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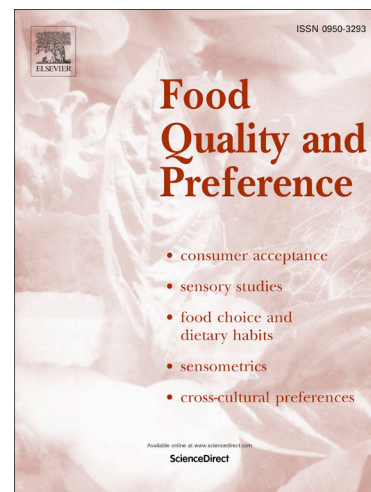
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1 **Consumer Preferences for New Fermented Food Products**  
2 **that Mix Animal and Plant Protein Sources**

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## 21 **Consumer Preferences for New Fermented Food Products** 22 **that Mix Animal and Plant Protein Sources**

23

24 **Abstract:** Consumers are being encouraged to increase the proportion of plant protein in their  
25 diets to enhance the sustainability of food systems. One approach is to develop plant-protein-  
26 rich foods that are acceptable to consumers. This study examined French people's reactions to  
27 cheese alternatives—new fermented products that mixed animal and plant protein sources. We  
28 conducted experimental sessions with 240 French participants to assess their responses to three  
29 fermented products containing different percentages of yellow pea and cow's milk. First, we  
30 asked the participants to blind-taste the three products and solicited hedonic scores of products.  
31 We then provided the participants with simple information about the products' composition  
32 and asked them to taste and score the liking of the products a second time. We also asked  
33 consumers to estimate their willingness to pay (WTP) for each product before and after  
34 revealing additional information about the nutritional or environmental benefits of consuming  
35 pea-based foods. The product with the lowest percentage of pea and the highest percentage of  
36 milk received the highest hedonic scores, and WTP was correlated with the hedonic scores.  
37 The additional information about the nutritional and environmental benefits of pea-based foods  
38 led to significant increases in WTP for two of the fermented products, but not for the least  
39 preferred product, namely the one with the highest percentage of pea. This finding suggests  
40 that participant reactions to information depended on hedonic preferences.

41

### 42 **Highlights:**

- 43 -We combined hedonic and willingness to pay (WTP) approaches to study consumer behavior
- 44 -Information about nutritional and environmental impacts may promote dietary transitions
- 45 -Participant preference increased as the product's pea percentage decreased
- 46 -WTP increased with hedonic preferences but was differentially affected by nutritional and  
47 environmental information
- 48 -Developing fermented products that mix animal and plant protein sources is a major challenge
- 49 -Partially replacing animal ingredients with plant ingredients could enhance dietary  
50 sustainability

51

52 **Keywords:** Plant-based product, consumer behavior, economic approach, sensory analysis

53

## 54 **1. Introduction**

55 The global population is predicted to reach 10 billion by 2050, and there is thus increasing  
56 concern about how human diets affect human health and the environment (Poore & Nemecek,  
57 2018, Springmann et al., 2018a, McClements, 2019). One of the major factors responsible for  
58 the negative impacts of modern diets is that they are based on large quantities of animal-based  
59 foods (Poore & Nemecek, 2018). Indeed, unbalanced diets are responsible for obesity, diabetes,  
60 and/or cardiovascular diseases in many countries (WHO, 2015, and Willett et al., 2019), and  
61 food production accounts for 25% of the world's greenhouse gas emissions (Lock et al., 2010  
62 and Tilman and Clark, 2014).

63 To promote healthier and more sustainable food systems, consumers are being  
64 encouraged to explore alternative diets and to switch to more plant-based diets (Floros et al.,  
65 2010, Springmann et al., 2017). The EAT-Lancet Commission on Food, Planet, Health (Willett  
66 et al., 2019) defined ambitious sustainable diets for different regions of the world and suggested  
67 that dietary improvements could result in significant benefits for human health and the  
68 environment. In particular, this commission recommended (1) a decrease in the consumption  
69 of meat, sugar-based products, and processed industrial dishes and (2) an increase in the  
70 consumption of fruits, vegetables, seeds, nuts, and legumes (e.g., peas and lentils). It also  
71 advised that the populations of North America, Asia, and Europe (including France) should  
72 reduce their consumption of dairy products.

73 Several other studies have highlighted the substantial benefits that can be obtained by  
74 reducing the consumption of animal-based foods (see for instance Aston et al., 2013,  
75 Springmann et al., 2018b, WCRF, 2018, and WHO, 2015). However, developing animal-based  
76 substitutes products that consumers will accept is a significant challenge. To this end, it is  
77 important to conduct studies in which researchers present consumers with plant-based

78 alternatives to traditional animal-based products and assess their responses (Hartmann and  
79 Siegrist, 2017). Indeed, increasing the desirability of plant-based products is one option for  
80 reducing the consumption of animal-based foods. In this context, fermented products are of  
81 interest because they can contain mixtures of animal and plant protein sources, allowing for  
82 product reformulations that are compatible with greater dietary sustainability.

83         However, the consumption of legumes is relatively low in many countries belonging to  
84 the Organization for Economic Co-operation and Development (OECD) (Tobler et al., 2011;  
85 Siegrist et al., 2015; Weinrich, 2019). This trend may be due to consumers perceiving plant-  
86 based foods as having multiple unpleasant flavors and tastes (e.g., bitter, vegetal, earthy) or  
87 being unfamiliar with plant-based alternatives to meat or dairy products (Schösler et al., 2012;  
88 Hartmann and Siegrist, 2017). Consequently, it is challenging to develop plant-based foods  
89 that will appeal to consumers. Furthermore, this process involves better understanding the  
90 trade-off between consumer preferences and health/environmental benefits and exploring how  
91 such dynamics are affected by the relative percentage of different protein sources in food  
92 products.

93         In this study, we developed new fermented products that combined animal and plant  
94 protein sources and studied participants' behaviours. We chose to employ this food type  
95 because it has been overlooked in previous researches. Our approach is original because we  
96 used different percentages of animal and plant protein sources in the products. Our plant protein  
97 source was the yellow pea, a legume commonly cultivated in northern Europe, including  
98 France. The yellow pea (*Pisum sativum*) is particularly rich in proteins, fiber, and minerals  
99 (González et al., 2011). Compared to cow's milk, legumes have a relatively low impact on the  
100 environment, which includes a weaker carbon footprint. Legumes such as yellow peas require  
101 the use of very few pesticides. Moreover, they can be grown without any nitrogen fertilizers  
102 because they fix their own nitrogen. When used in crop rotations, legumes provide a major

103 boost to subsequent crops such as wheat, barley, and corn; for example, a 20% gain in yield  
104 has been observed (Knight, 2012).

105 Consumer acceptance of and willingness to pay for fermented foods containing  
106 mixtures of animal and plant protein sources may be driven by hedonic preferences, including  
107 participants' awareness of health and environmental impacts. We thus investigated whether  
108 participants who were informed of food-related health and environmental issues were more  
109 willing to purchase these types of products. Briefly, we first asked participants to provide a  
110 hedonic score for the food products before and after being given basic information on the  
111 products' composition. Then, the participants were asked to indicate their willingness to pay  
112 (WTP) for a given product before and after being given additional information about the  
113 product; half the participants were told about the nutritional benefits of consuming pea-based  
114 foods, and half were told about the environmental benefits of consuming pea-based foods. The  
115 study's goal was to identify the various drivers and barriers involving in consumer preferences  
116 and WTP.

117 The remainder of the paper is organized as follows. Section 2 focuses on the protocol  
118 design, and Section 3 presents the results. Section 4 discusses the implications of results and  
119 Section 5 concludes.

120

## 121 **2. Materials and methods**

122 This section describes the design and production of the fermented food products used in the  
123 study, the experimental sessions with the study participants, and the statistical analyses.

### 124 **2.1. Design and production of the fermented products used in the study**

#### 125 ***2.1.1. Ingredients and raw materials***

126 We obtained pea protein isolate (NUTRALYS®S85F) from Roquette Frères (Lestrem,  
127 France), skimmed cow's milk powder from Lactalis (Bourgarré, France), and rapeseed oil  
128 (Fleur de Colza, Lesieur, France) from a local supermarket. Glucono delta-lactone (GDL) was  
129 used for coagulation (Sigma Aldrich, Steinheim, Germany). Agar (HP700IFG, Kalys, Bernin,  
130 France) was used to strengthen the gels.

### 131 **2.1.2. Microbial strains and inoculation preparation**

132 To ferment the products, we used four cheese strains (CNRZ212, S3, 3550, and ATCC 204307)  
133 from the following species (respectively): *Lactobacillus rhamnosus* (a lactic acid bacterium),  
134 *Lactococcus lactis* (a lactic acid bacterium), *Kluyveromyces lactis* (a yeast), and *Geotrichum*  
135 *candidum* (a yeast); all these microorganisms have been granted qualified presumption of  
136 safety (QPS) status. These strains were chosen because they can grow on pea protein isolate  
137 and change the isolate's initial green off-note (Ben Harb et al., 2019). Strains were cultured  
138 separately at 28°C for 48 to 72 h on the following broth media: Man, Rogosa, and Sharpe  
139 (MRS) agar for the lactic acid bacteria and potato dextrose broth (PDB, Biokar Diagnostics)  
140 for the yeasts. When the stationary phase of growth was reached, cells were harvested by  
141 centrifugation (5000×g, 10 min, 4°C), washed in sterile physiological saline (NaCl 9g/l), and  
142 re-suspended in sterile physiological saline at a cell density of 8.0 log<sub>10</sub> CFU/ml.

### 143 **2.1.3. Preparation of gels**

144 We prepared two types of initial emulsions—100% pea and 100% milk. We then made four  
145 further emulsions intended for fermentation: i) a 100% pea emulsion; ii) a mixture containing  
146 75% pea emulsion and 25% milk emulsion; iii) a mixture containing 50% pea emulsion and  
147 50% milk emulsion; and iv) a mixture containing 25% pea emulsion and 75% milk emulsion.

148 Further details about the preparation, gelation, and fermentation of the food products  
149 are given in Appendix A. After 14 days of fermentation, the products were packed and stored



150 at 4°C for 5 days until they were consumed during the experimental sessions. The composition  
151 of the four foods is described in Table 1. Fermentation took place at the INRAE Joint Research  
152 Unit for Cheese in Aurillac, France (see <https://www6.ara.inrae.fr/umrf/>), which respected  
153 all necessary food safety procedures.

154 The fermented products were transported to Paris in a refrigerated vehicle a few days  
155 before the experimental sessions began and were stored at 4°C. Figure 1 shows the products  
156 just before the tasting trials were initiated. The products were all tested for five foodborne  
157 pathogens—*Listeria monocytogenes*, *Staphylococcus aureus*, *Salmonella*, *Bacillus cereus*, and  
158 *Escherichia coli*—by two COFRAC-accredited testing laboratories (Eurofins Scientific and  
159 AGROLAB’S).

160 Four days before beginning the experimental sessions and after conducting some  
161 preliminary tests, we decided not to use the 100% pea product for organoleptic reasons: it was  
162 deemed to be too different from the three other products.

163

## 164 **2.2. Experimental sessions with the study participants**

### 165 **2.2.1 The experimental conditions**

166 The experiment was carried out over multiple sessions in October 2019 at Eurosyn, a  
167 private consumer testing company in Villebon-sur-Yvette, a city located 20 km south of Paris.  
168 The company has a tasting room that can accommodate up to 16 people simultaneously. There  
169 were 11–16 participants in each experimental session. Each participant was set up in an  
170 individual booth lit with a white light and equipped with the Fizz software (Biosystem,  
171 Couternon, France); the tasting room was kept at a stable temperature (20°C). Eurosyn has an  
172 established policy for protecting personal data, supporting innovation, and preserving  
173 individual liberty (n°2072127v0).

174 At the beginning of the session, all the participants received an informational document  
175 describing the conditions related to their informed participation in the study and signed a  
176 consent form. At the end of the session, the participants received €15 in compensation for their  
177 participation.

### 178 ***2.2.2 The participants***

179 Overall, 241 participants took part in the experiment. They all lived in the southern  
180 suburb of Paris (namely relatively close to Villebon-sur-Yvette), and were recruited about two  
181 weeks prior to the experiment using online and phone questionnaires focused on their  
182 sociodemographic characteristics and consumption habits. Participants were randomly selected  
183 using the quota method so that the composition of the sample was representative of the gender,  
184 age, and socioeconomic demographics of the city's population. First, equal percentages of  
185 women and men were chosen ex ante at the time of the recruitment, even if more women  
186 attended the sessions, as shown in Table 2. Second, one-third of participants were 20–34 years  
187 of age, one-third were 35–49 years of age, and one-third were 50–70 years of age. Third, 33%  
188 of participants were highly skilled professionals, 48% were professionals in middle or low-  
189 ranking occupations, and 20% were not actively employed (namely students or retired people).  
190 Moreover, participants were asked to indicate their diet in terms of animal and vegetable  
191 consumption habits. During the recruitment process, the participants were informed that the  
192 experiment would involve the consumption of fermented food products in association with a  
193 tasting procedure. Only individuals who ate cheese, even just occasionally, were selected.

### 194 ***2.2.3 Description of the experimental procedure***

195 Each session lasted 45 minutes and was organized as follows. At the beginning of the session,  
196 we orally provided the participants with some basic information. We told the participants that  
197 they would be tasting three food products twice. We underscored that all their responses would

198 be kept anonymous. We also made it clear that there were no “good” or “bad” responses and  
199 that they should freely express how they felt about the food products.

200 At that point, the experiment began and took place in three main stages (Figure 2).

201 *Stage 1: Blind tasting.* The products were served on plates (see Figure 3) and labeled  
202 with a 3-digit code. A balanced monadic presentation was used to limit carryover effects (see  
203 Figure 3).

204 We gave the participants a plate with a specific product, and we asked them to indicate  
205 a hedonic score based on the product’s visual appearance. The 7-point hedonic scale ranged  
206 from 1 for “strongly dislike” to 7 for “strongly like.” We then asked the participants to consume  
207 at least one mouthful of the product and indicate a hedonic score ranging from 1 for “very bad”  
208 to 7 for “very good.” The participants then replied to questions regarding their perception of  
209 the food (related to bitterness, flavor intensity, saltiness, stickiness, hardness, fattiness, caloric  
210 density, protein richness, and sensation of satiation) employing a 5-point Likert scale, where 1  
211 was equal to “strongly disagree” and 5 was equal to “strongly agree.” This procedure (visual  
212 liking, taste liking, and perception liking) was successively repeated for the three foods. No  
213 WTP were determined at this stage, since the “whole” product with a packaging and a name  
214 was not yet introduced at this early stage 1, making difficult a WTP elicitation. This stage 1  
215 was only focalizing on tasting, which is a crucial question for a completely new product.

216 *Stage 2: Informed tasting and initial willingness to pay.* We gave the participants basic  
217 information about the products’ composition. A simple text appeared on a screen within the  
218 booth that explained the different percentages of pea and milk in fermented products.  
219 Afterwards, the participants took part in a new tasting procedure. When the participants were  
220 given the plates, each plate indicated the product’s percentages of pea and milk (Figure 3). We  
221 then asked the participants to indicate a hedonic score based exclusively on the tasting. The

222 scale was the same as above: from 1 for “very bad” to 7 for “very good”. This procedure  
223 (hedonic scoring) was successively repeated for the three foods.

224 We subsequently assessed the participants’ willingness to pay (WTP) for the products.  
225 During the few introductory explanations about this step eliciting WTP, we made clear that  
226 none of the cheeses would be sold or given to the participants at the end of the session, because  
227 they were prototypes that could be put on the market in the near future. A declarative method  
228 for eliciting participants’ WTP was performed.<sup>1</sup> Participants were given sheets with a list of  
229 multiple prices for each product. There was one price-list sheet for each product. At the top of  
230 the page, above the price list, was a picture of the product in a packaged form. The packaging  
231 showed the percentage of pea and milk in the product. For the purposes of pictures, we created  
232 packaging from Camembert boxes (Figure 4). Camembert is a well-known traditional cheese  
233 in France, so using its packaging in the photos provided participants with a standard of  
234 reference for the potential size of the products. We named the products *Frompois* (short for  
235 *Fromage de Pois* in French), which means *Peacheese* in English. We created this hypothetical  
236 packaging represented on a picture to lend credibility to the idea that the products would be  
237 commercialized.

238

239 *Stage 3: Willingness to pay after receiving nutritional or environmental information.*

240 We communicated additional information to participants before reassessing their WTP. Half  
241 the participants received information about the nutritional benefits of consuming pea-based

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<sup>1</sup> **The absence of legal authorization for selling these cheeses** explained why an auction procedure could not be organized at the end of each session for potentially selling one packet of fermented product, based on elicited WTP. Performance-based financial incentives rely on providing the possibility to purchase the product based on the elicited WTP, via an auction or a Becker, DeGroot and Marschak (BDM) procedure (Becker et al., 1964). Lusk and Shogren (2007) underscore that simply asking for the "maximum amount participants are willing to pay for the products" without concrete products leads to risks of hypothetical biases, in which WTP are biased upward compared their “real” WTP.

242 foods; the other half received information about the environmental benefits of consuming pea-  
243 based foods. We then asked the participants to respond to the price list for each product a  
244 second time.

245 In the experiment, we controlled for the order in which the three different cheeses were  
246 served. Although serving order varied across sessions, it was fixed for a given session for all  
247 the participants (Table 3). For each session, the order of WTP elicitation for these three cheeses  
248 was organized in accordance with the specific serving order of the session.

#### 249 *2.2.4 Details on assessing willingness to pay during stages 2 and 3*

250 To assess WTP for the three cheeses previously tasted during stages 2 and 3, participants  
251 were asked to choose whether or not they would buy the product for prices ranging from €1.80  
252 to €3.60 that increased in increments of 10 cents on the multiple-price list (see Figure 5).<sup>2</sup> We  
253 based these prices on a supermarket survey during which we noted the observed prices of  
254 Camembert in Paris and the suburbs of Paris. As mentioned above, Camembert represented a  
255 good standard of reference against which to compare the new food products. Participants were  
256 given a new price-list sheet for each product during each round. Just above the price list was  
257 the following question: “Would you purchase the product at the following prices? For each  
258 line, check either yes, no, or maybe.”

259 During each round, participants had to provide an answer for each price in the list for  
260 each product. The WTP for a given product was determined by identifying the highest price to  
261 which a participant responded “yes.” If the answer was “no” or “maybe” for all the prices, the  
262 WTP was equal to €1.70, 10 cents below the lowest proposed price (an alternative

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<sup>2</sup> Alternatively, we could follow a discrete choice experiment approach (Train, 2009), in which respondents indicate choice(s) among different choice sets composed of different hypothetical products built up by different combinations of attributes and levels of selected prices. With this alternative method, the purchasing decisions would also be hypothetical because of constraints coming from cheeses prototypes.

263 configuration in which the minimum price was €0 was also studied leading to similar results).  
264 If the answer was “yes” for all the prices, the WTP was equal to €3.60 (the highest proposed  
265 price).<sup>3</sup>

266 In this experiment, we employed multiple-price lists to simplify the participants’ task of  
267 independently evaluating the products during the two rounds. In other words, the method was  
268 very easy to understand for participants, which constituted the main advantage of this list.  
269 Moreover, this “maybe” option in the list captures consumers’ hesitations, which is particularly  
270 important for new products, and often overlooked by other methods. However, the use of  
271 multiple-price lists has been criticized for two main reasons (Andersen et al., 2006). First, they  
272 elicit interval data rather than point estimates for WTP. In our study, the 10-cent interval helped  
273 ensure that the WTP displayed a higher degree of precision. Second, there is a framing effect  
274 where participants are psychologically biased toward the mid-range prices.<sup>4</sup> However, despite  
275 their shortcomings, multiple-price lists remain useful because they are straightforward when  
276 participants are being asked to carry out multiple tasks. Ariely et al. (2003) underscored that  
277 WTP, rather than being stable, are sensitive to various influences and anchoring, which  
278 suggests the absence of panacea for finding WTP (see the comments about the hypothetical  
279 WTP in the discussion of section 4). Marette et al. (2017) underlined that, if WTP are  
280 particularly unstable under different contexts, WTP variations following revelations of

---

<sup>3</sup>Our study defines WTP using the highest “yes” for the 241 participants. For only 19 participants a lower limit (LL) for “yes” was observed, where  $LL < WTP$ . In these cases, LL is the lowest price to which they replied “yes”; they replied “no” or “maybe” to prices strictly lower than the LL. Marette et al. (2013) interpret this limit LL as a perceived price under which the quality of the product cannot be guaranteed, leading to a purchase refusal. These LLs are not considered in this study.

<sup>4</sup>Andersen et al. (2006) controlled for this effect by changing the boundaries of the multiple-price list. Here, we chose to use consistent boundaries because we were studying the impact of revealing further information on WTP estimates, which required that the participants receive the same price list. However, it would be possible to test robustness by placing participants in subgroups and giving those subgroups price lists with different intervals and different boundaries (e.g., higher or lower than €0.40 and €2.10).

281 information are invariant across these contexts, which provides credibility to the impact of  
282 messages revealed between stages 2 and 3 of this study.

283

### 284 ***2.2.5 Details on the additional information provided during stage 3***

285 The informational texts shown to participants during stage 3 were written after studying articles  
286 in the nutritional and environmental sciences. We kept them relatively short because previous  
287 research has underscored that shorter texts are more efficient than longer texts with more  
288 complex information (Wansink et al., 2004). One text focused on nutrition/health, and the other  
289 focused on the environment. They discussed the nutritional or environmental benefits  
290 associated with the cultivation and consumption of peas. Because of time constraints,  
291 nutritional information was given during half the sessions (representing a total of 123  
292 participants), and environmental information was given during the other half of the sessions  
293 (representing a total of 118 participants). Translations of the informational texts are provided  
294 in Appendix B.

### 295 **2.3. Statistical analyses**

296 Data analyses were performed using R software and XLSTAT software (Addinsoft, Paris,  
297 France, 2014, 5.02). First, we looked at the hedonic scores and the WTP scores separately. We  
298 tested whether the scores differed significantly between rounds using the Wilcoxon test for  
299 paired samples. We examined the correlations between the hedonic scores and the WTP scores  
300 with Spearman correlations.

301 The liking scores reflecting how the participants liked the products (visual liking scores,  
302 tasting liking scores after initial consumption, and tasting liking scores after receiving  
303 information on product composition) were analyzed using a three-way ANOVA in which

304 product type, consumer identity, and serving order were the main effects. Preference patterns  
305 were explored by applying hierarchical cluster analysis (HCA, Euclidean distance, Ward's  
306 criteria) to the ~~normalized~~ liking scores. This approach allowed us to define clusters of  
307 participants with similar preference patterns. Differences among clusters and the specificities  
308 of each cluster were further analyzed using ANOVAs, as described above: cluster was added  
309 as a main effect, and the cluster  $\times$  product type interaction was also included.

310 We used econometric estimators to analyze the WTP data. We examined the impact of  
311 the informational texts by pooling the participants' WTP scores for the three food products  
312 during stages 2 and 3. Given that each participant produced two WTP scores, errors related to  
313 these variables were potentially correlated for each participant. Therefore, this random effect  
314 imposed constraints on the structure of the variance-covariance matrix. Moreover, the WTP  
315 scores were real numbers ranging between €1.70 and €3.60. This score could not be negative  
316 and was left-censored at €1.70; we therefore used the random effects Tobit estimator, which  
317 describes the relationship between a non-negative dependent variable and the independent  
318 variables. In our model, product type was represented with dummy variables. More  
319 specifically, the variable *25% pea* was equal to 1 for the products containing 25% pea emulsion  
320 and 0 otherwise; the variable *50% pea* was equal to 1 for the products containing 50% pea and  
321 0 otherwise; and the variable *75% pea* was equal to 1 for the products containing 75% pea and  
322 0 otherwise. We also used dummy variables for the informational text type. The variable  
323 *Information about Nutrition* was equal to 1 when participants had been exposed to this text  
324 type and 0 otherwise, while the variable *Information about Environment* was equal to 1 when  
325 participants were exposed to this text type and 0 otherwise. Regression analyses were also used  
326 to explore participants' perceptions and socioeconomic characteristics.

327



### 328 3. Results

#### 329 3.1. Hedonic scores

330 Overall, participants moderately liked the products. The mean visual liking score was 3.9; the  
331 mean initial liking taste score was 3.1; and the mean liking taste score after participants  
332 received compositional information was 3.2 (on a 7-point scale) (Figure 6).

333 There were significant differences in how the three products were scored over the course of the  
334 session (i.e., between the visual liking score, the initial taste liking score, and the post-  
335 compositional information taste liking score) ( $F_{\text{prod}}(2, 478) = 14.16; p < 0.0001$ ) and by different  
336 participants ( $F_{\text{subj}}(240, 478) = 6.02; p < 0.0001$ ). Serving order did not significantly affect the  
337 hedonic scores (or the WTP scores). For each subgraph of figure 6, the Newman Keuls tests  
338 show that liking scores of different products are statistically different. Regardless of the stage,  
339 participants clearly preferred the product with the lowest pea percentage, namely 25% Pea  
340 (Figure 6). After the participants first tasted the products, all the scores decreased by about one  
341 point. Providing participants with information about the products' composition had no effect  
342 on the scores ( $F_{\text{Info}}(1, 470) = 2.02; p = 0.157$ ). The differences in scores among products were less  
343 pronounced after the products were tasted, as highlighted by the results of the Newman Keuls  
344 tests (Figure 6).

345 When the participants evaluated the products' sensory attributes using the Likert scale,  
346 the products were found to differ in their bitter, salty, sticky, fatty, and flavor notes (Appendix  
347 C). The 25% pea product was perceived as less bitter and less fatty than the other two products  
348 (50% pea and 75% pea). These results, and notably the greater perceived bitterness, could  
349 explain why participants liked the products with greater pea percentages less.

350 Using the HCA, we identified three different groups of participants with distinct  
351 preference patterns (Figure 7). These group differences were confirmed by the significant

352 cluster  $\times$  product type interaction ( $F_{4, 478}=7.36$  and  $15.12$ ,  $p<0.0001$ ) that emerged for the initial  
353 taste liking score and the post-compositional information taste liking score. While this  
354 interaction was not significant for the visual score, there was a pronounced effect of product  
355 type (Table 4).

356 The participants in cluster 2 ( $n=65$ ) gave the products higher scores overall and were  
357 more sensitive to the products' pea percentages (Fig. 7). They liked the products with higher  
358 pea percentages less. In contrast, the participants in cluster 1 ( $n=32$ ) clearly rejected all the  
359 product types equally. Participants in cluster 3 ( $n=144$ ) displayed an intermediate response:  
360 they gave the products lower scores overall but demonstrated a preference for the 25% pea  
361 product. The results of the screening questionnaire found no clear differences in the socio-  
362 demographic and dietary habits of participants in the different clusters, maybe because, beyond  
363 hedonic scores, no particular anchorage effect could be isolated with such new fermented  
364 products. There were some slight differences in their consumption of fruit, starchy foods, and  
365 tofu. In particular, a portion of cluster 2 participants had a higher level of tofu consumption.

366

### 367 **3.2 Willingness-to-pay scores**

368 In our analysis of the WTP scores, we distinguished between non-engaged participants and  
369 engaged participants. Non-engaged participants never replied "yes" to any price on the six  
370 different price-list sheets, while engaged participants replied "yes" at least once.

371 A total of 239 study participants filled out the price-list sheets; 2 did not. Among these  
372 239 people, 111 were non engaged, and 128 were engaged. Figure 8 shows the average WTP  
373 score for the engaged participants. As a reminder, the WTP score indicates the maximum price  
374 a participant was willing to pay for the product, which was equal to the highest price associated  
375 with a "yes" or to €1.70, if the participant did not failed to reply "yes" to any price (subsection

376 2.2). Even if different explanations could be suggested to explain that 111 participants never  
377 replied “yes” to any price, the most likely one is the fact that participants do not adhere to this  
378 type of fermented products and would never want to buy it, since the bottom price on the price  
379 list was maybe too high (see a quasi-confirmation of this idea with Figure 10 below). Their  
380 purchasing intents are very likely to be zero with a WTP equal to €1.70, since almost all cheeses  
381 like Camembert were sold at a price higher than €1.80 on the French market at the time of the  
382 experiment. Note that 111 non-engaged bidders (with no “Yes”) is a big share of the sample  
383 with 239 participants, which is “classical” for food innovation.

384 For each product type, we present the mean WTP score for the three different products  
385 before and after the participants were shown an informational text about the nutritional or  
386 environmental benefits of consuming pea-based foods. Data were pooled including these two  
387 treatment groups receiving different informational texts.

388 In Figure 8, the average pre-information WTP score is the first bar for each product.  
389 These mean WTP scores were negatively associated with pea percentage: the 25% pea product  
390 had the highest average WTP score, even if these average WTP scores for the three products  
391 are relatively close <sup>5</sup>. After the participants were shown the informational texts, the WTP scores  
392 significantly increased for the three products. The greatest effect was seen for the 50% pea  
393 product (with an increase of 7.4%).

394 The econometric estimates clarified the impact of providing the participants with the  
395 nutritional or environmental information. As a reminder, we used dummy variables (1/0) to

---

<sup>5</sup> From Wilcoxon tests for comparing paired samples, the study of WTP scores before the revelation of information (corresponding to first bars on figure 8) leads to the following results. The WTP scores for the 25% pea product are statistically different from the WTP scores for the 75% pea product ( $P=0.010$ ). Conversely, the WTP scores for the 50% pea product are not statistically different from the WTP scores for the 25% pea product ( $P=0.113$ ) and for the 75% pea product ( $P=0.329$ ).

396 encode the product types (25% pea, 50% pea, 75% pea) and the informational types  
397 (*Information about Nutrition* and *Information about Environment*).

398 We also carried out regressions using the data from all the participants (n=239) and the  
399 engaged participants (n=128). Both regressions yielded similar results even if their coefficients  
400 were different. This difference was explained by the inclusion of non-engaged participants  
401 (WTP score of €1.70) in the first regression. The coefficients were higher in the second  
402 regression, which only included data for the engaged participants (much higher WTP scores).  
403 Table 5 confirms the results shown in Figure 8. In the second regression, before the participants  
404 were shown the informational texts, the WTP score for the 25% pea product (coefficient =  
405 2.142) was significantly higher than the WTP score for the 50% pea product (coefficient =  
406 2.071), which was, in turn, higher than the WTP score for the 75% pea product (coefficient =  
407 2.026). These results mean that participants preferred the product with the highest percentage  
408 of milk.

409 After the participants were shown the informational texts, the WTP scores increased  
410 significantly, but not across the board. In particular, the WTP score for the 75% pea product  
411 was uninfluenced. Both types of information had the strongest impact on the 50% pea product  
412 (coefficients = 0.161 and 0.144 in the second regression), although the nutritional information  
413 had a greater effect than the environmental information. For the 25% pea product, only the  
414 nutritional information had a significant impact, perhaps because the product contained a  
415 smaller percentage of pea. These results indicate that the participants internalized what they  
416 had been told when it came to the products they liked more (the 25% pea product and the 50%  
417 pea product); they did not apply it in the case of the least preferred product (the 75% pea  
418 product). In other words, the participants' reactions to the information depended on their  
419 preferences.

420 We also ran alternative regressions using socioeconomic characteristics (taken from the  
421 recruitment questionnaires) and the participants' perceptions of food innovations (taken from  
422 the end-of-session questionnaire), but these variables had no influence on the WTP scores  
423 (results not shown). As previous research has indicated (see Lusk and Shogren, 2007), in  
424 laboratory trials, the influence of factors such as income or educational level is limited  
425 compared to the influence of dietary habits.

426 We examined cases in which participants replied "yes" at least once on the price-list  
427 sheets but also sometimes answered "maybe". Indeed, a given participant might reply "yes" to  
428 the lowest prices and then "maybe" to some of the mid-range prices. For this analysis, we  
429 pooled all the responses for the three product types and the two assessment rounds for each  
430 participant. Out of the total of 1,416 observations (including situations in which "yes" was  
431 never chosen), there were 548 cases in which participants replied "maybe" at least once above  
432 the highest price to which they replied "yes." These cases represented a substantial percentage  
433 of the total observations (38.7%). This finding may indicate that many participants felt  
434 hesitation in the face of these new fermented products. We noted that the highest "maybe"  
435 always occurred above the highest "yes" and that the difference between the two was rather  
436 pronounced (Fig. 9), which lends support to this idea. Indeed, the difference was greater or  
437 equal to €0.40 in 48% of these cases, suggesting that WTP could increase if efforts were made  
438 to persuade individuals to consume these new products.

439

### 440 **3.3 Correlations between the hedonic scores and the willingness-to-pay scores**

441 During stage 2, the hedonic scores and the WTP scores were obtained in succession,  
442 which allowed us to examine their correlation. Figure 10 shows the relationships between the  
443 hedonic scores and the WTP scores, with the hedonic scores on the x-axis, and the average

444 WTP score for each subgroup defined by a specific score on the y-axis. The data for the three  
445 product types are pooled, and the numbers of observations associated with each score are  
446 indicated at the top of the figure.

447 The hedonic scores and the WTP scores were correlated (Spearman correlation  
448 coefficient = 0.532; Fig. 10). It is clear that when participants gave the products poor hedonic  
449 scores ( $\leq 3$ ), they also showed a low WTP for the products, which averaged between €1.70  
450 and €1.80. Many of them with this poor hedonic score never replied “yes” to any price of the  
451 list with a WTP arbitrarily equal to €1.70 (see subsection 2.2), simply meaning that they would  
452 never buy a fermented product they do not like. When the participants gave neutral or good  
453 hedonic scores ( $\geq 4$ ) to the products, there was a clear positive relationship between the  
454 hedonic scores and the WTP scores.

455

#### 456 **4. Discussion**

457 Previous results can help inform future work to develop plant-based fermented products that  
458 are attractive to consumers, regardless of their dietary habits. In general, participants  
459 moderately liked the products. This interest for the products was reinforced when participants  
460 were given additional information about the benefits of pea-based foods, especially when the  
461 information conveyed a nutritional message. The large number of “maybe” replies during the  
462 WTP assessments suggest that targeted marketing campaigns could help convince consumers  
463 of the benefits associated with new fermented products containing a mixture of animal- and  
464 plant-based protein sources. We observed marked differences among individual participants,  
465 which is common in research on innovative products. We found that participants demonstrated  
466 an interest in these fermented foods, which provides support for the products’ introduction onto  
467 the market. More specifically, there was a clear preference for the product with the highest

468 milk content and lowest pea content (the 25% pea product had the highest WTP scores). Our  
469 approach represents an alternative to classical solutions for reducing the consumption of animal  
470 products. Indeed, traditionally, efforts have focused entirely on replacing animal-based  
471 products with plant-based products. Here, we suggest a partial substitution within the context  
472 of a given product.

473 In our experimental design, we utilized both hedonic scores and WTP to delve more  
474 deeply into consumer behavior, an approach that shows great potential. Our results clearly  
475 show that a strong correlation exists between how well participants like a product and their  
476 WTP (see Roosen et al., 2007). Indeed, both hedonic and WTP scores provide crucial  
477 information that should be evaluated before introducing products onto the market.

478 Although the experiment took place in sensory booths, which do not necessarily  
479 replicate real-life conditions, they did allow us to analyze participant behavior under controlled  
480 conditions. This approach has clear advantages because certain “field” studies have  
481 underscored the problems engendered by information proliferation, imperfect recall, the lack  
482 of time before purchasing, the large number of purchased products, and/or confusion about  
483 complex information, which many consumers face *in situ* in stores. These issues often make it  
484 relatively difficult to interpret results from experiments conducted under real-life conditions  
485 (Falk and Heckman, 2009). However, it would be useful to conduct a complementary “field”  
486 experiment in which our study food products are made available in supermarkets, although  
487 such an experiment would be complicated because of the need to obtain regulatory  
488 authorization. However, in such an experiment, consumers would be purchasing real products,  
489 which should eliminate the hypothetical nature of the WTP scores obtained in this study using  
490 a multiple-price list. Clearly, two of the key limitations of our research are the artificial

491 conditions under which it was conducted and the estimates of WTP being based on hypothetical  
492 purchases.<sup>6</sup>

493 The results for the participants' perception of the products revealed significant  
494 differences in product bitterness. The 75% pea product was perceived as significantly more  
495 bitter than the other two products, which could explain why most participants rejected it  
496 entirely. Fermentation can help reduce perceived bitterness, but it appeared to be insufficient  
497 in this study in the case of the 75% pea product. Indeed, this product presented the sensory  
498 characteristics typical of pulses, notably bitterness (Bott and Chambers, 2006; Humiski and  
499 Aluko, 2007). The use of other legume species (e.g., faba beans, soybeans) could be another  
500 solution for modifying the perceived bitterness of fermented products.

501 In addition, the culinary role that products have the potential to play can greatly impact  
502 their perception and how well they are liked. For example, these fermented products could have  
503 different uses than classical cheeses, and they could be cooked, added to salads, or spread on  
504 bread. Participant acceptance and WTP could also change if the products were tested under  
505 real meal preparation conditions.

506 Consumer preferences and product composition (subsection 2.1) may also lead to  
507 broader industrial options and the possibility of further differentiating the products. The use of  
508 products that mix animal- and plant-based protein sources could receive support from  
509 policymakers, perhaps via subsidies for low-quality cheeses. The introduction of these new  
510 products could also impact supply chains and agricultural systems by lengthening crop

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<sup>6</sup>Even if hypothetical WTP are likely to be biased upward, recent research seems to show that the risks of such biases are limited for private goods. By comparing hypothetical and non-hypothetical responses, Lusk and Schroeter (2004) showed that the marginal WTP associated with changes in food quality/characteristics or the revelation of information (as in our study) does not tend to be statistically different between hypothetical and real payment situations.



511 rotations and increasing the frequency of legumes in classical rotations, which are often based  
512 on wheat, canola, and barley (Knight, 2012).

513

## 514 **5. Conclusion**

515 Our study has improved understanding of how consumers may respond to new products  
516 incorporating plant-based protein sources. This knowledge may help diversify food protein  
517 sources with a view to encouraging behaviors that increase dietary sustainability. We identified  
518 different groups of potential consumers who displayed distinct responses to the products. Some  
519 were clearly interested in consuming these mixed products; indeed, our results suggest that the  
520 products might be accepted by almost half the population. While participants appeared to be  
521 largely motivated to consume these products based on their sensory characteristics, desirability  
522 was also affected by providing information about the foods' nutritional and environmental  
523 benefits. Furthermore, the nutritional information had a stronger overall impact than the  
524 environmental information on the participants' appreciation of and willingness to pay for the  
525 products. Further research that includes life-cycle assessments of fermented products should  
526 be conducted to quantify their environmental benefits.

527         The results of this study underscore that creating new foods that combine animal- and  
528 plant-based ingredients should be promoted as part of the effort to design more sustainable  
529 diets. A significant percentage of consumers may actively support the release of these new  
530 products, which have significant benefits for human health and the environment.

531

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629 **Table 1. Composition of fermented products based on pea protein and milk - biochemical**  
630 **characteristics (pH and dry weight) after the day 0 when the fermented products were**  
631 **created and the day 16 that was the ripening day (% w/w)**

632

	Mix product 25% Pea 75% Milk	Mix product 50% Pea 50% Milk	Mix product 75% Pea 25% Milk	Pea product 100% Pea 0% Milk
<b>Day 0</b>				
<b>Proteins (%)</b>				
* pea	2.5	5	7.5	10
* milk	7.5	5	2.5	0
<b>Fat (%)</b>	9.5	9.5	9.5	9.5
<b>Lactose (%)</b>	12	8	4	0
<b>Salt (%)</b>	0.2	0.2	0.2	0.2
<b>pH</b>	5.5	5.6	5.7	5.9
<b>Dry weight (%)</b>	29.6	27.2	23	20.3
<b>Day 16</b>				
<b>pH</b>	4.6	4.5	4.5	6.6
<b>Dry weight (%)</b>	40.3	38.7	34.9	26.3

633

634

635

636 **Table 2: Sociodemographic and dietary characteristics of participants**

637

		241 participants
<b>Gender</b>	Women (%)	46
	Men (%)	54
<b>Age (year)</b>	20-34 (%)	40
	35-49 (%)	38
	Age 59 and over (%)	20

<b>Level of education<sup>1</sup></b>	< Baccalaureate (%)	20
	Bac and bac + 2 (%)	48
	Higher than bac + 2 (%)	33
<b>Dietary habits<sup>2</sup></b>	I prefer fish to meat, but I eat meat when the opportunity arises (%)	18
	I like meat a lot and eat a lot of it, it's hard to imagine a meal without it (%)	19
	I like meat, I consume it regularly (%)	63

638

639 *Note:* <sup>1</sup>Baccalaureate (bac): French high school diploma <sup>2</sup>From the recruitment questionnaire.

640

641

642

643 **Table 3. Subgroups with specific orders of products appearance**

644

<b>Order of products during sessions</b>	<b>Number of sessions</b>	<b>Overall number of participants</b>
Pea 25%, Pea 50%, Pea 75%	4	43
Pea 25%, Pea 75%, Pea 50%	4	48
Pea 50%, Pea 25%, Pea 50%	4	46
Pea 50%, Pea 75%, Pea 25%	3	36
Pea 75%, Pea 25%, Pea 50%	3	35
Pea 75%, Pea 50%, Pea 25%	3	33
<b>Total</b>	<b>21</b>	<b>241</b>

645

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647

648 **Table 4: Analyses of variance (ANOVA) on cluster and product with interaction for the liking related to the aspect, the blind tasting at stage 1 and after composition information at stage 2.**

649

650

651

	<b>cluster</b>		<b>Product</b>		<b>cluster*Product</b>	
	<i>F value</i>	<i>P value</i>	<i>F value</i>	<i>P value</i>	<i>F value</i>	<i>P value</i>
LIKING aspect - stage 1	230,84	< <b>0,0001</b>	10,16	< <b>0,0001</b>	1,02	<b>0,395</b>
stage2	190,27	< <b>0,0001</b>	2,54	<b>0,080</b>	7,38	< <b>0,0001</b>

*stage3*      187,13      < 0,0001      4,78      0,009      15,12      < 0,0001

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654

655

656 **Table 5. Estimations of pooled WTP with a Tobit random effects estimator** Note: \*\*:   
 657 significant at 1%; \*: significant at 5%. Standard errors in parentheses.   
 658

659

	239 participants WTP	128 engaged participants WTP
<i>25% Pea (1/0)</i>	1.767** (0.020)	2.142** (0.042)
<i>50% Pea (1/0)</i>	1.729** (0.019)	2.071** (0.042)
<i>75% Pea (1/0)</i>	1.704** (0.019)	2.026** (0.042)
<i>25% Pea (1/0) × Information about Nutrition (1/0)</i>	0.073* (0.032)	0.128* (0.061)
<i>25% Pea (1/0) × Information about Environment (1/0)</i>	0.036 (0.032)	0.074 (0.063)
<i>50% Pea (1/0) × Information about Nutrition (1/0)</i>	0.091** (0.032)	0.161** (0.061)
<i>50% Pea (1/0) × Information about Environment (1/0)</i>	0.074* (0.033)	0.144* (0.063)
<i>75% Pea (1/0) × Information about Nutrition (1/0)</i>	0.041 (0.032)	0.101 (0.063)
<i>75% Pea (1/0) × Information about Environment (1/0)</i>	0.056 (0.033)	0.070 (0.061)
Stand. devi $\varepsilon$	0.288*** (0.005)	0.388*** (0.010)
Stand. dev. $\mu$	0.391*** (0.012)	0.248*** (0.016)
Observations	N= 1 434	N= 768
Log likelihood	-468.55	-451.71

660

661

662

663 **Appendix A**

**664 Details about product preparation, gelation, and fermentation**

665 The pea emulsion was prepared by mixing 64 kg of tap water with 190 g of NaCl in an  
666 80-L stainless steel bioreactor. The solution was heated to 50°C and kept at that temperature  
667 for 30 min using the hot water circulation system in the double envelope of the bioreactor.  
668 Then, 11.4 kg of pea protein isolate were added. This protein suspension medium was agitated  
669 and maintained at 50°C for 20 min before being sterilized. Sterilization was performed via  
670 steam injection (110°C for 15 min). The medium was then kept at 60°C for 30 min; 7 kg of  
671 rapeseed oil was subsequently added. Lastly, the suspension was heated to 60°C and shaken  
672 for 55 min.

673 The milk emulsion was prepared by mixing 15.48 kg of skimmed cow's milk powder  
674 with 32.4 kg of tap water and 132 g of NaCl in a 60-L stainless steel bioreactor. The solution  
675 was heated to 50°C and kept at that temperature for 2 h using the hot water circulation system  
676 in the double envelope of the bioreactor. The reconstituted milk was then sterilized via steam  
677 injection (110°C for 15 minutes). The medium was cooled for 2 h until it dropped to a  
678 temperature of 60°C; 4.7 kg of rapeseed oil was then added. The mixture was stirred for 30  
679 min at 60°C.

680 The two emulsion types were drawn off into sterile cans. The cans were transported to  
681 the technology platform, where they were stored overnight in a cold room at 4°C. The two  
682 emulsion types were then distributed into four stainless steel manufacturing tanks based on the  
683 desired composition: tank 1—100% pea (29 kg); tank 2—75% pea (27.75 kg) and 25% milk  
684 (7.25 kg); tank 3—50% pea (14.5 kg) and 50% milk (14.5 kg); and tank 4—25% pea (7.25 kg)  
685 and 75% milk (27.75 kg). The four tanks were then heated to 60°C and subject to stirring for  
686 1 h. To initiate gelation, an agar solution (1 L at 1% w/v prepared in boiled water cooled to

687 50°C) and glucono delta-lactone (GDL; 0.5% w/v) were added to each tank. Tank temperature  
688 was then lowered to 40°C and kept there for 30 min before inoculation took place.

689 The four suspensions were inoculated with a physiological saline solution containing a  
690 defined microbial community. Cell density was 6.0 log CFU/g for each bacterial strain and 4.0  
691 log CFU/g for each fungus. The suspensions, which had not yet gelled, were rapidly poured  
692 into aluminium moulds (165 mL/type of gel with a mass of 190 g), which were placed in a  
693 room kept at 30°C with a relative humidity of 95%. They were left there overnight to allow  
694 coagulation to occur.

695 The products were dried for 24 h under conditions of continuous air circulation; the  
696 temperature was lowered by 5°C every 3 h until it reached a stable 10°C. The gels were  
697 removed from the moulds, placed on plastic moulds, and incubated in a maturing cellar for 14  
698 days at 9°C with a relative humidity of 92.5%.

699

## 700 **Appendix B**

701 **Informational texts shown to the participants during stage 3.**



## Do plant-based fermented cheese products have health/nutritional benefits?


The composition of fermented products has important nutritional consequences:

- On average, **70% and 30%** of the proteins consumed by French people are of animal and plant origin, respectively.
- French National Nutrition and Health Program (PNNS)** benchmarks and experts have proposed that OECD countries must recalibrate their dietary ratios of plant to animal proteins: it is recommended that **animal and plant proteins be balanced (50/50)**.

In the products offered to you, peas are the source of the plant proteins.


- The foods offered to you are **fermented products containing peas**. They were **minimally transformed** during the production process, and they are not considered to have been highly processed.
- Finally, these foods are a **source of microorganisms** and have health benefits.

The pea is a legume grown in France



**A powerful superfood** FAO 2018

- Zero cholesterol
- High content of iron and zinc
- Rich in nutrients
- Gluten free
- Rich in minerals and B-vitamins
- Source of protein
- Low glycaemic index
- Low fat content
- Source of dietary fibre



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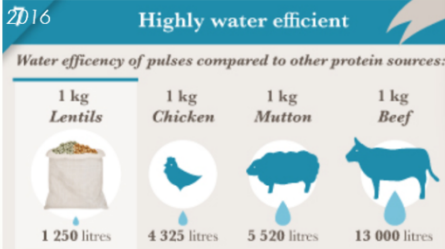
703 **Figure B1. Nutritional information about the benefits of pea-based foods shown to 123**704 **participants**

## Do plant-based fermented cheese products have environmental benefits?

The composition of cheese has important environmental consequences:





- The direct consumption of plant-based proteins from legumes (e.g., lentils, peas), such as in the form of plant-based cheeses, for example, would make it possible to :
  - significantly **reduce the area of cultivated land**
  - reduce the use of pesticides and chemical fertilizers**
  - reduce water consumption and greenhouse gas emissions**
- These benefits are notably present in association with the cultivation of peas, which are the source of the plant-based proteins used in the fermented products offered to you.


The pea is a legume grown in France



**D16** **Highly water efficient**

*Water efficiency of pulses compared to other protein sources:*

1 kg Lentils	1 kg Chicken	1 kg Mutton	1 kg Beef
			
1 250 litres	4 325 litres	5 520 litres	13 000 litres



705

706 **Figure B2. Environmental information about the benefits of pea-based foods shown to**707 **118 participants**

708

709 **Appendix C**710 **Specific perceptions of three fermented products**

711 Figure C1 **presents the** perceptions of three fermented products related to 8 criteria namely  
712 bitterness, flavor intensity, saltiness, stickiness, hardness, fattiness, protein richness, and  
713 sensation of satiation. At the end of stage 1 (blind tasting), we employed a 5-point Likert scale,  
714 where 1 was equal to “strongly disagree” and 5 was equal to “strongly agree”. For the three  
715 products, the y-axis indicates the percent of participants who agree (including the “strongly  
716 agree” replies), who are indifferent, and who disagree (including the “strongly disagree”  
717 replies). It shows that the products were found to particularly differ in their bitter, salty, sticky,  
718 fatty, and flavor notes.

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720



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722 **Figure C1. Specific perceptions of three fermented products**

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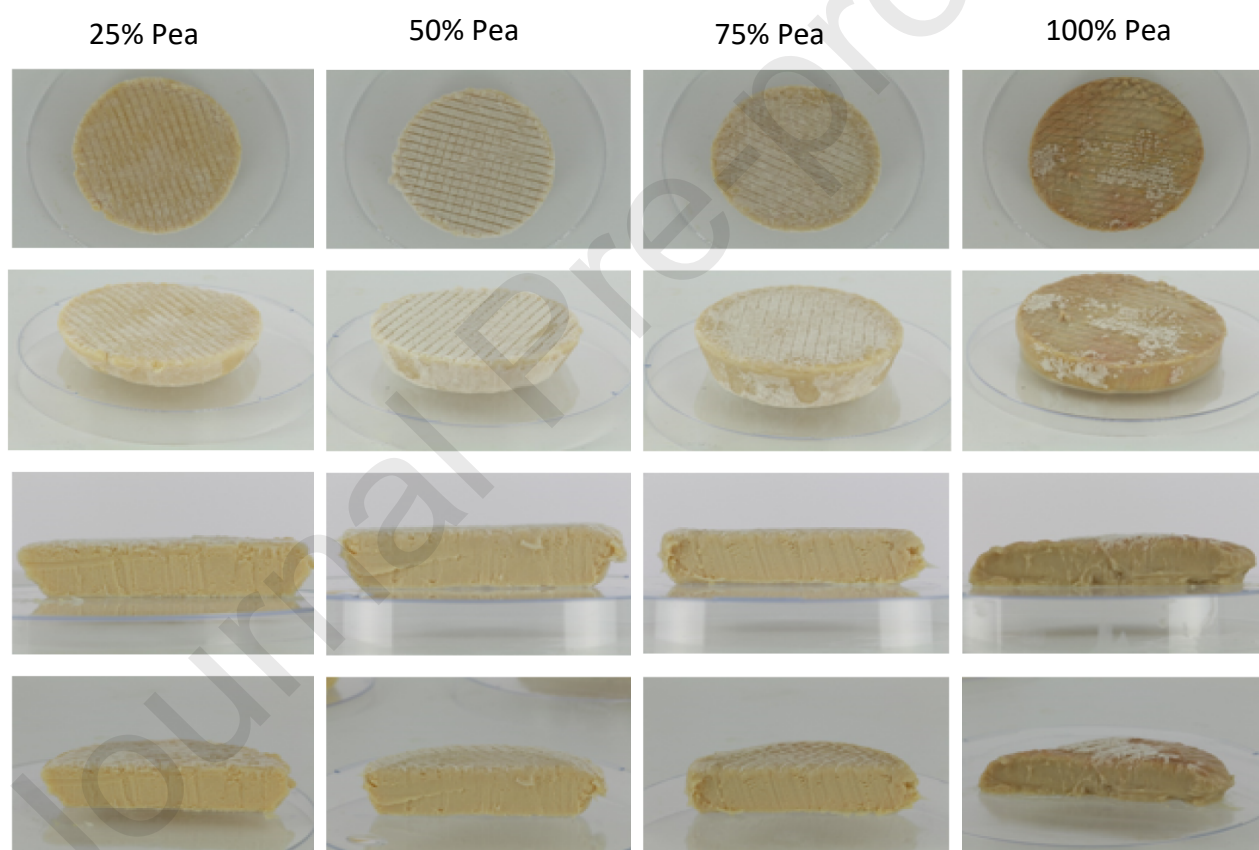
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727 **author statement**728 **Anne Saint-Eve**: Conceptualization, Writing- Reviewing, Methodology and Editing,729 **Françoise Irlinger**: Product conception and realization, Writing- Reviewing,730 **Caroline Pénicaud**: Methodology, Writing- Reviewing, **Isabelle Souchon**:731 Methodology, Writing- Reviewing, **Stéphan Marette**: Conceptualization,

732 Methodology, Writing- Reviewing

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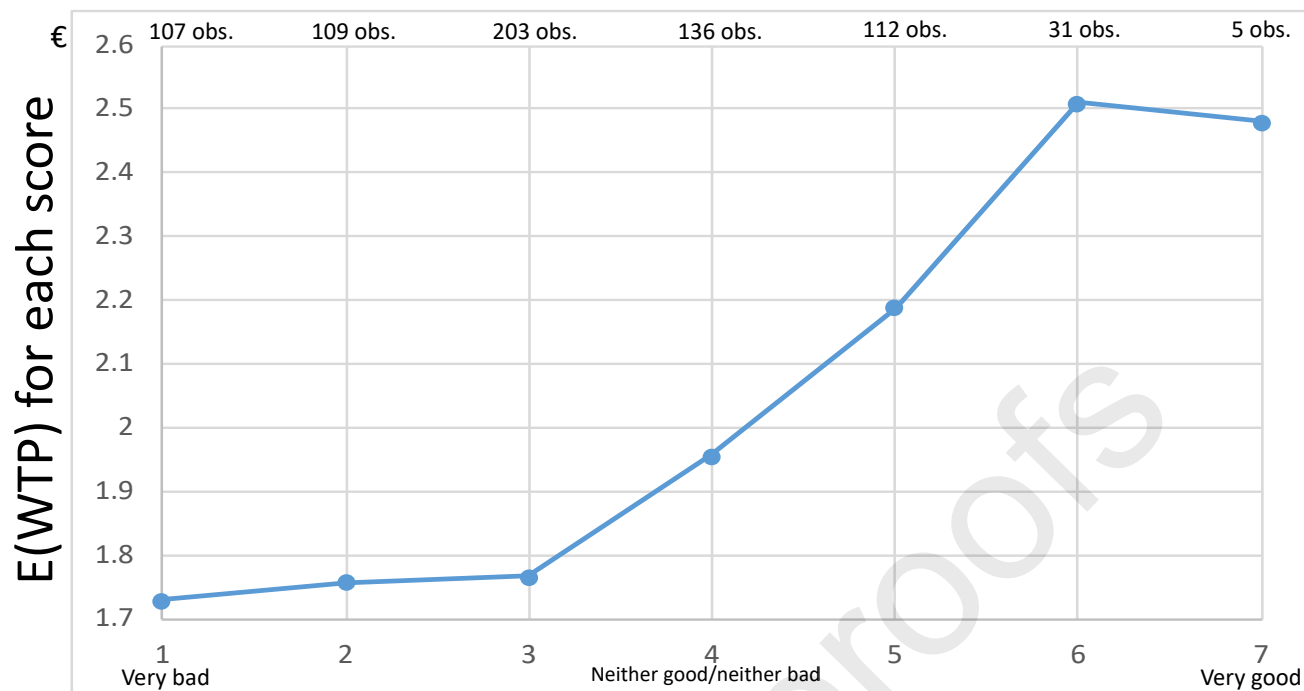


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736 **Figure 1: Pictures of the four fermented products the day where they were tasted: 25%**737 **Pea, 50% Pea, 75% Pea and 100% Pea.**

738

739



## TASTING

740 **Figure 10. Link between the hedonic score and WTP at stage 2 for the three types of**  
 741 **fermented products for which observations are pooled (Spearman correlation coefficient**  
 742 **0.532)**  
 743

740

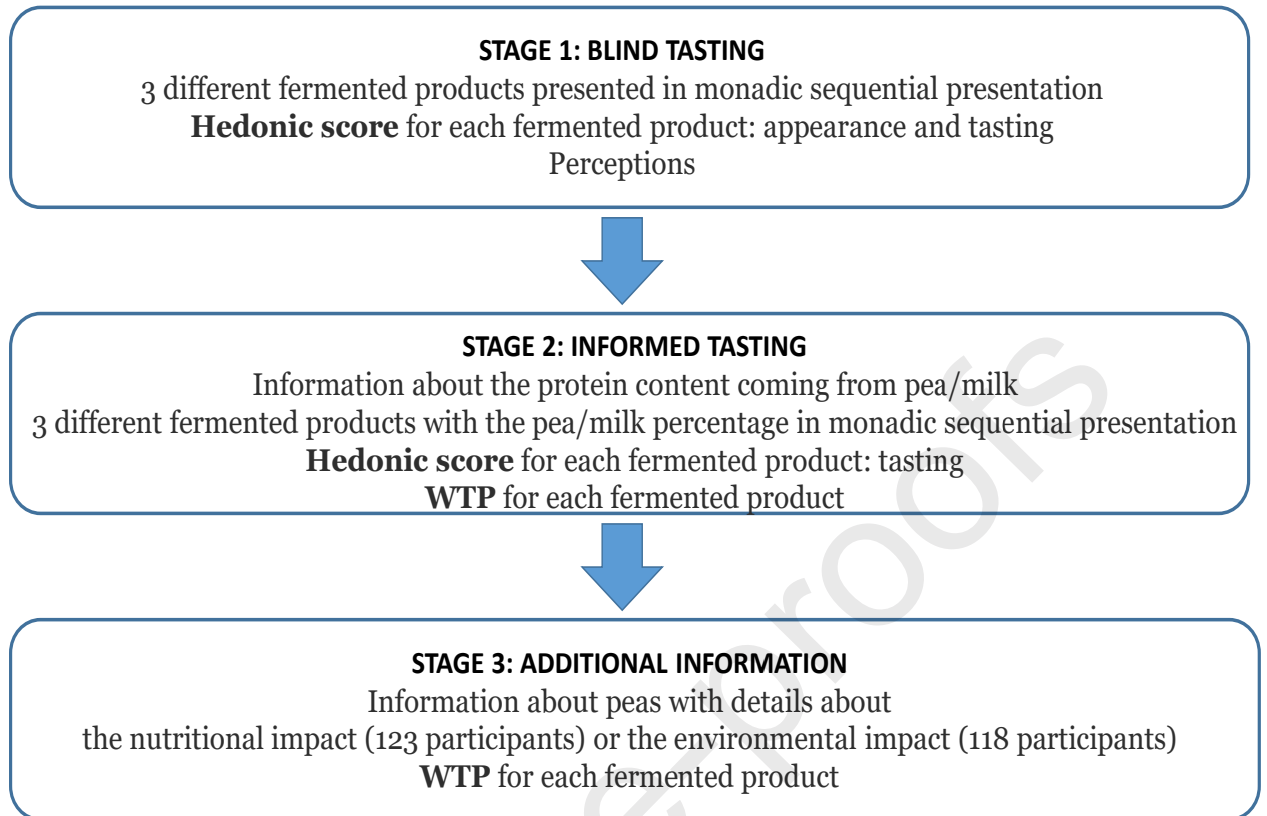
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748 to pay)

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750

**Figure 2. Timeline of the experiment organized in three stages (WTP : willingness**



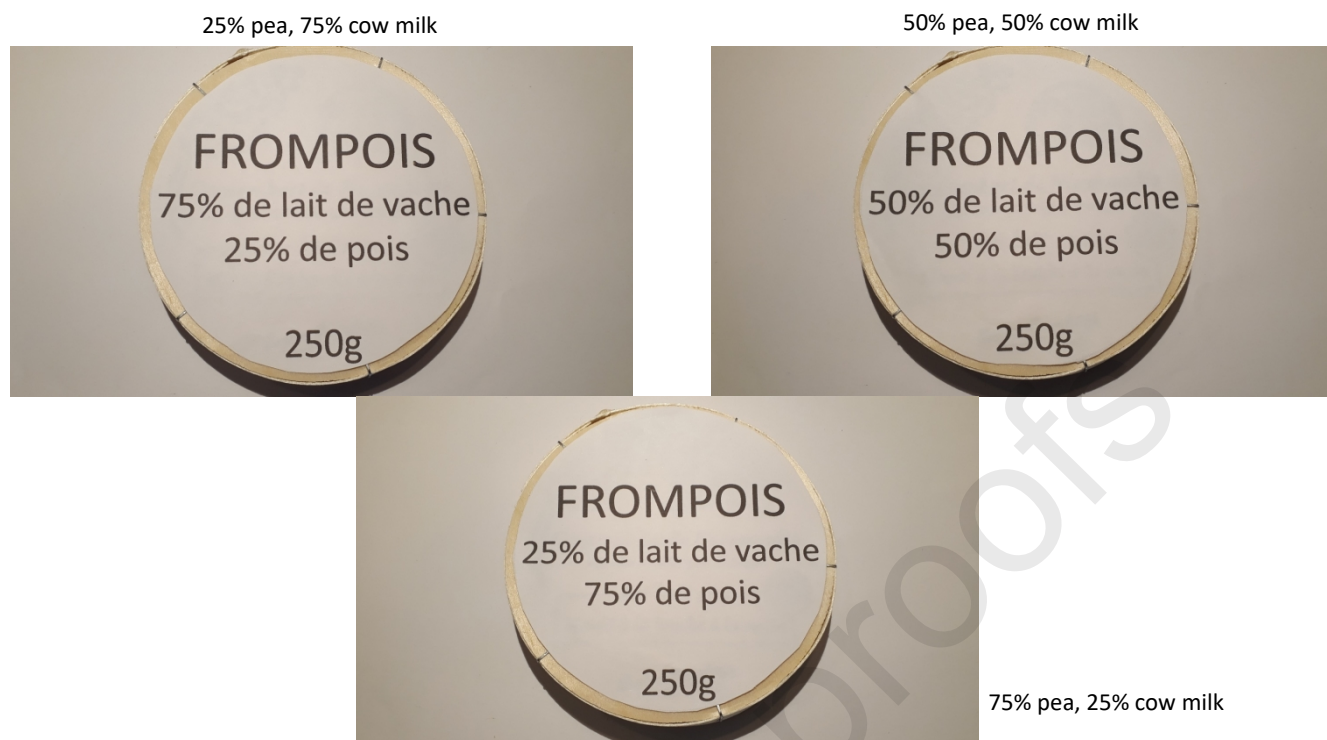
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752 **Figure 3. Plates served at stages 1 and 2 presented with fermented product samples. Note:**  
753 From French, *lait de vache* means *Cow Milk* and *Pois* means *Pea*.

754

755

756



757

758 **Figure 4. Pictures of fermented mix products above the multiple-price list for determining**  
 759 **the WTP at stages 2 and 3.** Note: From French, *Frompois* means *Peacheese*, *lait de vache*  
 760 means *Cow Milk* and *Pois* means *Pea*.

761

762

763

764

765		YES	NO	Maybe
766	1.80 Euro	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
767	1.90 Euro	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
768	2 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
769	2.10 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
770	2.20 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
771	2.30 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
772	2.40 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
773	2.50 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
774	2.60 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
775	2.70 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
776	2.80 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
777	2.90 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
778	3 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



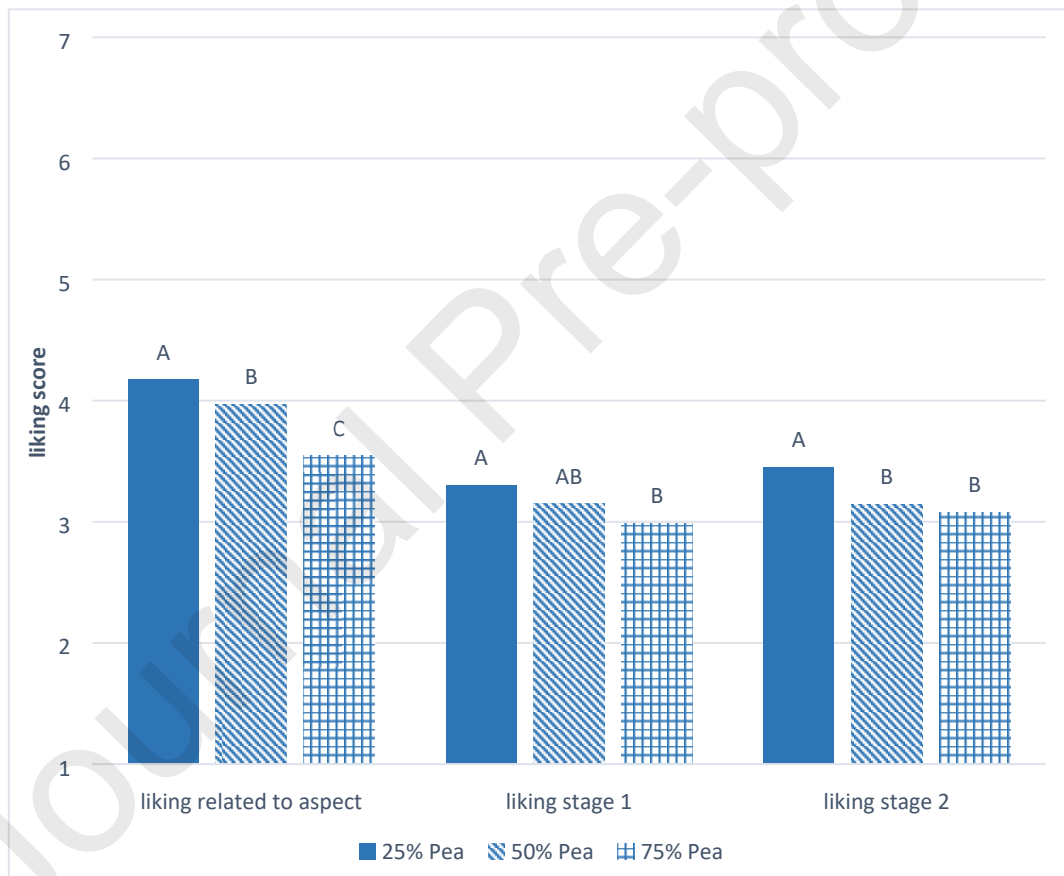
779	3.10 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
780	3.20 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
781	3.30 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
782	3.40 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
783	3.50 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
784	3.60 Euros	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

785 **Figure 5. The Multiple Price-List**

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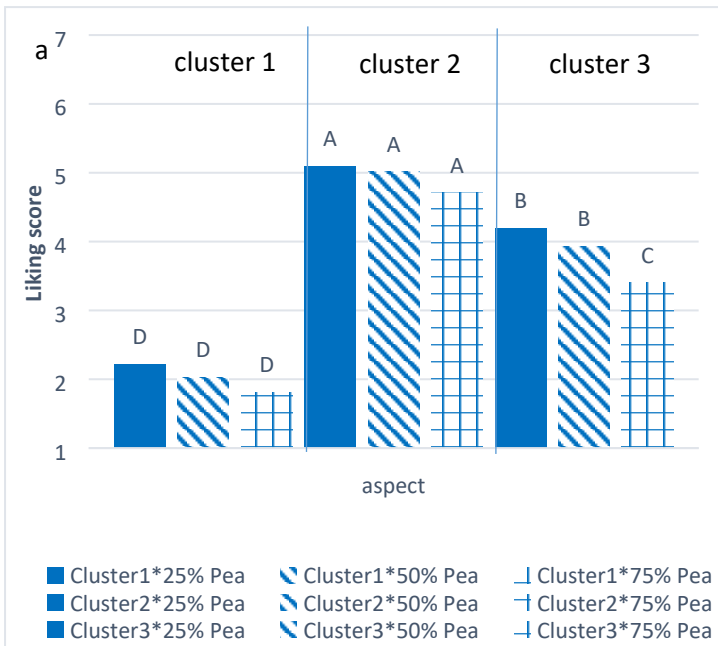


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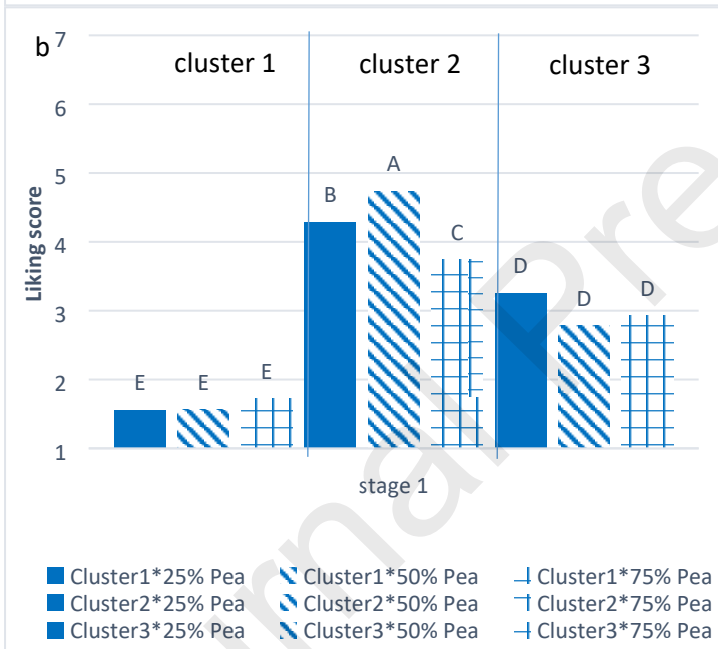
790 **Figure 6. Liking scores of the three fermented products (25% Pea, 50% Pea and 75%**  
 791 **Pea) evaluated at the different stages 1 and 2 (mean score of 242 consumers).** Note: Post-  
 792 hoc Newman Keuls tests were conducted to test paired-product differences ( $p < 0.05$ ). The  
 793 letters A to C correspond to the Newman-Keuls group associated and permit to identify sample  
 794 means that are significantly different from each other.

795

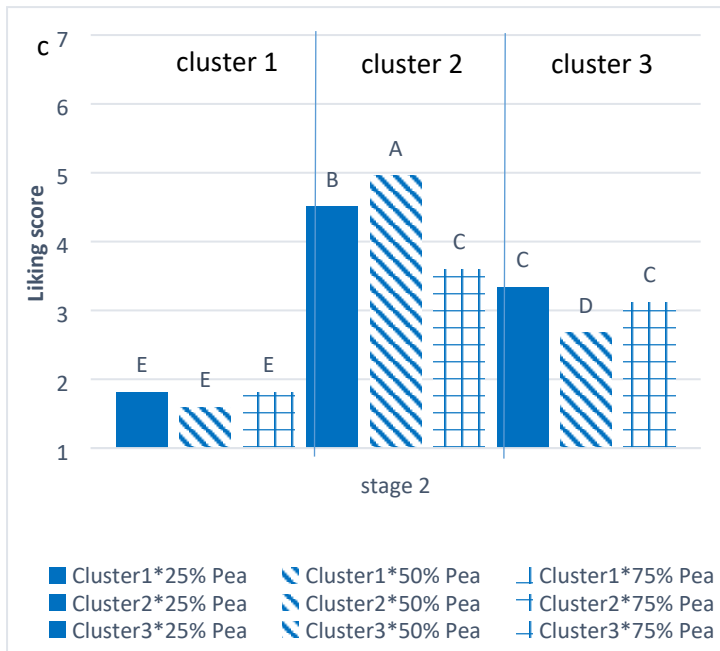
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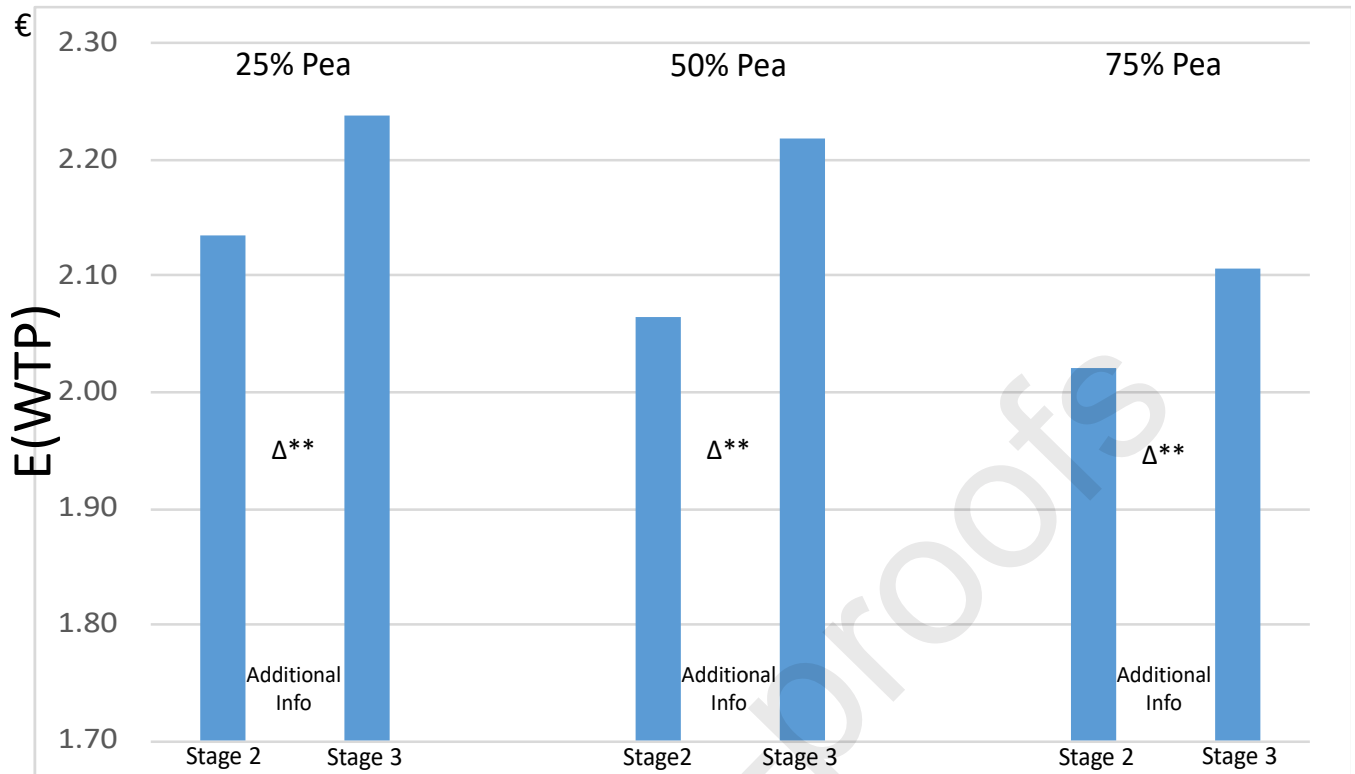


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800 **Figure 7. Liking scores related to the appearance (a), the blind tasting at stage 1 (b) and**  
 801 **after composition information at stage 2 (c) for the three clusters for each product. Note:**  
 802 Newman Keuls tests were conducted to test paired-product differences ( $p < 0.05$ ) and added for  
 803 cluster\*product interaction. The letters A to E correspond to the Newman-Keuls group  
 804 associated and permit to identify sample means that are significantly different from each other.

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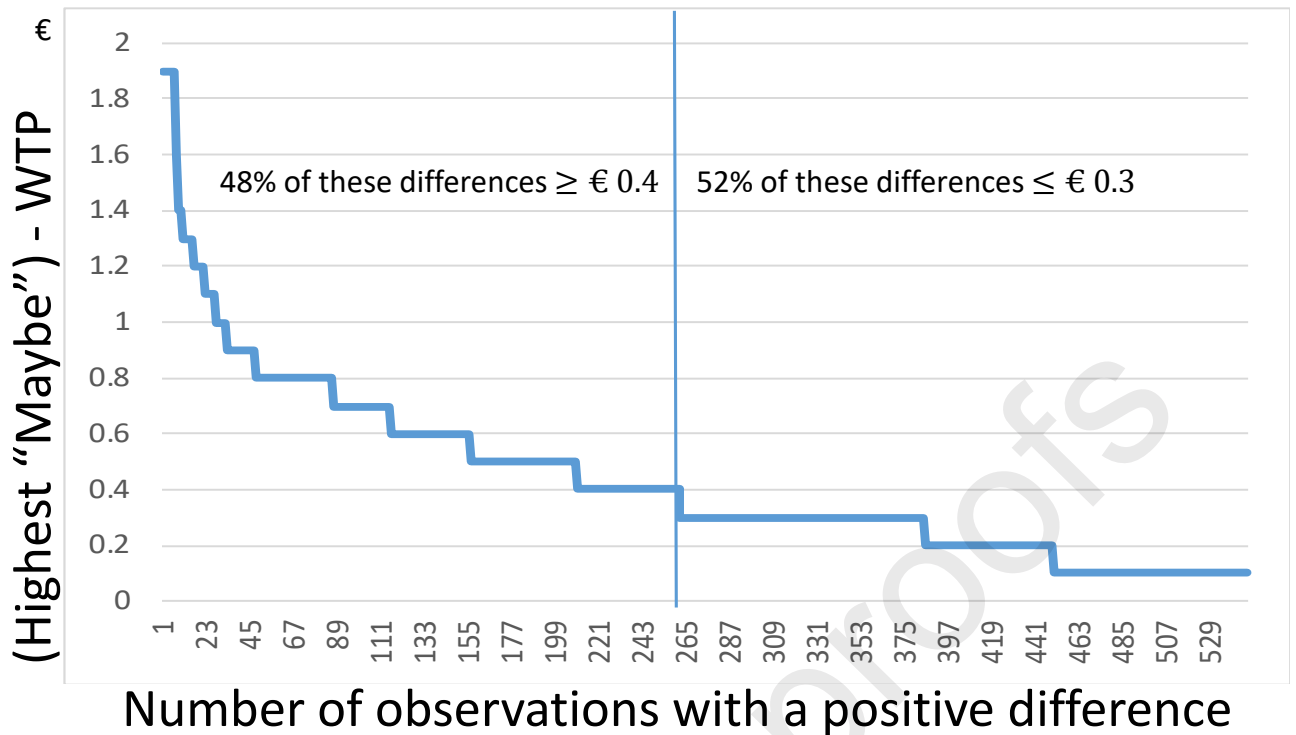
808 **Figure 8. Impact of additional information about nutrition and environment on WTP**  
 809 **for 128 engaged participants.**

810 Note:  $\Delta^{**}$  denotes significant difference at 1% as tested by the Wilcoxon test for comparing  
 811 paired samples.

812

813

814



815

816 **Figure 9. Differences between the highest "Maybe" and the highest "Yes" (WTP) by a**  
 817 **same participant. Pooled observations over both stages 2 and 3 and for the three types of**  
 818 **fermented products (548 observations with positive differences)**

819

820

821

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828