



# From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer

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Title: From expert knowledge and sensory science to a general model of food and beverage pairing with wine and beer.

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Abstract:

Pairing food and beverages is a traditional practice in French gastronomy. Culinary literature provides recommendations in terms of food and beverage pairing but identifying general strategies to create a match is still difficult.

This work aims at identifying what makes a match between food and beverage according to experts and at investigating whether explanations are domain-specific or generalizable.

Explanation interviews (or self-confrontation interviews) were conducted with sommeliers (n=10) and beer experts (n=10). They were asked to suggest food-beverage pairings and to explain why the pairs would or not would match.

From these interviews, fifteen pairing principles were identified. They correspond to strategies and prerequisites to consider to create a match. They are related to perceptual, conceptual and affective categories and aim at creating pairing according to various objectives: creating a unique match experience, highlighting one of the two products, and enjoying the experience of each product in the pair. These principles are related to both perceptual and physiochemical underlying mechanisms. Generally the same pairing principles may be considered to match food with either wine or beer. However matches based on norms and conceptual association were more often mentioned for wine than beer. Some differences were also highlighted between experts of different domain: beer experts used more experiential discourse than sommeliers who more often referred to conceptual principles.

Keywords: Wine, beer, food-beverage pairing, pairing principles, experts.

## 1. Introduction

Pairing food and beverages is a traditional practice of French gastronomy. Most (87%) French consumers consider wine to be the most important element to match with food (Ifop, 2014) and food-wine pairing is part of the French Gastronomic Meal, registered since 2010 in the Intangible Cultural Heritage of Unesco. Although beer is less culturally anchored in France, with the exception of some regions, it was added to the “French protected cultural, gastronomic and landscaped” heritage in 2014. Although only 11% of French people consume beer at meals (Ifop, 2012), pairing beer and dishes is emerging as a new trend in addition to the deeply embedded wine and food pairing (Pierre, 2014).

Generally, culinary books or blogs suggest dishes to go with a selection of beverages, or vice versa, but without any explanation on why they match. However, Maresca (1994, p.7) mentioned that “Success in wine and food matching depends on nothing more abstruse than finding out why certain foods and wines affect each other for good or for ill and learning how to generalize from that simple information to predict the way other wines and food will interact”. In line with this comment, some experts try to go further by listing the main pairing principles corresponding to strategies and prerequisites to consider to create a match (Harrington, 2008; Paulsen et al., 2015; Pierre, 2014). These principles rely primarily on products’ perceptual properties including all sensations perceived during tasting: tastes (acid, bitter, sweet, salty, umami), aromas (lemon, smoked, red fruits, etc.), texture (fattiness, astringency, carbonation), appearance (colour, shape, turbidity, etc.), temperature (hot, cold, cool etc.), and trigeminal sensations (pungency of mustard, fresh menthol or hot pepper). Principles are also based on non-perceptual properties, such as the principle based on “geographical identity” consisting of matching two products coming from the same area.

However, experts’ terminology related to pairing principles is not always standardized and different experts may use different words to refer to the same principle. It is often difficult to distinguish shared knowledge from personal opinions. Moreover, external factors such as context or social surrounding, considered as elements conditioning the overall gastronomic satisfaction, were also suggested as being involved in food and beverage pairing experience (Nusswitz, 1991; Pettigrew & Charters, 2006; Pierre, 2014).

The main objective of this work was to identify, in a more exhaustive way, what makes a match between food and beverage according to experts.

To overcome these issues, several experts were interviewed. They were placed in a realistic situation, asked to suggest food-beverage pairings, and asked to explain why the pairs would or would not match.

Another objective was to determine whether pairing principles are product-specific or can be generalised. As a matter of fact, Pettigrew and Charters (2006) reported that consumers' and experts' expectations differ when pairing food with either beer or wine. The symbolic, social, and hedonic aspects weight differently. Moreover, because sommeliers and beer experts differ in their expertise, the objective of this work was also to verify whether experts mention similar principles according to their expertise domain or if their discourse differs.

Thus, sommeliers and beer experts were interviewed and asked to suggest dishes that would match with two wines (one white and one red) and two beers (one blond and one white).

Pairing principles were first identified from the experts' statements based on a thematic analysis of the transcripts. Then, the use of these principles was compared according to expertise domains (sommeliers vs. beer experts) and product types (wine vs. beer).

## 2. Materials and Methods

### 2.1. Participants:

Ten sommeliers (3 women and 7 men) and ten beer experts (1 woman and 9 men) were interviewed. Wine experts, of French nationality, were recruited through the ASLERA (Association des Sommeliers Lyonnais et de la Région Rhône Alpes) and the Trophée Lyon Beaujolais Nouveau contest. Beer experts, 9 French and 1 French Belgian, were recruited through the Association Française des Biérologues (Association of French beer experts). All the experts practice in France with the exception of one who works in Belgium. The experts had a professional experience of 1 to 48 years (mean = 18 years). They have different occupations: consultants (3 sommeliers / 4 beer experts), teacher at culinary school (1 sommelier), wine or beer retailers (2 sommeliers / 4 beer experts), restaurant sommeliers (3 sommeliers), contests organizer (1 sommelier), brewing group employee (1 beer expert) and a beer expert still in the training period.

## 2.2. Procedure:

Face-to-face explanation interviews were conducted with the experts. Two French wines and two international Belgian beers were selected to be presented as descriptions to the experts in a randomized order. The two wines were selected by a French sommelier to represent French wines often offered with food (one red wine and one white wine). The two Belgian beers are among the most popular commercial beers in France. The beverages were chosen to be different enough to elicit different pairings.

For wines, the appellation, the vintage, the producer, the cuvée, and a general description from the producer's web site were available. For beers, the products' name and description were available and came directly from the producer (See Appendix A).

Interview guides were used to ensure topics of major interest were covered. For each beverage, experts were asked, first, to suggest dishes to match it and to explain the reasons for their choices and second, to suggest dishes that do not go well with the beverage and to explain these choices also. Appendix B provides a list of suggested dishes, for each beverage. Before starting the interview, all experts gave their informed consent. Each interview lasted about one hour and was recorded with a voice recorder. The participants' anonymity was assured according to the laboratory's instructions.

## 3. Analyses

The discourse analysis was performed by three investigators. In the first step, they identified principles used by experts from interviews. This led to an analysis matrix used for the final analysis. Each investigator, independently, identified for each expert and each wine/beer the mentioned principles. Then, they compared their analyses. Whenever disagreement was observed, they sought consensus by discussion. When consensus was not possible, the verbatim was not considered for further analysis.

In the second step, the number of sommeliers and beer experts who had mentioned each principle was determined for wines and beers separately. Data were arranged in a frequency matrix with principles in columns and every expert type/beverage type combinations in rows. The matrix was analyzed by a Correspondence Analysis (CA) which converts data into graphical display to describe the relationships among variables (pairing principles) (Benzécri & Bellier, 1976).

## 4. Results and discussion

### 4.1. Identified pairing principles

Experts mentioned eighteen pairing principles related to three categories: a perceptual category related to characteristics such as aroma, taste, texture, etc., a conceptual category related to geographical identity and context of consumption, and an affective category related to consumers' preferences and emotions.

Category	Pairing principle	Proportion of experts mentioning the principle (%)				
		Total experts	Sommeliers	Beer experts	Wine	Beer
Perceptual	Balance of intensity	100	100	100	90	90
	Balance of quality	75	70	80	70	50
	Harmony	65	60	70	45	55
	Similarity	100	100	100	90	95
	Culinary practices	75	80	70	65	50
	Avoid off-flavor	30	40	20	30	5
	Rinsing effect	70	70	70	55	45
	Decrease of sensory property	85	90	80	70	50
	Enhancement of sensory property	80	80	80	70	35
Conceptual	Norms	65	60	70	60	40
	Geographical identity	75	90	60	65	35
	Quality level	65	90	40	40	55
	Moment of the meal	80	80	80	60	45
	Specific situation	65	90	40	50	50
	Season	40	40	40	20	30
Affective	Individual preferences	60	50	70	30	40
	Surprise	40	30	50	25	30
Other	Experience	25	20	30	10	15

Table 1: Identified pairing principles and proportion of experts who used them, in total, by expert specialty (sommelier vs beer experts) and by beverage type (wine vs beer).

#### 4.1.1. Perceptual pairing principles

##### **Balance of intensity**

The prerequisite to match food and beverage seems to be a global balance of intensity between the two products such that neither the food nor the beverage dominates overly within the pair:

*“We stay in a range where both wine and dish are balanced in terms of power, degree of power, that is very important at that level” “on reste dans un registre où on a à la fois un vin, à la fois un plat qui s’équilibrent en terme de puissance, de degrés de puissance qui est très important à ce niveau-là” (Sommelier).*

Balance of intensity seems so obvious that experts specified this principle to explain reasons for bad matches, whereas they rarely mentioned it when suggesting good matches. Indeed, they stated that whenever the properties of the dominant product completely mask the properties of the other one, it is not a match.

*“we would not choose a cabbage stew, because there is pork with a lot of salt, and with strong tastes, so the white beer will be crushed” “on ne mettrait pas une potée au chou, parce qu'on est sur du porc avec beaucoup de sel, et avec des goûts marqués, donc là, la bière blanche elle va se faire écraser” (Sommelier).*

Few studies have demonstrated such a principle except Paulsen et al. (2015) who showed that for beer and soup pairing, balance of intensity was a good predictor of liking the match.

Others studies showed similar results (Bastian et al., 2010; Bastian et al., 2009; Donadini et al., 2008; King and Cliff, 2005). However, the authors used bi-polar rating scales anchored with “the food dominates” at one extremity, “the drink dominates” at the other, and “ideal match” in the middle. As the scale itself conveys the idea that balance of intensity leads to a good match, finding a link between those two dimensions seems to be tautological. By contrast, Donadini and colleagues (2012, 2013, 2014), reported that unbalanced pairs are favoured over balanced ones. The discrepancies between Donadini's findings and experts' statements may come from the fact that experts refer to a massive imbalance with one product that "overwhelms" the other one or one product that "disappears". In Donadini's studies, imbalance seems rather moderate; one product is more intense than the other one but both are still perceived. Therefore, a strong imbalance could be detrimental to pairing whereas a moderate imbalance may leave room for other association principles. Donadini et al. (2012) and Donadini and Fumi (2014) hypothesised that unbalanced pairing could be favoured over perfectly balanced ones as long as the dominant property has a positive hedonic valence.

Experts bring out another consideration in justifying a slight imbalance of intensity in pairing: the aim of the association. If the pairing is aimed at valuating one of the two products in the pair, this product should be slightly more intense. The second product is then perceived in the background, highlighting or enhancing the “main” product.

*“Sometimes a food and wine pairing can be ah ... Stéphane Montez (a wine producer) presents his products, we may imagine that we make dishes a little bit below, a little more discreet, which finally let the wine express fully, because we will try to flatter the wine. [...] the wine will dominate the dish a little” “Parfois un accord mets et vin ça peut être ah... Stéphane Montez présente ses produits on peut imaginer qu’on fasse des plats un petit peu en-dessous, un peu plus discrets, qui laissent finalement le vin s’exprimer, parce qu’on va chercher à flatter le vin. [...] le vin va dominer un peu le plat” (Sommelier).*

This shows that food-drink pairing may address two goals. It can either promote a unique consumer’s experience where food and drink are perceived as a whole with both products’ characteristics perceived together, or it could be aimed at promoting one product, the characteristics of which should dominate, whereas the companion product is in the background.

### **Balance of quality**

Together with balance of intensity, a good match needs a balance of quality. Balance of quality implies that contrasted flavors are perceived with equivalent intensity levels, as illustrated by this quote: *“I would choose Blue cheese for its smooth, fresh, sweet, acid characteristics, so with the sweet bitterness of the white beer, there will be sweetness, sourness, bitterness, forming some balances in the mouth” “pour le côté onctueux, frais, sucré, acide donc avec la douce amertume de la blanche là on aura le sucré, acide, amer et en bouche il y a des équilibres qui se formeraient” (Sommelier).*

Here, sweetness, sourness, and bitterness intensities are balanced; thus, the resulting flavor is equilibrated. Such balance of quality, also called “contrast” in expert literature, seems close to the oenologists’ notion of well-balanced wine. It refers to a balance in intensity of taste and astringency perceptions, in line with the definition of wine balance provided by Meillon et al. (2010): “none of the perceived sensations dominate in the mouth”.

However, experts moderate this statement, explaining that if the intensities of the opposed flavors are too strong, the contrast is too pronounced and does not lead to a good match:



“A total opposition between sweetness and sourness, very strong on both sides, too much to match” “opposition complète de l’univers du sucre et l’univers de l’acidité très marqué des deux côtés, trop pour qu’ils puissent s’entendre” (Sommelier).

In both balance of intensity and balance of quality principles, the pair is considered as a whole and the match as a global perceptual experience. Characteristics of the two products should be perceived as a harmonious whole.

“For me, in a pair, the ideal is that the two products express themselves, are harmonious [...] the idea is that we can taste both of them” “Pour moi, dans un accord, l’idéal est que les deux produits s’expriment, soit harmonieux [...] l’idée c’est qu’on puisse sentir les deux” (Beer expert).

### **Harmony**

Experts stated that a good match should have a high level of harmony. Harmony, defined as “how well sensations go together”, highly correlates with the liking of the match (Eschevins et al., 2018; Paulsen et al., 2015). Therefore, harmony seems to be the objective to reach in matching food and beverages.

### **Experience**

In some occasions, experts suggested matches based on autobiographic memories. They only mentioned that they already tasted the association and experienced harmony. In this case, they do not analyze the match in terms of pairing principles. However, this way of suggesting pairing is not very frequent. Generally, experts refer to one or several principles to explain their choice.

### **Similarity**

Similarity consists of associating two products that share one or more properties namely aroma and taste but other modalities such as texture and color were also considered. For aromatic similarity, the idea is that similarity between the two products increases with the number of their shared aromatic note.

“a small fruit salad with a small scoop of vanilla ice-cream because we would have also the vanilla aroma that is there (in the beer)” “une petite salade de fruit avec une petite boule de glace vanille parce qu’on retrouverait la vanille qui est là (dans la bière)” (Sommelier).

Or " A St Joseph wine with a "black forest" patisserie [(a cake with cherry, Chantilly cream, and chocolate)] where we would have also the red fruit aromas" "avec une Forêt Noire où on va retrouver les arômes de fruits rouges" (Beer expert).

Aromatic similarity has been found to increase harmony as well as to modulate complexity of the pairing and thus increase pair liking (Eschevins et al., 2018).

Experts reported similarity as an easy and safe way to match products, while minimizing risks of mismatch. They also mentioned that associating food and beverages based on similarity increases the intensity of the shared properties in the match. Therefore, the pleasurable disposition of this type of pairing may depend on both the hedonic valence and the resulting intensity of the shared characteristics.

“with a vanilla dessert, all of a sudden, it will drive the Blond Leffe in a totally different direction, suddenly the vanilla of the blond Leffe stands out with an enhancement on both sides” “si on la met sur un dessert à la vanille tout à coup ça va mettre la Leffe blonde en avant sous un angle totalement différent, tout à coup la vanille de la Leffe blonde ressort de façon qu'il y ait une accentuation qui se répète des deux côtés” (Beer expert).

### **Culinary practices**

More challenging than similarity, associating characteristics that have different qualities was mentioned by 75% of the experts. They stated that this association mimics common culinary practices. The principle is that one product, usually the drink, adds some target property to the food. This type of pairing works because it echoes a classical accord in the culinary tradition, in which food is often consumed in association with another one, for instance a seasoning, which brings about a target property:

“you have that fruit, so it's like you'd served a red and black fruit coulis with your chocolate mousse” “vous allez avoir que le fruit donc c'est comme si vous avez servi un coulis de fruit rouge et noir avec votre mousse au chocolat” (Sommelier).

Because two flavors are encountered together on a regular basis, the association becomes familiar and its appreciation increases. This could be explained by a mere-exposure effect (Zajonc, 1968).

## Avoid off-flavor

Associating similar or dissimilar aromas aims to create harmonious associations. However, experts explain that it may also lead to an opposite effect by creating an “off-flavor” or “off-taste” that was not originally perceived in the food or in the drink. The idea is therefore to avoid the emergence of off-flavor to create good match.

*“Of course, we will avoid goat cheese [...] for the chemical issue, tannins flocculate in the presence of lactic acid. Then, they become soapy, sapid and generate a lot of bitterness” “on évitera bien entendu tous les chèvres [...] pour la problématique chimique, les tannins floculent avec la présence de l’acide lactique. Donc ils vont devenir savonneux, sapide et générer énormément d’amertume” (Sommelier).*

Off-flavor or off-taste seems to result from physicochemical interactions leading to new compounds as mentioned above. For example, Spence, Wang, and Youssef (2017) mentioned that the association of red wines with seafood is known to develop an unpleasant fishy aftertaste resulting from physicochemical interactions between the wine’s ferrous ions and lipid hydroperoxides derived from unsaturated fatty acids in seafood (Tamura et al., 2009).

The pairing principles presented so far create a match because the food-drink association leads to a unified experience. But, experts also match products in order to preserve or even enhance the experience of each product. They distinguish three principles: 1) **rinsing** aims to preserve the original qualities of each product, 2) **masking** aims to suppress off-flavor in one product, and 3) **synergy** aims to enhance one positive characteristic in one product. All three principles relate to temporal modulation of perceptions in repeated and alternate consumption, originating from carry-over effects.

## Rinsing effect

In a pair that employs the rinsing effect, the beverage allows the taster to take full advantage of the next bit of food by “rinsing his palate” and preventing an increase in intensity. A number of experts stated that some beverage characteristics allow for taking the grease out of the mouth. This rinsing effect may be due to acidity, astringency, or carbonation:

*“Blond Leffe will give me a light fizzing on the tongue, [...], and thus, I will get rid of the greasiness of my foie gras. So, I would not have saturation enjoying the slice of foie gras”*

*“Leffe blonde va me donner un léger pétilllement sur la langue, [...], et que du coup, je vais me débarrasser du gras de mon foie gras. Donc, je vais dire que je n’aurais pas de saturation pour apprécier la tranche de foie gras.” (Beer expert)*

This phenomenon has also been raised in interviews in which the interviewee claimed to drink a great deal of wine “because it’s a good beverage to wash down food” (Pettigrew and Charters, 2006, p 174).

Peyrot des Gachons et al. (2012) demonstrated that tea consumption between bites of fatty food decreased oral fattiness more than water. This phenomenon is due to the highly emulsifying properties of tea-leaf saponins (Mura et al., 2017). Conversely fatty food consumption decreases astringency perception. For instance, Donadini et al. (2015) showed that cheeses such as Gorgonzola or Mozzarella decrease beer astringency. Peyrot des Gachons et al. (2012) also found a similar effect with dried meat and tea. This effect is especially noticeable in repeated consumption. For instance, Galmarini et al. (2016) showed that wine astringency increases over repeated sips, leading to a decrease in liking. However, this effect almost disappears when bites of cheese are consumed between consecutive sips.

Consequently the liking of the wine was stable over the series of sips. In this case, matching wine and cheese keeps both products enjoyable over the whole tasting experience.

The mechanisms that underlie astringency perception are complex (Laguna, Bartolomé, et al., 2017; Laguna, Sarkar, et al., 2017). Among others, astringency is related to the creation of an insoluble complex between astringent compounds (tannins in wine for instance) and salivary proteins, inducing a loss in lubrication of oral surfaces (Garcia-Estevez et al., 2018; Ployon et al., 2018). But when wine is consumed with cheese, fat from the cheese decreases friction in the mouth and restores lubrication (de Wijk and Prinz, 2005).

### **Decrease of sensory property**

Beyond a mere rinsing effect, the companion product may have a corrective effect by masking a negative or disliked characteristic in the primary product:

*“(the Blond Leffe beer) will bring a refreshing side, it will somewhat mitigate the violence of anchovies or certain olives” “(la bière Leffe Blonde) apportera un côté rafraichissant, ça atténuera un peu la violence des anchois ou de certaines variétés d’olives” (Sommelier).*

Such interactions were demonstrated for pairings between wine and cheese (Madrigal-Galan and Heymann; 2006). The prior consumption of cheese induced a decrease in the perceived intensity of oak and mushroom aromas in wine. Such aromas were identified as factors that negatively influence pair liking.. In the same vein, prior consumption of Parmigiano cheese decreases bitterness, astringency, malty flavor, carbonation, and level of alcohol of beer (Donadini et al., 2013); high fat Hollandaise sauce decreases the citrus flavor

of Chardonnay unoaked wine (Nygren et al., 2001); and wine decreases the buttery flavor, saltiness, and sourness of blue cheeses (Nygren et al., 2003). This modulation occurs with off-flavor (Bastian et al., 2010) or with a property at a higher than optimal intensity. In both cases, pairing improves liking of a product which was initially moderately liked. Such an effect may involve several mechanisms. It could involve peripheral interactions such as bitterness suppression by umami due to suppression of the salicin-induced activation of the hTAS2R16 bitter taste receptor (Kim et al., 2015), or the competitive interactions at the olfactory-receptor level for aroma-aroma interactions. It could involve perceptual interactions occurring at the central level, such as lateral inhibition in the olfactory bulb, leading to a loss of information about an odorant in a mixture (Thomas-Danguin et al., 2014). Such an intensity decrease could also originate from a change in the stimuli themselves. For instance, increasing viscosity decreases aroma diffusion and thus increases the time to reach maximum aroma intensity (Tournier et al., 2009). Thus, consuming a drink (liquid) and food (solid or semi-solid) in sequence increases the viscosity of the bolus and decreases the intensity of some of the drink aromas. Once again, as stressed by one expert, if the masking effect can act for the best by decreasing negative characteristics, it can also be detrimental by decreasing the intensity of positive characteristics; the product is less liked and the match is not so pleasant.

### **Enhancement of sensory properties**

Finally, experts mentioned the enhancement of sensory properties. This refers to the increase of the intensity of one or more positive characteristics of one product by the other one: *“The slightly spicy aspects that we will find in this beer with cloves, delicately spiced, even a little caramelized will be able to bring out the aromas of the cheese” “les aspects un peu épicés qu'on va retrouver dans cette bière là avec clous de girofle, délicatement épicé, voire même un peu caramélisé va pouvoir faire ressortir les goûts du fromage” (Beer expert).*

In their studies, Nygren et al. (2001) and Madrigal-Galan and Heymann (2006) demonstrated that buttery flavor in wine was enhanced by the prior consumption of fatty food (cheese or hollandaise sauce). Donadini and Fumi (2014) found that after the prior consumption of chocolate with 30% cocoa content, teas were perceived as sweeter and richer in milky, caramel, and dried fruit aromas. However, they also found that teas, paired with 70% and 99% cocoa, were perceived as more astringent, sour, bitter, and salty than when tasted alone,

384 stressing that according to the hedonic valence of the enhanced property, the carry-over effect  
385 can lead to a good or bad match.

386 Carry-over effects may be due to a change in the stimuli. For instance, residues from the first  
387 product remain in the mouth and distort the perception of the subsequent product. They can  
388 involve central mechanisms such as a synergy effect in aroma mixture perception (two  
389 odorants in a mixture are both perceived with an intensity higher than their perceived  
390 intensities alone) (Thomas-Danguin et al., 2014). Nevertheless, the taste-aroma interaction is  
391 a well-known phenomenon inducing aroma enhancement (Noble, 1996). An expert indirectly  
392 mentioned this type of interaction without necessarily knowing the underlying perceptual  
393 mechanism:

394 *“in the mouth it could develop the lemon pie aromas as there is sourness” “en bouche ça*  
395 *pourrait développer les arômes de la tarte au citron comme on est sur de l'acidité” (Beer*  
396 *expert).*

#### 398 4.1.2. Conceptual pairing principles

399 Although perceptual principles are the most often mentioned and usually in first position,  
400 experts consider other kinds of principles that rely on extrinsic properties of the foods and  
401 drinks as well as the context of consumption.

#### 403 **Geographical identity**

404 Experts also suggested to associate two products that have the same geographical identity  
405 related to a region or country (ex: Muscadet Sèvre et Maine with oysters or Belgian beer with  
406 Flemish carbonade).

407 *“We echo the designation of origin that echoes a region, and that by default, when we have*  
408 *regions with some gastronomic typicality, we speak of a local pairing and it may be*  
409 *interesting to consider all products that can be found in this region” “on fait écho à*  
410 *l'appellation qui fait écho à une région et que par défaut, lorsqu'on a des régions avec*  
411 *certaines typicités de gastronomie, on parle d'accord de terroir et ça peut être intéressant de*  
412 *s'orienter sur l'ensemble des produits qu'on peut trouver dans cette région” (Sommelier).*

413 In the culinary literature, this pairing is also called “Terroir” pairings (Pierre, 2014). However,  
414 the word “terroir” is not only related to geographical origin but also refers to some traditional  
415 practices. Thus, the wording “geographical identity” seems more relevant. In this case,  
416 conceptual categorization rather than perceptual features orients the match.

## Norms

Some experts evoked norms when suggesting matches. This refers to usual/classical associations encountered in the French culinary culture, such as white wine with fish, or beer with sauerkraut:

*“It's purely dogmatic, that's because we've got used drinking [...] we've maintained this dogma to the point that it's a constant, that in the bibliography you will find a lot, but that's just transmitted and reproduced for no other reason than its existence at a given moment”*  
*“c'est purement dogmatique, c'est à dire que c'est parce qu'on a pris l'habitude de boire ou de dire [...] on a entretenu ce dogme au point que c'est une constante qui là dans la bibliographie vous allez pouvoir retrouver énormément mais qui est juste transmise et reproduite sans aucune autre raison que son existence à un moment donné” (Beer expert).*

Such pairings are often encountered, thus they are familiar and consequently widely appreciated (Borgogno et al., 2015).

The principles of norms and geographical identity might overlap as, historically, food transportation was limited and people tended to consume local products. However, what may have once been related to “geographical identity” may have evolved. The norms are rather related to the type of products than to the products' geographical identity. For instance, pairing sauerkraut and beer may come from the fact that both used to be commonly consumed in Alsace. At this time, it was a match related to products geographical identity. But, nowadays it becomes pairing norms as it may work with Belgian beer as well.

## Quality level

The same principle applies to products' quality level. An exclusive wine matches with a fine dish made with high quality products. It is irrelevant to associate it with a basic dish even though their perceptual properties would go well together.

*“even though this wine is beautiful, it remains a Muscadet, hm and so we will not necessarily give it dishes of exceptional nobility, so we must also stay in a pairing according to nobility”*  
*“donc aussi belle cette cuvée là, ça reste un Muscadet, hum et donc on va pas forcément lui accorder des plats d'une noblesse exceptionnelle, donc il faut aussi rester dans cet accord de noblesse” (Sommelier).*

In their study, Pettigrew and Charters (2006) also reported such a principle. One of their interviewees indeed stated that “good” wine would be wasted at a barbecue, but at a formal dinner, it was appropriate while cask wine would fail.

## **Moment of the meal**

According to experts the moment of the meal i.e., starter, main dish, or dessert, modulates pairings and not only because the kinds of food consumed at these moments, are different. Experts refer to vertical pairing as when the pairs consumed before and/or after are taken into account.

*“So it makes it possible to finish a meal on a kind of lightness, a kind of thirst-quenching”*  
*“Donc ça permet de finir un repas sur une forme de légèreté enfin une forme de désaltérant”*  
(Sommelier).

## **Specific situation**

In addition to the moment of the meal, experts took into account the context of consumption and some of them mentioned a specific situation in which the pair would work well. They mentioned for instance, an aperitif with a friend on a terrace or a dinner in a gastronomic restaurant. Giacalone et al. (2015) demonstrated that consumers perceived several beers as significantly different in appropriateness across different usage contexts. For example Steinlager classic beer, gold medal Ale beer and Lion red beer were considered as more appropriated to sport event such as rugby match, camping or fishing than Hopwired IPA beer or Pot Kettle Black beer more appropriated to serve to guests or drink in a public house (e.g. Bars). The same principle holds for food and beverage pairs and the pair needs to be congruent with the consumption situation. Sester et al. (2013) showed that congruence between the ambiance and the drink would orient consumers' choices. There is a large body of literature dedicated to contextual effect on food choice and liking. The underlying processes at work are also relevant to understanding food-beverage pairing.

## **Season**

As part of the context, 40% of the experts took into account the season during which the pairing is consumed:

*“But in mid-summer, I would make a citrus salad, slightly spicy, with sweet spices such as a little bit of cinnamon and I would serve this wine, and it would be surprising because when one thinks of a dessert wine, one thinks of a sweet wine, and there in summer I do not want to offer a sweet wine”* *“Mais en plein été je ferais une salade d'agrumes, légèrement épicées, avec des épices douces comme par exemple un petit peu de cannelle et je servirais ce vin, et ça serait d'ailleurs étonnant parce que quand on pense à un vin de dessert, on pense à un vin sucré, et là en été j'ai pas du tout envie d'offrir un vin sucré”* (Beer expert).



Indeed, preferences may change according to the season. Seo et al. (2009) found that cinnamon aroma was more pleasant during the Christmas season than summertime. Wada et al. (2012) demonstrated that infants tend to prefer an image of a strawberry tasted with a congruent odor of strawberry when the task was performed during the strawberry season than when the task was performed out of the strawberry season. In another study, Ristic et al. (2019) asked participants to indicate their preference for different wine aromas in different seasons. They found that chocolate aroma is more appropriate for winter whereas lemon, strawberry, rose and passionfruit aromas are more appropriate for summer. These changes can be explained by the ecological valence theory which suggests that stimulus preferences arise from people's average affective responses to stimulus-associated objects (Palmer and Schloss, 2010). This theory explains seasonal changes in color liking such as preference for dark-warm colors (dark-red, brown, olive, and dark-chartreuse) during fall more than other seasons (Schloss et al., 2017), following the color of leaves in nature. This explains why the adequacy between the seasonal natural colors and dish colors contributes to the creation of a pleasurable dining experience (Lightner and Rand, 2014). This theory can be transposed to other sensory modalities and seems relevant in the area of food-drink pairing.

#### 4.1.3. Affective pairing principles

##### **Individual preferences**

A large share of the experts included individuals' preferences as a parameter to consider in the search for a good match:

*“It may work with a buffet, if people prefer to take beer over wine” “ça peut aller sur un buffet campagnard par exemple, si les gens préfèrent prendre de la bière plutôt que d’aller prendre des vins” (Sommelier).*

The liking of the products, tasted alone, affects the liking of the pairing in which they are associated (Bastian et al., 2010; Donadini and Fumi, 2014; Donadini et al., 2012, 2013; Donadini et al., 2015; Harrington et al., 2008; Paulsen et al., 2015). However, pairing the preferred food with the preferred beverage is not enough to create the perfect match (Donadini et al., 2013; Tuorila et al., 1994). The enhancement of certain properties in food-drink pairs could explain inter-individual differences in match assessments. Appreciation will depend on the valence of the dominant notes in the pair for each consumer. If a pairing

induces the development of a lemon aroma, the liking of the match will depend on the consumers' liking of lemon.

## **Surprise**

Tradition and custom are often at stake in pairing principles. However, thinking outside the box may be relevant on some occasions. Experts sometimes suggested a pairing that deliberately breaks the rules, especially conceptual rules. Because the association is unexpected, it would surprise tasters.

*“We prepare a very classic meal and we have a big surprise, we have blond Leffe beer and a cake for dessert” “on fait un repas tout à fait classique et pis on fait une grosse surprise, on fait goûter Leffe blonde et un gâteau au dessert” (Beer expert).*

## 4.2. Comparison of the usage of pairing principles according to expert and beverage types.

[Insert Figure 1 about here]

Use of pairing principles according to expert and beverage types was examined with a correspondence analysis (Fig 1). The two first dimensions explain 89.03% of total variance. The F1 axis distinguishes beer experts, represented on the positive part of the axis, from sommeliers, represented on the negative part of the axis. The F2 axis divides pairings with wine on the positive part of the axis, and pairings with beer, on the negative part. Moreover, to help with reading, the principles of “Season”, “Specific situation” and “moment of the meal” were merged in “context of consumption”.

Overall, perceptual principles such as “similarity”, “balance of intensity”, or “rinsing effect”, are equally mentioned by sommeliers and beer experts whatever the beverage. Beer experts seem to use pairing principles in a similar way when creating pairings with beer and wine. In addition to perceptual principles, they used experiential arguments to justify a match. They refer more often than sommeliers to their own tasting experiences and to the individual preference of consumers. Sommeliers more often use conceptual principles and include contextual considerations to match food and beverages. The relative weight of experiential and conceptual dimensions has already been pointed out as an indicator of level and kind of expertise in wine (Langlois et al., 2011).

Overall, matching food with either wine or beer seems to mobilise the same principles. A few differences were observed. “Norms” and “Geographical identity” were more often mentioned with wine than with beer. This is not surprising as in France, pairing food with beer is a relatively new trend whereas pairing food and wine is part of the French culture and history. The region of production of wine is an important characteristic of the beverage but it is less advertised for beer.

By contrast, the notion of “surprise” was mentioned more often with beer than wine. In France, pairing wine with food is very normative. Unlike drinking beer, drinking wine is a habit and an element of the French cultural background (Do, Patris, & Valentin, 2009). Hence offering beer as companion to food may be a first source of surprise for French consumers. From a more methodological point of view, these differences could also be explained by the differential anchoring of selected beers and wines in the French culture and terroir. For example, the two beers were industrial Belgian beers not linked to a specific production area for French experts. By contrast, the two wines were AOC (Appellation d’Origine Contrôlée) wines with a strong regional identity. AOC is one of the French geographical indications. This system works in parallel to the European PDO (protected designation of origin) / PGI (protected geographical indication) system. This regulation protects the reputation of regional products and promotes rural and agricultural activity. It is well known by French people in general and in the area of wine particularly. A study with French craft beers, for which the production area is emphasized, would be necessary to see whether the “Geographical identity” pairing principle would be used as frequently for beer than for wine or if it is really product-dependent.

Sommeliers also used the notion of “new characteristics” that emerge when associating food and beverages but only for wine. They actually mentioned a potential risk of creating “off-flavor” when pairing food and wine.

## 5. General discussion

This work confirms that pairing food and beverages is a complex task. There are several methods to match food and beverages. The method to implement primarily depends on the objective of the pairing: to create a unique perceptual experience by combining the two products, to highlight one of the two products and make it more attractive, or to enjoy each of the two products in the pair as much as possible. According to the objective, one principle or

another would be as a means to reach the objective. Moreover, principles are used in combination including several perceptual, conceptual, and affective principles. The weights of the three kinds of principles may vary according to the expertise of the person pairing the food and beverage as well as the person for whom the pair is intended.

Individual factors were also mentioned by experts. They acknowledged inter-individual differences in food-pairing perception, underlining the importance of liking (liking of each product, tasted alone). This is undoubtedly a major issue. But other inter-individual differences based on attitudes and motivations such as health issues, cultural specificities, or social influences, are probably as relevant, since they are known to affect eating behavior (Higgs and Thomas, 2016; Renner et al., 2012).

Interviews were conducted with 10 wine and 10 beer experts. Considering such a number, analyses based on number of occurrence needs to be confirmed with a larger group. Moreover, all experts were French. Thus, results have to be considered cautiously when generalized to other cultures. Culture may affect the content of the principles. For instance, when considering the principle of “Culinary practices”, two flavors that would work in one culture may not be relevant in another. So experts of different cultures, calling upon this same principle, would end up with different pairings according to classical accords in their own culinary culture. Culture may also affect the relative weight of principles used in combination. The principle of “geographical identity” is likely to be more important in a country such as France where products of origin (PDO) are numerous and well established, compared to other countries where the notion of geographical identity is less developed. Ultimately, experts from different cultures may consider principles other than those considered by French experts.

## 6. Conclusion

The results demonstrate that French sommeliers and beer experts use pairing principles related to perceptual, conceptual and affective categories. Overall, matching food with either wine or beer seems to rely on the same principles. However, matches based on norms and conceptual association, were more often mentioned for wine than beer. Beer experts used more experiential discourse than sommeliers who referred more often to conceptual association.

Further work is needed to experimentally test the principles listed by experts. Some have already been studied using sensory science approaches. But others need to be explored deeper. Finally, as principles are called upon in combination rather than in isolation, further work

needs to be undertaken to understand how experts choose one combination rather than another.

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<b>Muscadet Sèvre et Maine</b>	<b>Vintage</b>	2014
	<b>Producer</b>	Joseph Landron, domaine de la Louveterie
	<b>Cuvée</b>	Cuvée amphibolite nature
	<b>Description (from the producer's website)</b>	Dry white wine Produced at the top of the Nantes vineyards, on the slopes of the Sèvre Alcohol content: 12% Intense aroma of ripe citrus Lemon flavor Grapefruit flavor Rich and complex palate, underpinned by mineral acidity. Superb balance with a crystalline mineral density. Persistence of salinity remains pure with high precision of the fruit.
<b>St Joseph</b>	<b>Vintage</b>	2013
	<b>Producer</b>	Stéphane Montez, domaine du Monteillet
	<b>Cuvée</b>	Cuvée du papy
	<b>Description (From the producer's website)</b>	Red wine produced on the right bank of the Rhone, in the department of the Loire Alcohol content: 12.5% Red fruit aromas (blackcurrant) Violet aroma Spice (nutmeg, pepper) Licorice aroma Vanilla aroma The palate is elegant and long with a solid tannic structure with soft tannins.
<b>Hoegaarden</b>	<b>Description (from the producer)</b>	Belgian white beer internationally sold Alcohol content: 4.9% Lemon aroma Sweet Acid Smooth Clove aroma Coriander aroma Creamy Bitter Banana aroma
<b>Blond Leffe</b>	<b>Description (from the producer)</b>	Belgian blond beer internationally sold Alcohol content: 6.6% Fruity Delicately spiced



		Clove aroma Vanilla aroma Smoky aroma Phenolic aroma Caramel aroma Butterscotch aroma Grilled aroma Sulphide in aftertaste Sweet Bitter Dense Alcohol aroma
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## Appendix A: Product information provided to the experts

## Appendix B: Examples of dishes suggested by experts (at least three of them) to match each beverage (no matches were also included).

Table B1. Example of dishes suggested to be matched with **Hoegaarden** beer.

Match/no match	Dishes category + number of experts (total and by specialty (B= beer experts/ S= Sommeliers))	Dishes
Match	Cheese (10 experts (B=6/ S=4))	Bannons, chaource, raclette, panacotta, comté, beaufort goat cheese
	Desserts (7 experts (B=7))	Lemon pie, fruit pie, tiramisu with beer, meringue
	Fish (5 experts (B=5))	
	Seafood (5 experts (B=5))	Shrimp, Oysters, mussels with French fries
	Mixed salad (3 experts (B=3))	Cesar salad, avocado salad, rocket salad
No match	Red meat (8 experts (B=2/S=6))	Beef meat
	Desserts (7 experts (B=4/S=3))	Chocolate desserts, coffee desserts
	Game meat (6 experts (B=3/S=3))	Duck, deer meat
	Cheese (4 experts (B=2/S=2))	Roquefort, intense cheese, Epoisse, Maroilles
	Dishes with sauce (3 experts (B=1/S=2))	Powerful sauce

Table B2. Example of dishes suggested to be matched with **Blond Leffe** beer.

Match/no match	Dishes category + number of experts (total and by specialty (B= Beer experts/ S= Sommeliers))	Dishes
Match	Cheese (11 experts (B=5/S=6))	Mainly cow cheeses (Comté, St Marcelin, Maroilles, Livarot, etc...)
	White meat and poultry (8 experts (B=3/S=5))	
	Dessert (5 experts (B=4/S=1))	Dessert with vanilla, yellow or white fruits pie, chocolate, cakes ...
	Fish (4 experts (B=1/S=3))	Fried fish, smoked or grilled fish, with vanilla or honey;
	Mixed salad (3 experts (B=2/S=1))	
	Red meat (3 experts (B=1/S=2))	Horse meat, beef meat
No match	Dessert (6 experts (B=3/S=3))	Speculoos biscuit (crunchy biscuits flavoured cinnamon), chocolate
	Red meat (5 experts (B=1/S=4))	Beef meat, red meat with sauce
	Fish (5 experts (B=3/S=2))	Red mullet, fine-textured fish
	Cheese (3 experts (B=1/S=2))	Brie de Melun, Maroilles
	White meat (3 experts (B=1/S=2))	Calf sweetbread, pork meat

Table B3. Example of dishes suggested to be matched with **Muscadet Sèvre et Maine** wine.

Match/no match	Dishes category + number of experts (total and by specialty (B= Beer experts / S= Sommeliers))	Dishes
Match	Fish (17 experts (B=8/S=9))	
	Seafood (16 experts (B=6/S=10))	Oysters, seafood
	Cheese (12 experts (B=5/S=7))	Mainly Goat cheese
	Mixed salad (3 experts (S=3))	Salad with citrus fruit
No match	Red meat (5 experts (S=5))	Beef meat
	Dessert (3 experts (S=3))	Chocolate, cake, cream

Table B4. Examples of dishes suggested to be matched with **St Joseph** wine.

Match/no match	Dishes category + number of experts (total and by specialty (B= Beer experts/ S= Sommeliers))	Dishes
Match	Red meat (10 experts (B=2/S=8))	Beef, lamb meat
	Game meat (8 experts (B=3/S=5))	Duck, deer, guinea fowl, hare, boar meat
	Dessert (7 experts (B=5/S=2))	Chocolate cake, Forêt Noire cake, Pear with wine
	White meat (6 experts (B=3/S=3))	
	Fish (5 experts (B=3/S=2))	Salmon, eel, fish prepared with wine
	Cheese (5 experts (B=3/S=2))	St Nectaire, Nanterre cheese, Picodon
	Barbecue (4 experts (B=2/S=2))	
No match	Charcuterie (3 experts (B=2/S=1))	
	Fish (12 experts (B=5/S=7))	White fish
	Cheese (5 experts (B=1/S=4))	Goat cheese
	Seafood (4 experts (B=2/S=2))	Oysters, shellfish
	Red meat (4 experts (B=2/S=2))	Powerful meat, kangaroo meat
	Game meat (3 experts (S=3))	Boar meat, doe and pheasant meat

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Figure caption

Figure 1: Overview of the usage of pairing principles according to expert type and beverage type (+, blue). Markers shapes and colors represent the categories to which pairing principles are related: perceptual (●, red), conceptual (◆, green) and affective (■, purple). “Experience”, (▲, black) is not related to any of the categories.

