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

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

3

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13

14 Abstract:

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

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

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

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

33

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

35

## 36 1. Introduction

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

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

59

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

66

67 The main objective of this work was to identify, in a more exhaustive way, what makes a  
68 match between food and beverage according to experts.  
69 To overcome these issues, several experts were interviewed. They were placed in a realistic  
70 situation, asked to suggest food-beverage pairings, and asked to explain why the pairs would  
71 or would not match.  
72 Another objective was to determine whether pairing principles are product-specific or can be  
73 generalised. As a matter of fact, Pettigrew and Charters (2006) reported that consumers' and  
74 experts' expectations differ when pairing food with either beer or wine. The symbolic, social,  
75 and hedonic aspects weight differently. Moreover, because sommeliers and beer experts differ  
76 in their expertise, the objective of this work was also to verify whether experts mention  
77 similar principles according to their expertise domain or if their discourse differs.  
78 Thus, sommeliers and beer experts were interviewed and asked to suggest dishes that would  
79 match with two wines (one white and one red) and two beers (one blond and one white).  
80 Pairing principles were first identified from the experts' statements based on a thematic  
81 analysis of the transcripts. Then, the use of these principles was compared according to  
82 expertise domains (sommeliers vs. beer experts) and product types (wine vs. beer).

83

## 84 2. Materials and Methods

85

### 86 2.1. Participants:

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

98

99

100

## 101 2.2. Procedure:

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

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

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

118

## 119 3. Analyses

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

126

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

133

134

135 4. Results and discussion

136 4.1. Identified pairing principles

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

141

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

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

144

145

146

147

148 4.1.1. Perceptual pairing principles

149

150 **Balance of intensity**

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

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

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

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

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

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

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

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

193  
194 This shows that food-drink pairing may address two goals. It can either promote a unique  
195 consumer’s experience where food and drink are perceived as a whole with both products’  
196 characteristics perceived together, or it could be aimed at promoting one product, the  
197 characteristics of which should dominate, whereas the companion product is in the  
198 background.

### 199 200 **Balance of quality**

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

208 Here, sweetness, sourness, and bitterness intensities are balanced; thus, the resulting flavor is  
209 equilibrated. Such balance of quality, also called “contrast” in expert literature, seems close to  
210 the oenologists’ notion of well-balanced wine. It refers to a balance in intensity of taste and  
211 astringency perceptions, in line with the definition of wine balance provided by Meillon et al.  
212 (2010): “none of the perceived sensations dominate in the mouth”.

213  
214 However, experts moderate this statement, explaining that if the intensities of the opposed  
215 flavors are too strong, the contrast is too pronounced and does not lead to a good match:



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

219

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

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

227

### 228 **Harmony**

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

233

### 234 **Experience**

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

240

### 241 **Similarity**

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

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

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

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

254

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

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

265

## 266 **Culinary practices**

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

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

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

279

280

281

282

### 283 **Avoid off-flavor**

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

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

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

298  
299 The pairing principles presented so far create a match because the food-drink association  
300 leads to a unified experience. But, experts also match products in order to preserve or even  
301 enhance the experience of each product. They distinguish three principles: 1) **rinsing** aims to  
302 preserve the original qualities of each product, 2) **masking** aims to suppress off-flavor in one  
303 product, and 3) **synergy** aims to enhance one positive characteristic in one product. All three  
304 principles relate to temporal modulation of perceptions in repeated and alternate consumption,  
305 originating from carry-over effects.

306

### 307 **Rinsing effect**

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

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

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

317 This phenomenon has also been raised in interviews in which the interviewee claimed to drink  
318 a great deal of wine “because it’s a good beverage to wash down food” (Pettigrew and  
319 Charters, 2006, p 174).  
320 Peyrot des Gachons et al. (2012) demonstrated that tea consumption between bites of fatty  
321 food decreased oral fattiness more than water. This phenomenon is due to the highly  
322 emulsifying properties of tea-leaf saponins (Mura et al., 2017). Conversely fatty food  
323 consumption decreases astringency perception. For instance, Donadini et al. (2015) showed  
324 that cheeses such as Gorgonzola or Mozzarella decrease beer astringency. Peyrot des Gachons  
325 et al. (2012) also found a similar effect with dried meat and tea. This effect is especially  
326 noticeable in repeated consumption. For instance, Galmarini et al. (2016) showed that wine  
327 astringency increases over repeated sips, leading to a decrease in liking. However, this effect  
328 almost disappears when bites of cheese are consumed between consecutive sips.  
329 Consequently the liking of the wine was stable over the series of sips. In this case, matching  
330 wine and cheese keeps both products enjoyable over the whole tasting experience.  
331 The mechanisms that underlie astringency perception are complex (Laguna, Bartolomé, et al.,  
332 2017; Laguna, Sarkar, et al., 2017). Among others, astringency is related to the creation of an  
333 insoluble complex between astringent compounds (tannins in wine for instance) and salivary  
334 proteins, inducing a loss in lubrication of oral surfaces (Garcia-Estevez et al., 2018; Ployon et  
335 al., 2018). But when wine is consumed with cheese, fat from the cheese decreases friction in  
336 the mouth and restores lubrication (de Wijk and Prinz, 2005).

337

### 338 **Decrease of sensory property**

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

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

344

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

351 of Chardonnay unoaked wine (Nygren et al., 2001); and wine decreases the buttery flavor,  
352 saltiness, and sourness of blue cheeses (Nygren et al., 2003).  
353 This modulation occurs with off-flavor (Bastian et al., 2010) or with a property at a higher  
354 than optimal intensity. In both cases, pairing improves liking of a product which was initially  
355 moderately liked. Such an effect may involve several mechanisms. It could involve peripheral  
356 interactions such as bitterness suppression by umami due to suppression of the salicin-induced  
357 activation of the hTAS2R16 bitter taste receptor (Kim et al., 2015), or the competitive  
358 interactions at the olfactory-receptor level for aroma-aroma interactions. It could involve  
359 perceptual interactions occurring at the central level, such as lateral inhibition in the olfactory  
360 bulb, leading to a loss of information about an odorant in a mixture (Thomas-Danguin et al.,  
361 2014). Such an intensity decrease could also originate from a change in the stimuli  
362 themselves. For instance, increasing viscosity decreases aroma diffusion and thus increases  
363 the time to reach maximum aroma intensity (Tournier et al., 2009). Thus, consuming a drink  
364 (liquid) and food (solid or semi-solid) in sequence increases the viscosity of the bolus and  
365 decreases the intensity of some of the drink aromas.  
366 Once again, as stressed by one expert, if the masking effect can act for the best by decreasing  
367 negative characteristics, it can also be detrimental by decreasing the intensity of positive  
368 characteristics; the product is less liked and the match is not so pleasant.

369

### 370 **Enhancement of sensory properties**

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

377

378 In their studies, Nygren et al. (2001) and Madrigal-Galan and Heymann (2006) demonstrated  
379 that buttery flavor in wine was enhanced by the prior consumption of fatty food (cheese or  
380 hollandaise sauce). Donadini and Fumi (2014) found that after the prior consumption of  
381 chocolate with 30% cocoa content, teas were perceived as sweeter and richer in milky,  
382 caramel, and dried fruit aromas. However, they also found that teas, paired with 70% and 99%  
383 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).*

397

#### 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.

402

#### 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.

417

## 418 **Norms**

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

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

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

431  
432 The principles of norms and geographical identity might overlap as, historically, food  
433 transportation was limited and people tended to consume local products. However, what may  
434 have once been related to “geographical identity” may have evolved. The norms are rather  
435 related to the type of products than to the products' geographical identity. For instance,  
436 pairing sauerkraut and beer may come from the fact that both used to be commonly consumed  
437 in Alsace. At this time, it was a match related to products geographical identity. But,  
438 nowadays it becomes pairing norms as it may work with Belgian beer as well.

439

## 440 **Quality level**

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

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

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

452 **Moment of the meal**

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

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

460

461 **Specific situation**

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

475

476 **Season**

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

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



486 Indeed, preferences may change according to the season. Seo et al. (2009) found that  
487 cinnamon aroma was more pleasant during the Christmas season than summertime. Wada et  
488 al. (2012) demonstrated that infants tend to prefer an image of a strawberry tasted with a  
489 congruent odor of strawberry when the task was performed during the strawberry season than  
490 when the task was performed out of the strawberry season. In another study, Ristic et al.  
491 (2019) asked participants to indicate their preference for different wine aromas in different  
492 seasons. They found that chocolate aroma is more appropriate for winter whereas lemon,  
493 strawberry, rose and passionfruit aromas are more appropriate for summer. These changes can  
494 be explained by the ecological valence theory which suggests that stimulus preferences arise  
495 from people's average affective responses to stimulus-associated objects (Palmer and Schloss,  
496 2010). This theory explains seasonal changes in color liking such as preference for dark-warm  
497 colors (dark-red, brown, olive, and dark-chartreuse) during fall more than other seasons  
498 (Schloss et al., 2017), following the color of leaves in nature. This explains why the adequacy  
499 between the seasonal natural colors and dish colors contributes to the creation of a pleasurable  
500 dining experience (Lightner and Rand, 2014). This theory can be transposed to other sensory  
501 modalities and seems relevant in the area of food-drink pairing.

502

#### 503 4.1.3. Affective pairing principles

504

##### 505 **Individual preferences**

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

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

511

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

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

521

## 522 **Surprise**

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

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

530

531 4.2. Comparison of the usage of pairing principles according to expert and beverage types.

532

533 [Insert Figure 1 about here]

534

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

542

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

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

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

574

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

578

## 579 5. General discussion

580

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

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

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

596

597 Interviews were conducted with 10 wine and 10 beer experts. Considering such a number,  
598 analyses based on number of occurrence needs to be confirmed with a larger group.

599 Moreover, all experts were French. Thus, results have to be considered cautiously when  
600 generalized to other cultures. Culture may affect the content of the principles. For instance,  
601 when considering the principle of “Culinary practices”, two flavors that would work in one  
602 culture may not be relevant in another. So experts of different cultures, calling upon this same  
603 principle, would end up with different pairings according to classical accords in their own  
604 culinary culture. Culture may also affect the relative weight of principles used in combination.  
605 The principle of “geographical identity” is likely to be more important in a country such as  
606 France where products of origin (PDO) are numerous and well established, compared to other  
607 countries where the notion of geographical identity is less developed. Ultimately, experts  
608 from different cultures may consider principles other than those considered by French experts.

609

## 610 6. Conclusion

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

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

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

622

623

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629

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631

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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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776 **Appendix A:** Product information provided to the experts

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

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781 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

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783 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

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785 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

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789 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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810 Figure caption

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

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