were considered to be validated by previous research and theoretical grounding. The instrument included five sections: (1) tasting instructions, (2) wine and food expertise self-evaluation, (3) value bands with food/wine level descriptions, (4) evaluation of wine sweetness, acidity, and tannin levels, and (5) food and wine level of match.

Prior to tasting, participants were instructed to complete a self-evaluation regarding levels of competence in food tasting, wine tasting, and food and wine matching. These scales used a continuous 0 to 10 line scale with anchors of novice, average, and expert (0 = novice, 5 = average, 10 = expert). The second step was for participants to evaluate each wine for level of sweetness, acidity, and tannin using a 0 to 10 line scale. Participants were provided with and instructed on value bands with descriptor terms for each following value band level and descriptions of the perception for each value band.

Wines were evaluated with each food in order of lightest to fullest style (Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Port). The wines were served in 25cl INAO tasting glasses, and participants were provided with one ounce of wine for each evaluation. The wine temperatures were as follows: 9 degrees Celsius for the Sauvignon Blanc and Chardonnay and 16–17 degrees Celsius for the Cabernet Sauvignon and Port. The Sauvignon Blanc and Chardonnay wines were produced in Canada, the Cabernet Sauvignon in Argentina, and the Port in Portugal. The wines ranged in price from \$13.95 to \$16.95 and their alcohol levels ranged from 12.7% to 20%. Descriptions of the specific wines used are shown in Table 1.

After evaluating each wine, the participants were instructed to complete a mixed food and wine tasting and evaluation addressing the basic question: What is your perception of match sensation? The match level used a 0 to 10 line scale that included descriptive anchors (0 = no match, 5–6 = average match level, 10 = synergistic or ideal match). Participants were asked to cleanse their palate with water and crackers, and were given a short break between pairings. The foods were evaluated with each wine in the following order: (1) chèvre (fresh goat's milk cheese), (2) brie (soft cow's milk cheese), (3) spicy Italian salami, and (4) milk chocolate. The foods used in the study are briefly described below and in Table 2. The selection was based on purposeful variation in components, textures, and flavors of the foods that are likely to impact perceived match level with wine (e.g. Harrington, 2008; Rosengarten & Wesson, 1989).

Table 1. Wine identification and sensory descriptions.

Wine style	Vintage	Origin	Price	Composition	Sensory description
Sauvignon Blanc	2009	Dan Aykroyd Lakeview Winery Niagara, ON, Canada	\$14.95 750 ml	Alcohol: 12.7% Dryness: 1	Pale straw color; aromas of citrus, peach, and flinty mineral notes; dry, light-bodied, and refreshing, with peach and grapefruit flavors on the finish
Chardonnay	2008	Angels Gate Winery Niagara, ON, Canada	\$13.95 750 ml	Alcohol: 13.5% Dryness	Yellow gold in color; aromas and flavors of pineapple, pears and melon; off-dry, soft with a warm finish
Cabernet Sauvignon	2007	La Casa del Rey, Argentina	\$14.95 750 ml	Alcohol: 14% Dryness: 1	Aged in 50% American and 50% French oak for one year, imparting toasty coconut and vanilla notes to the ripe black currant and black cherry fruit
Port	LBV	Taylor, Fladgate and Yeatman Douro, Portugal	\$16.95 750 ml	Alcohol: 20% Sweetness: 10	Deep purple/black velvet color; plum, raisin, dried fig, and spice nose; sweet, full bodied, rich and ripe palate; milk chocolate, dried fruit, mincemeat, fig and plum flavors; balanced with some wood tannins and a warm finish

Chèvre is a fresh cheese made from goat's milk; it has a lower fat content and is generally mild, creamy, and sometimes tangy. The texture of chèvre is moist and creamy. Brie is a soft-ripened cheese made from cow's milk, and it usually has a higher fat content and a smooth rich texture. Brie is ripened from the outside in and has a firm and edible rind and a soft, creamy, and buttery center (Herbst, 1995; Simon, 1996).

Salami is a type of sausage that is air-dried, and the meat does not have to be cooked before eating because the curing process preserves the meat. Typically, it is made from a mixture of beef and pork, salamis are often heavily seasoned, and Italian varieties are often rich, fatty and studded with black or white peppercorns (Herbst, 1995).

Milk chocolate has a gluey mouth-coating texture that often blocks the taste buds and deadens the palate due to its richness and sweetness. Milk chocolate is made through the addition of dry milk to sweetened chocolate. With less chocolate liquor than dark chocolate, the taste of chocolate flavor is not as pronounced (Harrington, 2008; Simon, 1996).

### **Data analysis**

The data collected was analyzed with t-tests and regression using SPSS 19.0. Because the line scales used were assumed to provide equally spaced numerical values, t-tests and regression were appropriate for analysis (Meilgaard et al., 2007). For data requiring regression, stepwise regression was utilized. Stepwise regression is a technique that 'instructs a computer to find the "best" equation by entering independent variables in various combinations and orders' (Vogt, 1999, p. 280). Because there was no clear theoretical basis driving the entry order of the wine elements of interest in this study, it was determined that a stepwise approach was appropriate.

Table 2. Food identifications and sensory descriptions.

Food	Producer	Food name	Nutrition summary	Sensory description
Chèvre	Saputo of Canada	Caprini	Serving size: 3 cm <sup>3</sup> Calories: 80 Fat: 6 g Carbs: 1 g	Plain goat cheese, soft and creamy, slightly acidulous
Brie	Saputo of Canada	Brie de Portneuf	Serving size: 3 cm <sup>3</sup> Calories: 90 Fat: 7 g Carbs: 2 g Protein: 6 g	Regular brie with a white, bloomy rind; supple body; slightly fruity
Spicy Italian Salami	Mastro; Santa Maria Foods, Inc.	Calabrese Salami Hot	Serving size: 5 slices Calories: 100 Fat: 7 g Carbs: 1 g Protein: 7 g	Dry-cured, spicy-hot salami; generously seasoned with a selection of bold spices and hot peppers
Milk Chocolate	Lindt and Sprungli, Inc.	Classic Milk Chocolate	Serving size: 4.4 oz Calories: 230 Fat: 13 g Carbs: 24 g Protein: 3 g	Classic smooth, creamy, milk chocolate

Paired t-tests were conducted to assess if significant differences existed among perception of match with each food and wine combination. Stepwise regression was conducted to identify key wine characteristics that significantly impacted the perception of food and wine match with all four food items.

The means and standard deviations for key wine elements (sweetness, acidity, and tannin) are depicted in Table 3 (the highest mean for each wine element are in bold). The means for the wine elements assessed supported typical characteristics of each wine type.

The wines with the highest mean when combined with each food item (perceived level of match) were identified. The highest rated combinations are as follows and are depicted in bold in Table 4. The wine that ranked the highest with the chèvre was the Sauvignon Blanc. This combination had a mean of 5.69. According to the defined scale, the participants considered this match to be slightly above average. The wine that ranked the highest with the brie was the Chardonnay; the mean of the perceived level of match for this combination was 4.08. On average, the participants

Table 3. Perceived wine sweetness levels ( $N=248$ ).

Perceived means	Sweetness <sup>a</sup>	Acidity <sup>b</sup>	Tannin <sup>b</sup>
Sauvignon Blanc	4.43 (2.01)	<b>5.30</b> (1.87)	.20 (.90)
Chardonnay	4.13 (1.99)	5.15 (2.01)	.26 (1.15)
Cabernet Sauvignon	3.43 (1.82)	5.06 (1.81)	<b>5.81</b> (1.98)
Port	<b>7.98</b> (1.67)	4.19 (2.17)	4.52 (2.12)

<sup>a</sup>1 = bone dry, 10 = very sweet.

<sup>b</sup>1 = imperceptible, 10 = highly perceived.



Table 4. Perceived level of food and wine match for each food and wine combination.

Variable	Mean <sup>a</sup>	SD	<i>n</i>
<b>SB and Chèvre Match</b>	<b>5.69</b>	2.32	248
CD and Chèvre Match	5.13	2.29	247
CS and Chèvre Match	4.21	2.42	248
PT and Chèvre Match	3.44	2.97	245
SB and Brie Match	3.96	2.35	245
<b>CD and Brie Match</b>	<b>4.08</b>	2.36	245
CS and Brie Match	3.87	2.38	245
PT and Brie Match	3.36	2.57	247
SB and Salami Match	4.05	2.63	247
CD and Salami Match	3.86	2.41	247
<b>CS and Salami Match</b>	<b>5.09</b>	2.45	247
PT and Salami Match	3.70	2.70	246
SB and Chocolate Match	4.60	2.60	247
CD and Chocolate Match	4.37	2.47	246
CS and Chocolate Match	4.27	2.49	246
<b>PT and Chocolate Match</b>	<b>5.46</b>	2.87	246

<sup>a</sup>1 = no match, 10 = synergistic match.

perceived this match as being slightly below average. The wine with the highest perceived match with the spicy Italian salami was the Cabernet Sauvignon. This combination had a mean of 5.09, and this was an average match according to the scale. The wine that ranked the highest with the milk chocolate was the Port. This match was also slightly above average with a mean of 5.46.

## Results

The results of the statistical analysis are discussed in detail in the following sections in relation to the research questions and their corresponding hypotheses.

### *Differences in food and wine match perception*

Using t-tests, we show in Table 5 that there were significant differences among wine and food matches. The results provide strong support for Hypothesis 1; significant differences were found among several food and wine combinations. Specific differences are described below.

With the chèvre, the Sauvignon Blanc was a significantly better match than the Chardonnay ( $p < .01$ ), Cabernet Sauvignon ( $p < .001$ ), and the Port ( $p < .001$ ). The Chardonnay was significantly better than the Cabernet Sauvignon ( $p < .001$ ) and the Port ( $p < .001$ ), and the Cabernet Sauvignon was significantly better than the Port ( $p < .001$ ).

The only significant differences with the brie were that the Sauvignon Blanc ( $p = .007$ ), Chardonnay ( $p = .006$ ), and Cabernet Sauvignon ( $p = .009$ ) ranked significantly higher than the Port. While the Chardonnay proved to be the best match with the brie, it was not significantly better than the Sauvignon Blanc or the Cabernet Sauvignon.

The Cabernet Sauvignon match with spicy Italian salami was significantly greater than the Sauvignon Blanc ( $p < .001$ ), Chardonnay ( $p < .001$ ), and the Port ( $p < .001$ ). The Sauvignon Blanc match was higher than the Chardonnay and Port, and the Chardonnay ranked higher than the Port. None of these differences were significant however.

The perception of match between the Port and the milk chocolate was significantly higher than with the Sauvignon Blanc ( $p < .001$ ), Chardonnay ( $p < .001$ ), and Cabernet Sauvignon ( $p < .001$ ).

Table 5. Wine match levels with each food item using t-tests.

Paired comparisons	<i>n</i>	Mean difference	SD	Significance (two-tailed)
<i>Wine match levels with Chèvre (N = 248)</i>				
SB-CD	248	.55	2.90	.003
SB-CS	247	1.48	3.36	<.001
SB-PT	248	2.25	3.91	<.001
CD-CS	247	.93	3.16	<.001
CD-PT	248	1.69	3.77	<.001
CS-PT	247	.79	3.28	<.001
<i>Wine match levels with Brie (N = 248)</i>				
SB-CD	245	-.40	5.33	.24
SB-CS	245	.09	3.08	.63
SB-PT	245	.60	3.50	.007
CD-CS	245	.50	5.61	.17
CD-PT	245	1.01	5.66	.006
CS-PT	245	.51	3.02	.009
<i>Wine match levels with Spicy Italian Salami (N = 248)</i>				
SB-CD	247	.19	2.55	.25
SB-CS	247	-1.04	3.38	<.001
SB-PT	246	.35	3.85	.16
CD-CS	247	-1.23	3.02	<.001
CD-PT	246	.18	3.30	.41
CS-PT	246	1.38	3.28	<.001
<i>Match with Milk Chocolate (n = 248)</i>				
SB-CD	246	.22	2.42	.15
SB-CS	246	.33	3.37	.13
SB-PT	246	-.86	4.16	.001
CD-CS	246	.10	2.94	.59
CD-PT	246	-1.09	3.92	<.001
CS-PT	246	-1.19	3.41	<.001

Although non-significant, Sauvignon Blanc was rated higher than the Chardonnay and Cabernet Sauvignon, and the Chardonnay was higher than the Cabernet Sauvignon.

### ***Impact of key wine elements on match perception***

Stepwise regression was conducted to determine which key wine elements (sweetness, acidity, and tannin), if any, significantly impacted the perceived level of match with all four foods used in the study. The results are provided in Table 6.

Both wine tannin level and acidity had significant effects on the perception of match between wine and the chèvre. Sweetness level was excluded as a key characteristic impacting a match with chèvre. Tannin had a highly significant negative relationship ( $\beta = -.21, p < .001$ ), indicating a higher tannin level lowered the perceived match. The relationship between acidity and the chèvre was positive ( $\beta = .09, p < .01$ ) as higher levels of acidity increased the perception of match. Further, the wine acidity level had a significant positive relationship with brie ( $\beta = .07, p < .05$ ) with higher acidity levels increasing the perception of match. Tannin and sweetness were excluded as a key characteristic that would predict level of match. Tannin had a highly significant positive relationship with the spicy salami ( $\beta = .13, p < .001$ ); higher perceived levels of tannin increased the perception of match. Acidity and sweetness were non-significant. Sweetness had a highly significant positive relationship with the milk chocolate ( $\beta = .14, p < .001$ ); tannin and acidity were non-significant.

Table 6. Food item match level regressed on wine attributes.

Variable	Acidity	Tannin	Sweetness
<i>Chèvre</i>			
Chèvre Match	<b>.09**</b>	<b>-.21***</b>	X
R	.23	.23	X
R <sup>2</sup>	.05	.05	X
F (df)	<b>23.27***</b> (2, 887)	<b>23.27***</b> (2, 887)	X
<i>Brie</i>			
Brie Match	<b>.07*</b>	X	X
R	.07	X	X
R <sup>2</sup>	.01	X	X
F (df)	<b>4.53*</b> (1, 868)	X	X
<i>Spicy Italian Salami</i>			
Salami Match	<b>.13***</b>	X	X
R	.13	X	X
R <sup>2</sup>	.02	X	X
F (df)	<b>15.02***</b> (1, 877)	X	X
<i>Milk Chocolate</i>			
Chocolate Match	<b>.14***</b>	X	X
R	.14	X	X
R <sup>2</sup>	.02	X	X
F (df)	<b>18.47***</b> (1, 872)	X	X

Note: All Betas are standardized; X= variable excluded in stepwise regression.  
 \*\*\*  $p < .001$ ; \*\* $p < 0.01$ ; \* $p < 0.05$  (two-tailed).

Hypothesis 2a predicted that sweetness would significantly affect the perceived level of food and wine match. Support was found only between the wine sweetness and milk chocolate. The impact sweetness had on the perceived level of match was positive and highly significant ( $p = .00$ ). Therefore, H2a received strong support for this particular match but moderate support overall.

In contrast to earlier studies, strong support was found for Hypothesis 2b because acidity impacted the perceived level of match with the chèvre and the brie. Acidity had a positive relationship with both cheeses, as higher acidity levels resulted in higher perceived level of food and wine match. The impact acidity had on the match with the chèvre ( $p = .01$ ) was greater than the impact it had on the brie ( $p = .03$ ).

Hypothesis 2c predicted that tannin would significantly affect the perceived level of food and wine match. Strong support was found for Hypothesis 2c with the perceived level of match with the chèvre (negative) and the salami (positive). Both relationships were highly significant.

***Impact of food and wine expertise on match level***

The food and wine combinations selected for this analysis were the wines that resulted in the highest mean match with each food item. Food and wine expertise level impacted the perception of match between all food and wine combinations (Table 7). Overall, higher food and wine expertise resulted in higher perceived level of match across all selected food and wine combinations. The Chardonnay and brie combination ( $p = .02$ ) and the Cabernet Sauvignon and spicy Italian salami combination ( $p = .02$ ) were significantly impacted by food and wine expertise. The impact food and wine expertise level had on the Port and milk chocolate match level was highly significant ( $p < .01$ ). For the chèvre and Sauvignon Blanc match, 1% ( $R^2 = .01$ ) of the variance in match perception can be explained by food and wine expertise; 2% ( $R^2 = .02$ ) of the

Table 7. Selected levels of food and wine match regressed on food and wine experience level.

Variable	Chèvre/SB	Brie/CD	Salami/CS	Chocolate/PT
FWE $\beta$	.11 <sup>+</sup>	.15*	.15*	.30**
<i>R</i>	.11	.15	.15	.30
<i>R</i> <sup>2</sup>	.01	.02	.02	.09
<i>F</i> (df)	3.11 <sup>+</sup> (1, 242)	5.41*(1, 239)	5.33*(1, 241)	23.09**(1, 240)

Note: FWE = food and wine experience; all Betas are standardized.

\*\* $p < 0.01$ ; \* $p < 0.05$ ; + $p < 0.10$  (two-tailed).

variance in match perception for both the brie and Chardonnay match and the spicy Italian salami and Cabernet Sauvignon match is explained by food and wine expertise level, and 9% ( $R^2 = .09$ ) of the variance in match perception for the Port and milk chocolate match can be explained by food and wine expertise levels.

Hypothesis 3 predicted that food and wine expertise would impact the perceived level of food and wine match; thus, Hypothesis 3 was supported. Food and wine expertise had a positive relationship with the perceived level of match. Higher food and wine expertise resulted in higher perceived level of match for the selected food and wine combinations.

## Discussion and conclusions

This study evaluated several food and wine combinations to explore the effects that wine characteristics and food and wine expertise had on perception of match. The larger sample size and the variety of food items used in the study separate this research from previously conducted studies. Many food and wine pairing recommendations are based on anecdotal evidence, and minimal scientific research has been conducted to test these relationships. This study validated some of the claims that food and wine pairing authors have made about the success of certain food and wine combinations and identified some perception differences between novices and more expert participants. A greater understanding of key wine elements and their potential to influence the success of a food and wine match is important to increase food and wine pairing enjoyment. Also, the role of food and wine pairing expertise in relation to overall perception of match (and which elements help to create a more successful match) is helpful to acknowledge for the purposes of making recommendations that will satisfy the consumer.

### *Food and wine match perceptions*

It was found in this study that certain food and wine combinations are significantly better than others, and that sweetness, acidity, and tannin levels in wine impact the level of food and wine match. Overall, the highest levels of perceived match for different food and wine combination were the Sauvignon Blanc and chèvre, Chardonnay and brie, Cabernet Sauvignon and spicy Italian salami, and Port and milk chocolate. According to food and wine pairing literature, Sauvignon Blanc and chèvre are a classic match as both the food and wine are acidic, and the acid in the wine helps cut through the fat in the cheese (Harrington, 2008; Immer, 2002). Also, this finding is in line with King and Cliff (2005) because they found overall that while wine and cheese are compatible, the white wines tended to be better with cheese than red or specialty wines. King and Cliff (2005) also found that out of all the wines used in their study, Sauvignon Blanc was the second most cheese-friendly wine. In contrast, Harrington and Hammond (2005) found Sauvignon Blanc to be one of the least cheese-friendly wines; however, their study did not

assess a match with Sauvignon Blanc and goat cheese in their study. Bastian et al. (2009) found that Sauvignon Blanc was one of the hardest wines to match with cheese, and consumers used in their study did not rank the Sauvignon Blanc and chèvre combination as close to ideal because the Sauvignon Blanc dominated the chèvre. The researchers did suggest that since, 'only a single example of a varietal wine was matched with each cheese, it is difficult to conclude that a specific varietal is better matched to a certain cheese type' (Bastian et al., 2009, p. 181). Hence, the variation in Sauvignon Blanc varietal as well as the style of chèvre used is likely to contribute to the inconsistencies in perception of match.

When paired with the brie, the Chardonnay had the highest perception of match, but there were no significant differences in perception of match between the Chardonnay, Sauvignon Blanc, and the Cabernet Sauvignon. Harrington (2008) suggested that brie may pair well with high acid wines and some red or dessert wines; therefore, one could assume that brie is a wine friendly cheese based on these recommendations and the results found in this study. In contrast, Simon (1996) stated that brie is one of the trickiest cheeses to match with wines, and this could explain why *one* wine was not significantly greater than all others with the brie. King and Cliff (2005) found that consumers did not rate the Chardonnay and brie match to be close to ideal, so even though Chardonnay and brie had the highest perception of match in this study it may be incorrect to assume that the pair is an above average match.

The Cabernet Sauvignon and spicy Italian salami match was the fourth best food and wine match overall. The Cabernet Sauvignon was significantly greater with the salami than the remaining three wines. There has only been one study conducted to date using meat products to assess level of match with wines, and it was found that fattiness-to- tannin match had a significant relationship with level of food and wine match (Harrington & Hammond, 2006). The results of this study are consistent with this finding (red meats pair well with red wines), and this also aligns with recommendations from popular literature (Immer, 2002; Simon, 1996).

The Port and milk chocolate match was the second highest ranking food and wine combination overall. The Port was significantly better than the Sauvignon Blanc, Chardonnay, and Cabernet Sauvignon. Food and wine pairing literature suggests that the Port pairs well with sweeter foods, such as desserts, and that milk chocolate pairs well with sweet, full bodied, high alcohol wines (Harrington, 2008; Rosengarten & Wesson, 1989). The findings of this study are consistent with these theories.

### ***Impact wine sweetness, acidity and tannin on match perception***

When exploring which wine elements impacted the level of match with the foods, all three elements (sweetness, acidity, and tannin) impacted perceived level of match. Sweetness was the only significant predictor for food and wine match with all cheeses used in the study. This reflects Simon's (1996) as well as Harrington's (2008) recommendation that wine sweetness level should be equal to or greater than food sweetness level. This is consistent with the findings of this study because sweetness had a positive significant relationship with the milk chocolate, which is characteristically sweet. The Port had the highest perceived sweetness out of the wines used in the study, and the mean perceived match scores of the remaining wines when paired with the milk chocolate ranked in descending order of perceived sweetness level (Sauvignon Blanc, Chardonnay, Cabernet Sauvignon). This finding implies that milk chocolate (or possibly sweet foods in general) is better paired with wines that are sweeter than or at least as sweet as the food.

In contrast to earlier studies, higher perceived acidity levels impacted the level of match with both the chèvre and the brie in a positive way. The Sauvignon Blanc had the highest perceived acidity levels followed by the Chardonnay. With the chèvre, the wines ranked in order of

acidity level in relation to the overall perception of match. Since chèvre is typically a tangy or acidic cheese, this validates recommendations in food and wine pairing literature that suggest wine acidity levels should be greater than or equal to food acidity levels otherwise the wine will taste flat and dull; and, more specifically, chèvre pairs well with higher acid wines (Rosen-garten & Wesson, 1989; Simon, 1996). While higher acidity levels also impacted the level of match with the brie, the Chardonnay was perceived as a better match than the Sauvignon Blanc, implying that additional food and wine components, textures, and flavors played a role in the perceived level of match. With the brie it is important to restate that there were no significant differences in perception of match between the Sauvignon Blanc, Chardonnay, or the Cabernet Sauvignon. The participants' evaluation of acidity levels in these three wines were fairly similar, suggesting that brie may pair with moderately to high acidic white and red wines.

When exploring the impact of perceived tannin level, the study found it positively impacted the level of match with the spicy Italian salami. The highly rated match between the Cabernet Sauvignon (wine with highest perceived tannin levels) and the spicy Italian salami (a fatty meat) mirrors the Harrington and Hammond's (2006) finding that a match between food fattiness and wine tannin level strongly impacts level of match. This finding supports the old adage of 'red wine with meat' and also validates many assumptions made in popular literature. Authors in this area suggest that tannin is meat's major ally because tannins help cut through the fat of the meat and red meats also moderate tannin perception (Harrington, 2008; Immer, 2002). It is important to note that, with the exception of the Cabernet Sauvignon, the wines did not rank in order of tannin level in regard to their perception of match with the spicy Italian salami; in this case, the results were reversed. The wine with the lowest perceived tannin level (Sauvignon Blanc) was the second best match with the spicy Italian salami, the Chardonnay (third highest tannin level) was next, and then the Port (second highest tannin level) was last. Once again, this implies that additional food and wine components, textures, and flavors played a role in the perceived level of match.

Tannin also impacted the level of match with the chèvre. This relationship, however, was negative as higher perceived levels of tannin decreased the perception of match with the chèvre, indicating the need to pair less tannic wines with this type of cheese. In general, the other wines' level of match with the chèvre ranked according to perceived level of tannin.

### ***Impact of expertise level on match perception***

When exploring the impact of food and wine expertise, 9% of the variance in perception of match with the Port and milk chocolate was explained by food and wine expertise. Thus, participants with more food and wine experience rated this food and wine combination much higher than more novice participants. Prior exposure to food and wine pairing (in educational or even casual atmospheres) may account for the higher levels of match for several reasons. Those who evaluated themselves as above average in food and wine pairing competency may have tasted many food and wine combinations and experimented more than those who ranked themselves below average; therefore, the more experienced participants may have a more varied comparison base than the novices. For example, experienced participants more than likely have tasted many more food and wine matches that were unsuccessful and in turn were more likely to rank the selected food and wine matches closer to ideal. Also, the experienced participants may have more knowledge of expert food and wine pairing recommendations and were more apt to give higher scores to certain combinations such as the Sauvignon Blanc and chèvre match; a classic match according to popular literature. Perhaps experienced participants have a more holistic approach to food and wine pairing, and from experience they may have learned certain strategies such as swirling the wine to release aroma and 'chewing' the wine to experience flavors that allow them to better evaluate a food and wine match.

### *Practical implications*

The increase in consumer interest in food and wine pairing elevates the need for better understanding of consumer food and wine pairing preferences. Minimal empirical research has been conducted to explore what food and wine combinations match well together and why. Also, little is known in regard to the likings of individuals with limited food and wine pairing knowledge. This knowledge is crucial so that the relevant industries can better educate and serve the public in a manner that is both enjoyable for the consumer and profitable for the industry. The findings of this study contribute to the gap in the food and wine pairing literature as well as illuminate future research ideas and suggestions.

The wines with the highest match score with each food item reflect many recommendations in food and wine pairing literature and text books. Any person in the position to recommend, sell, or choose food and wine combinations may follow these recommendations, validated by this study, with the comfort of knowing that they will be an average match if not above average. Since individuals with greater food and wine pairing experience rated all of these combinations higher than those with less experience, it may also be assumed that with more exposure and 'practice' those with limited experience will grow to enjoy these combinations more or be willing to try them.

The finding that sweetness, acidity, and tannin all impact perceived level of match is highly valuable as well. Knowing what wine elements create positive or negative impacts with certain food items can be used to suggest or avoid certain food and wine combinations. These findings can act as guidelines, or a template, in which to base future recommendations upon, or simply to experiment in a nonscientific atmosphere to discover other great food and wine matches.

With this knowledge, a desire may blossom in the consumer to become more adventurous with their food and drink selections, and also the likelihood that the frequency in which they choose to enjoy wine with food will amplify. The consumer, as Harrington (2005) and Pettigrew and Charters (2006) suggested, has a more enjoyable experience every time they decide to purposely take part in the decision to enhance their food *and* wine by enjoying them together.

Food and wine service professionals may use this knowledge to increase both wine and food sales. Educated bartenders, servers, and managers can, with more accuracy and confidence, recommend certain wines to pair with food selections (or vice versa) and answer questions that customers may have. Impeccable customer service, which includes menu and wine list knowledge, leads to happy customers and increased customer satisfaction (Harrington & Hammond, 2006; Stanich, 2004). Happy customers return and also provide free advertising through word-of-mouth, which leads to more customers. Van Westering (1996) suggested that this increased satisfaction can help businesses boost their revenue. Educators may also use this information to enlighten pupils, in both employment and educational settings, to encourage a more well-rounded knowledge of food and wine pairing and better training systems can be developed to enhance the overall program of study (Harrington & Hammond, 2005).

Researchers may also benefit from the findings of this study. Expanding upon this research can lead to greater knowledge regarding the effects that certain wine characteristics have on perception of match as well as further exploring the differences between individuals based on food and wine pairing knowledge and individual preferences.

### *Limitations and recommendations*

Future research is necessary to better understand the relationship between food and wine. Future researchers should take into consideration several additional factors to receive more in depth exploration. Providing detailed descriptions, like those used in the wine value band form, for

food and wine expertise and match level description terms may result in a more accurate view of the participants' knowledge and preferences. Researchers could also gain more knowledge by having participants rank certain food component, texture, and flavor elements, such as sweetness, acidity, and fattiness, to better understand additional factors that play a role in the success or failure of a food and wine match. Also, additional wine component, texture, and flavor elements could be assessed for the same purpose. With an assessment of certain food and wine characteristics, researchers could better predict successful matches based on matching or contrasting elements in food and wine.

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