

1           **How consumers with different food neophobia level react to health and environmental**  
2                           **information? A case study on pulse-based formulations**

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10          Running title: food neophobia role in reacting to information  
11

12          **ABSTRACT**

13          The aims were to evaluate: 1) the liking of a whole corn-based formulation including chickpeas or  
14          red lentil flour; 2) the health and environmental information effect on liking; 3) how consumers with  
15          different food neophobia (FN) level react to the conveyed information; 4) the association between  
16          FN and different sustainability dimension. A 100% whole-corn sample and two samples added with  
17          20% of chickpea or red lentil flour were tested by 127 consumers in blind, expected, and real  
18          conditions. Subjects completed questionnaires about FN and their sustainable behavior, perceived  
19          environmental impact of food products, beliefs and attitudes towards sustainable food.

20          No significant differences in liking scores were found. The information conveyed increased  
21          consumers' hedonic expectations, however, incomplete assimilation was recorded for samples with  
22          pulses; a complete assimilation for neophilics (chickpea sample) and for neutrals (red lentil sample)  
23          was found, while no significant effect was found for neophobics. A significant negative association  
24          was found between FN and sustainability commitment.  
25

26          **PRATICAL APPLICATION**

27          Results of the present study demonstrate that the development of sustainable food formulations using  
28          pulses is promising, since the consumers generally accepted all the samples. However, for consumers

29 with high levels of FN as well as low interest in sustainability, the use of these ingredients remains  
30 challenging. As a practical application, it is suggested to associate new sustainable foods with  
31 beneficial information about health and environment to promote their consumption. Furthermore, it  
32 is advisable to develop personalized communication strategies when specific innovations are  
33 launched on the market with the aim of reaching different types of consumers.

34

## 35 **KEYWORDS**

36 Food sustainability; Legumes; Alternative protein sources; Food liking; Food acceptance; Hedonic  
37 expectation

38

## 39 **1 | INTRODUCTION**

40 The agri-food system is one the main drivers of global environmental change contributing to climate  
41 crisis, agricultural intensification and diminishing drinking water (FAO, 2017). In recent years,  
42 animal-based proteins consumption has increased substantially, such that their intake exceeds  
43 recommended amounts in developed countries (Godfray et al. 2018). One strategy to tackle this  
44 challenge is to seek for new and sustainable alternative food sources to overcome the ensuing food  
45 shortages considering consumer's needs and expectations (Willet et al. 2019).

46 Currently, the main food sources used as animal origin substitutes and alternative proteins are pulses,  
47 fungi, and edible insects (Laureati and Proserpio, 2021). Among all these sources, pulses seem the  
48 most promising solution since they are already part of the Mediterranean diet (Circus and Robinson,  
49 2019), and consumers may be more inclined to consume them compared to less familiar alternative  
50 protein sources, such as cultured meat and edible insects (Slade, 2018; Sharma et al. 2015; Hartmann  
51 and Siegrist, 2017) that are also less affordable.

52 Pulses have many advantages including health benefits and a low environmental impact production  
53 (Nemecek et al. 2008; Preissel et al. 2015), which improves soil quality and requires few natural  
54 resources (water, soil and energy) (FAO, 2017). Concerning health benefits, pulses show a great

55 ability to increase satiety (McCrorry et al. 2010) due to the presence of fibre, which is absorbed slowly  
56 by intestine playing a role in reducing body's glycemic response (Rebello et al. 2014). Legumes  
57 consumption has also been shown to have beneficial effects on the prevention and management of  
58 obesity (Papanikolaou and Fulgoni, 2008) and related disorders (Rebello et al. 2014), such as  
59 coronary heart disease (Bazzano et al. 2001), diabetes (Jenkins et al. 2012) and the metabolic  
60 syndrome (Mollard et al. 2012). Therefore, promoting the exploitation of legumes in new food  
61 formulations could contribute to foster agri-food systems sustainability while preserving biodiversity  
62 and human wellbeing. In this context, legumes are versatile ingredients, as they can both be added  
63 into meat products to lower their energy density providing important nutrients (Rebello et al. 2014),  
64 or they can be used as functional ingredients in food preparation that would normally be low in protein  
65 such as starchy foods (Boye et al. 2010). Moreover, pulses are a valuable ingredient to increase quality  
66 of gluten-free diets which are often nutritionally unbalanced (Hajas et al. 2022). Due to the exclusion  
67 of gluten proteins, gluten-free products are generally deficient in B group proteins (B12 and B) (Di  
68 Cairano et al. 2018; Jnawali et al. 2016; Naqash et al. 2017; Cardo et al. 2021) as well as certain  
69 nutrients including fibre, iron, zinc, magnesium, calcium, vitamin D, E that are typically present in  
70 pulses (Hall et al. 2017). In this context, the addition of lentils, chick-peas, and peas to gluten-free  
71 bakery products such as biscuits and crackers (Hajas et al. 2022; Malcolmson et al. 2013; Han et al.  
72 2010) as well as extruded snacks (Proserpio et al. 2020) has been successfully implemented,  
73 achieving high acceptability.

74 On the other hand, some limitations related to the exploitation of legumes into food products should  
75 be mentioned. Indeed, pulses are often characterized by a bitter taste, directly related to a negative  
76 consumers' hedonic responses, they are considered as a food mainly targeted to vegetarians (Figueira  
77 et al. 2019; Melendrez-Ruiz et al. 2019) that cause flatulence (Lemken et al. 2017) and they require  
78 also long cooking time for preparation (Schneider, 2002). These are probably the main factors that  
79 lead to a low legume consumption, below 50 g per day, in Europe (Hughes et al. 2022).

80 However, evidence suggests that information about legumes health benefits could be a leverage to  
81 increase consumers' interest in legume-enriched food products. As supported by previous literature  
82 data (Han et al. 2010; Laureati et al. 2013, 2016; Sabbe et al. 2009; Vidigal et al. 2011; Higa et al.  
83 2017; Proserpio et al. 2020), if consumers are informed about the positive health effects of consuming  
84 a certain product, their liking expectations of that product could increase.

85 Even in the case of less familiar alternative proteins such as edible insects, it has been shown that if  
86 consumers are aware of the potential health (Laureati et al. 2016; Menozzi et al. 2017; Schlup and  
87 Brunner, 2018) and environmental (Laureati et al. 2016; Menozzi et al. 2017; Sogari et al., 2016;  
88 Vanhonacker et al. 2013; Verbeke, 2015) benefits associated with the consumption of foods enriched  
89 with insects, the propensity towards the consumption of these products increased significantly  
90 (Adámek et al. 2018).

91 To the best of our knowledge, no prior studies have evaluated the effect of information about  
92 environmental and health on consumer acceptability and expectation considering different clusters of  
93 individuals that vary in their level of food neophobia, namely the reluctance to try unfamiliar and new  
94 food (Pliner and Hobden, 1992). This behavior is considered maladaptive since high level of food  
95 neophobia are associate with a decrease in diet variety and a reduction daily fruit and vegetable intake  
96 (Laureati et al. 2018). Moreover, data on the relationship between neophobic attitudes and  
97 sustainability are very limited in number.

98 Therefore, the main aims of the present study were to evaluate: 1) the overall liking of a whole corn-  
99 based formulation added with either chickpeas or red lentil flour; 2) the effect of information about  
100 legumes health and environmental benefit on consumer liking; 3) how consumers with different level  
101 of food neophobia (FN) are influenced by the above-mentioned information; 4) the association  
102 between FN and different sustainability dimensions related to consumer behavior.

103 Our hypotheses were: H1) the addition of chickpea and red lentil flour in the whole corn-based  
104 formulation could negatively influence consumer liking; H2) the information about environmental  
105 and health benefits of pulses could lead to an increase in the hedonic responses to whole-corn-based

106 gluten-free formulations enriched with 20% of red lentil or chickpea flours; H3) people with a  
107 different neophobic reaction to food differ in their response to food information; H4) food neophobia  
108 and sustainability commitment are negatively related.

109 The present study contributes to a better understanding of the expectations and needs of different  
110 population clusters and investigates the sensory characteristics that drive the acceptability of healthy  
111 and sustainable ingredients as well as making an important contribution to food companies by  
112 proposing new sustainable food formulations.

113

## 114 **2 | MATERIAL AND METHODS**

115

### 116 **2.1 | Participants**

117 One-hundred twenty-seven volunteers (63 women and 64 men) aged 19 – 60 years (mean age  $37.8 \pm$   
118  $12.6$  years) were recruited by a professional sensory market agency. Only subjects who were  $\geq 18$   
119 years of age, who did not suffer from food allergies or intolerances and who liked food formulations  
120 based on corn and legumes, were involved in the study.

121 Consumers were asked for informed written consent prior to participation. The present study was  
122 performed according to the principles established by the Declaration of Helsinki and the protocol was  
123 approved by the Institutional Ethics Committee of the University of Milan (protocol number 56/21).

124

### 125 **2.2 | Food Samples**

126 Whole-corn, chickpea and red lentil flours (Molino Filippini S.r.l., Toglio, Sondrio, Italy) were used  
127 to prepare experimental gluten-free food formulations. This formulation, called “polenta” in Italy, is  
128 a porridge-like typical dish of the northern regions. Overall, three formulations were tested: a control  
129 sample with 100% whole-corn flour and two samples where 20% of whole-corn flour was replaced  
130 with either chickpea or red lentil flour, respectively.

131 The experimental samples were prepared according to Appiani et al. (2021), by adding 400 g of flour  
132 mix (320 g whole corn flour + 80 g either chickpea or red lentils) to 1500 g of water with 8 g of salt  
133 at boiling and then cooking the formulation for 40 min at 100 °C in an automatic cooking-mixer  
134 (Thermomix TM 31 - Vorwerk Contemporanea S.r.l., Milano, Italy). Samples were prepared the day  
135 before the evaluations and, after reaching room temperature, stored at 4 °C. On the day of evaluations,  
136 samples were removed from the fridge two hours before the tasting session, cut into cubes of 2cm<sup>3</sup>  
137 and served at room temperature.

138

### 139 **2.3 | Experimental procedure**

140 The evaluations were carried out in a controlled area (sensory laboratory) in individual booths under  
141 white lights. Participants were instructed to refrain from smoking, eating and drinking (except water)  
142 in the hour before tasting and were invited to participate in two separate sessions held on two different  
143 days one week apart. Each session took approximately 35 min. The activities conducted in each  
144 session are summarized in figure 1.

145 According to Deliza and MacFie (1996), samples overall liking was evaluated under blind, expected  
146 and real conditions. On the first day of testing, participants took part in the blind and expected liking  
147 tests. Firstly, participants completed a short questionnaire about sociodemographic information (age  
148 and gender). Subsequently, each participant was presented with the three experimental samples and  
149 asked to rate liking under blind conditions (i.e., tasting without receiving any information about the  
150 products). The only information participants were given before the start of the test was that they were  
151 going to taste whole corn-based formulations some of which made with legume flour. Liking was  
152 measured using a 10 cm linear scale anchored by the extremes “Extremely disliked” (rated 0) and  
153 “Extremely liked” (rated 100; Lawless and Heymann, 2010). Approximately 15 g of each sample was  
154 presented at room temperature to the consumers in small white plastic cups coded with three-digit  
155 numbers. Samples were presented simultaneously in a randomized and balanced order (MacFie et al.

156 1989). Participants were instructed to taste at least half of the sample before proceeding with the  
157 evaluation of liking and to rinse their mouths with still mineral water between each sample.

158 After a short break, expected liking, i.e. a visual assessment without tasting based on general  
159 information regarding the advantages of using legumes as a food ingredient and on the presentation  
160 of images of the samples was assessed. Each participant was provided with the following general  
161 information about legumes: *“Legumes represent an alternative protein source compared to those of  
162 animal origin. Their cultivation also has a low environmental impact because it improves the quality  
163 of the soil and requires few natural resources (land, water and energy). Their use as an ingredient,  
164 in addition to improving the nutritional properties of a food, is one of the possible solutions to  
165 increase the sustainability of agri-food systems.”*. Thereafter, each consumer was presented with the  
166 images of the samples (Fig. 2) labeled, respectively, *“Whole corn-based formulation”* (Figure 2a),  
167 *“Whole corn-based formulation with 20% chickpea flour”* (Figure 2b) and *“Whole corn-based  
168 formulation with 20% lentils flour”* (Figure 2c).

169 Consumers were then asked to rate for each image their expected liking (i.e., how much they would  
170 like it) using a 10 cm linear scale anchored by the extremes “Extremely disliked” (rated 0) and  
171 “Extremely liked” (rated 100; Lawless and Heymann, 2010). The first session ended with the  
172 completion of the food neophobia questionnaire.

173 After one week, the same participants were invited again to the laboratory to conduct the real liking  
174 session (i.e., samples tasting under informed conditions). Participants were asked to taste the samples  
175 and were given the same information as during the expected liking session (see Figure 2 a-c). The  
176 scale used to evaluate real liking was the same used to evaluate liking under blind and expected  
177 conditions. The second session ended with the completion of the questionnaire about consumer’s  
178 attitude towards sustainability.

179

## 180 **2.4 | Questionnaires**

### 181 2.4.1 | Food Neophobia Questionnaire

182 In the first session (day 1), after the assessment of blind and expected liking, participants were asked  
183 to complete the validated Italian version of the Food Neophobia Scale (FNS, Laureati et al., 2018).  
184 The questionnaire consists of 10 items, 5 related to neophilic and 5 to neophobic attitudes. The items  
185 presentation was randomized. Participants scored the items using a 7-point agreement scale (1 =  
186 “Strongly disagree”, 4 = “Neither agree nor disagree”, 7 = “Strongly agree”).

#### 187 188 2.4.2 | Questionnaire about consumer attitude towards sustainability

189 During the second session (day 2), after the assessment of real liking, participants were asked to  
190 complete a questionnaire about attitude towards sustainability (modified from Laureati et al. 2013).  
191 The questionnaire was divided into three sections, each corresponding to a specific aspect of  
192 sustainability. The first section was designed to investigate current general sustainable behavior by  
193 investigating the frequency with which ten sustainable (e.g. “Saving electric energy”) and five non-  
194 sustainable (e.g. “Leaving the lights on when unnecessary”) actions were performed by consumers.  
195 For each action, consumers had to indicate how often they did it in the last period. Answering options  
196 were: “Never = 0 times”, “Rarely = 2-3 times a month”, “Sometimes = 1-2 times a week”, “Often =  
197 3-4 times a week”, “Always = every day”. The items presentation was randomized.

198 The second section, which explored the degree of consumer knowledge about the impact of the  
199 consumption of a series of food products on environmental sustainability, was inspired by the  
200 questionnaire developed by Migliavada et al. (2022). The original version consisted of five animal  
201 origin food items (eggs, farmed fish, beef, chicken meat, cheese) and five plant-based products  
202 (pulses, vegetables, tofu, fruits, nuts) with different environmental impact. In the present study,  
203 among the plant-based products, the item “fruit” was substituted with two distinct items, i.e. “exotic  
204 fruit” (unsustainable in the case of Italy) and “seasonal fruit” (sustainable), leading to a total of six  
205 plant-based items. The environmental impact of food items was based on data by Smiglak-Krajewska  
206 et al. (2020) and Poore and Nemecek (2018). Each participant was asked to answer the following  
207 question "In your opinion, does the consumption of the following food harm the planet or cause

208 environmental damage in any way?" using a 7-point agreement scale (1=Strongly disagree; 4=Neither  
209 agree nor disagree; 7=Strongly agree). The order of food items presentation was randomized across  
210 participants.

211 Finally, the last section was aimed at investigating opinions and beliefs towards sustainable food  
212 products using ten statements (e.g. "In my opinion, the quality of sustainable food products is low"  
213 or "It's difficult to find these products on the market"). For each statement, the consumer was asked  
214 to indicate the degree of agreement using a 7-point agreement scale (1=Strongly disagree; 4=Neither  
215 agree nor disagree; 7=Strongly agree). The items presentation was randomized.

216

## 217 **2.5 | Data Analysis**

218 The SAS/STAT (version 9.4 SAS Institute Inc., Cary, NC, USA) and XLSTAT (version 2022.5.1,  
219 Addinsoft, Boston, MA, USA) statistical software packages were used for the data analysis. Effects  
220 showing a  $p$ -value of 0.05 or lower were considered significant, while a  $p$ -value ranged between 0.10  
221 and 0.05 was considered as a trend.

222

### 223 2.5.1 | Liking data

224 The liking scores distribution was calculated and checked for normality. According to the Shapiro–  
225 Wilk test, liking data were normally distributed, except in the expected condition. However,  
226 inspection of the Q–Q plots suggested a normal pattern, and thereby all data were handled as normally  
227 distributed (Naes et al. 2010).

228 Firstly, liking data were compared within each experimental condition (Blind, Expected and Real)  
229 using one-way ANOVA. *Post-hoc* comparisons using the Bonferroni test adjusted for multiple  
230 comparison was conducted when appropriate. Then, the effect of information on liking was analyzed  
231 comparing the scores obtained in the different conditions using paired t-tests (Siret and Issanchou,  
232 2000). According to Siret and Issanchou, 2000, t-tests on the difference between blind and expected  
233 mean hedonic ratings for each sample enabled establishing whether a hedonic disconfirmation took

234 place. A disconfirmation occurs when this difference is significantly different from zero. In the same  
235 way, paired t-tests on the difference between the real and blind mean hedonic ratings allowed  
236 verifying whether the disconfirmation was associated with an assimilation or a contrast effect. When  
237 this difference is significantly different from zero, it means that there was a significant effect of the  
238 health and sustainable information on hedonic scores. More specifically, if this difference is higher  
239 than zero, an assimilation effect occurs; if the difference is lower than zero, a contrast effect occurs.  
240 In the assimilation case, when the difference between expected and real liking is significantly  
241 different from zero, the consumers do not completely assimilate toward their expectation and  
242 assimilation is not total (Siret and Issanchou, 2000).

243

#### 244 2.5.2 | Food neophobia

245 The internal consistency of the questionnaire was assessed by Cronbach alpha coefficient ( $\alpha = 0.84$ ).  
246 The answers to the ten items were summed up (after reversing the scores of the neophilic items)  
247 yielding a food neophobia index (FN index) ranging from 10 to 70. A higher index indicates a higher  
248 level of food neophobia. The FN index frequency distribution was calculated, and participants  
249 obtained a FN index range between 10 and 58 (mean value: 22). Subjects were then divided in 3  
250 groups according to quartiles: Neophilics (22.8% of the total sample) with a FN index within the  
251 lowest quartile ( $\text{score} < 16$ ), Neutrals (54.4% of the total sample) with a medium FN index  
252 ( $16 \leq \text{score} \leq 26$ ) and Neophobics (22.8% of the total sample) with a FN index within the highest  
253 quartile ( $\text{score} > 26$ ). The effect of information on liking data provided by individuals with different  
254 level of FN was inspected comparing hedonic scores in the three different conditions using paired t-  
255 tests as previously described.

256

#### 257 2.5.3 | Consumer attitude towards sustainability

258 The reliability of each dimension of the questionnaire (current sustainable behavior, perceived  
259 environmental impact of food products, beliefs and attitudes towards sustainable food products) was

260 investigated by calculating internal consistency (Cronbach's  $\alpha$ ). The internal consistency of the 15  
261 items related to current sustainable behaviors ( $\alpha = 0.68$ ) was considered satisfactory being very close  
262 to the acceptability threshold of 0.70 (Nunnally et al., 1994; Bland, 1997) and comparable with a  
263 previous study (Laureati et al. 2013); for this reason, all 15 items were retained. Internal consistency  
264 was satisfactory also for the other two dimensions, consumers' perceived environmental impact of  
265 food products ( $\alpha=0.87$ ) as well as for beliefs and attitudes regarding sustainable foods ( $\alpha=0.78$ ).

266 A sustainability index (SUS index) was calculated considering the 'current sustainable behavior'  
267 dimension since it reflects consumer's actual behavior and commitment about general aspects related  
268 to environmental sustainability (Laureati et al. 2013). For each consumer, the SUS Index was  
269 calculated as sum (after reversing scores of the non-sustainable actions) of the responses for each of  
270 the 15 actions. This resulted in a SUS index ranged from 15 to 75, with higher scores representing  
271 higher sustainability commitment. Participants in the present study obtained a SUS index comprised  
272 in a very narrow range between 40 and 64 (mean value: 50.7) describing a group of sustainable  
273 consumers. Therefore, participants were not clustered according to SUS index.

274

#### 275 2.5.4 | Association between sustainability commitment and food neophobia level

276 The association between FN and the sustainability commitment was evaluated by means of Pearson  
277 correlation considering individual FN against SUS indices as well as FN index against single items  
278 of the three dimensions of the sustainable behavior questionnaire. Regarding the questionnaire on  
279 current sustainable behavior based on 15 actions, the correlation was run without reversing the non-  
280 sustainable actions, thus correlating FN with the frequency of each action.

281

### 282 **3 | RESULTS**

#### 283 **3.1 | Blind, expected and real liking**

284 The mean liking scores by samples in each experimental condition are provided in Figure 3.  
285 According to 1-way ANOVA results, the three formulations were equally appreciated by consumers

286 in each experimental condition ( $F_{\text{Blind}}(2,378)=1.04$ ;  $p=0.35$ ;  $F_{\text{Expected}}(2,378)=1.45$ ;  $p=0.24$ ;  $F_{\text{Real}}(2,378)$   
287  $=0.45$ ;  $p=0.64$ ) meaning that samples enriched with pulses were always comparable to the control in  
288 terms of liking. Overall, the samples were well accepted, with mean liking scores above the middle  
289 of the scale (range: 58.9 – 76.2).

290

### 291 **3.2 | Effect of health and environmental information about pulses on consumers' liking and** 292 **expectation (whole consumers group)**

293 Results deriving from the t-test performed on the mean liking scores of each product in each condition  
294 are reported in Table 1. For all samples there was a disconfirmation of expectation ( $\text{Expected}-\text{Blind}$   
295  $>0$ ), this means that consumers rated the products worse than their expectations. This disconfirmation  
296 was associated with an assimilation effect ( $\text{Real}-\text{Blind} >0$ ) for both samples containing pulses. This  
297 result suggests that the conveyed health and environmental information influenced liking, leading  
298 consumers to change their hedonic score in the direction of their expectations. However, this  
299 assimilation was incomplete ( $\text{Real}-\text{Expected} <0$ ).

300

### 301 **3.3 | Effect of health and environmental information about pulses on consumers' expectation** 302 **according to FN level**

303 The influence of health and environmental information on FN groups' expectations is reported in  
304 Table 2. The information affected differently consumers hedonic responses according to their FN  
305 index. A negative disconfirmation of expectation ( $\text{Expected}-\text{Blind} >0$ ) was found only for Neophilic  
306 and Neutral groups. This disconfirmation was associated with a complete assimilation effect for the  
307 red lentil sample for Neophilic people and for chickpea sample for Neutral ones, while incomplete  
308 assimilation was found for red lentil sample for Neutral subjects. No significant differences between  
309 blind and expected conditions were found for the Neophobic group.

310

311

312 **3.4 | Association between sustainability commitment and FN**

313 3.4.1 | Association between current sustainable behavior and FN

314 FN index was significantly and negatively correlated with SUS index ( $r = -0.24$ ;  $p < 0.05$ ).

315 The mean frequency of responses provided by the total sample of subjects as well as by subjects  
316 grouped according to FN level to the question: "Recently, how often have you performed the  
317 following actions?" is shown in Table 3. The table also provides the association between FN index  
318 and the mean frequency of each action. FN was negatively associated with all sustainable actions.  
319 This negative association was significant for the actions: "Buying local food" and "Eating seasonal  
320 food". Concerning non sustainable actions, FN was negatively and significantly associated with  
321 "Leaving lights on when not necessary".

322

323 3.4.2 | Association between consumer knowledge about food impact on environmental  
324 sustainability and FN

325 The mean frequency of responses provided by total respondents as well as respondents grouped  
326 according to FN level to the question: "In your opinion, does the consumption of the following food  
327 harm the planet or cause environmental damage in any way?" is shown in Table 4. In general, the  
328 group of respondents showed a good knowledge of the impact of different food products on the  
329 environment as they provided respectively high and low agreement scores to non-sustainable and  
330 sustainable food. Knowledge was independent by FN level as shown by the lack of significant  
331 association between FN index and responses to all items.

332

333 3.4.3 | Association between consumers' opinions and beliefs on sustainability and FN level

334 The mean frequency of responses provided by the total sample of participants and participants  
335 grouped according to FN level to the questions related to opinions and beliefs about sustainable  
336 products is shown in Table 5. FN was positively associated with all items and this association was  
337 significant for six out of ten: "It is difficult to find these product on the market"; "There is little

338 information about these products”; “The information about these products is not clear”; “These  
339 products seem less safe than traditional ones”; “It is difficult to distinguish between food products  
340 that harm the environment and food products that respect the environment”; “Sustainability is just an  
341 image choice and there is nothing concrete in the actions of companies”. It is noteworthy that all items  
342 reflected negative attitudes and beliefs towards sustainable food products, thus a positive association  
343 with FN score indicates that neophobic subjects have negative feelings about such products.

344

#### 345 **4 | DISCUSSION**

346 The aim of the present study was to evaluate the effect on consumer acceptance of the incorporation  
347 of new sustainable ingredients (chickpea and red lentil flours) to a whole corn-based gluten free  
348 formulation and to explore whether the information about environmental and health benefits of pulses  
349 may influence hedonic responses and expectation in consumers grouped according to the level of  
350 food neophobia. The relationship between food neophobia and sustainability commitment was also  
351 investigated. Although the use of legumes as a high-fiber and high-protein ingredient in food  
352 formulation (Bresciani and Marti, 2019) as well as the study of the effect of information on  
353 consumers’ liking and expectation (Manohar et al. 2021; Ares et al. 2010) have been widely  
354 investigated, to our knowledge this is one of the first studies that has evaluated the possible  
355 associations between the information conveyed, consumers’ food neophobia and sustainable  
356 commitment.

357 The initial hypothesis that the addition of chickpea and red lentil flour in the whole corn-based  
358 formulations could negatively influence consumer liking was not confirmed. On the contrary, all other  
359 hypotheses were confirmed, i.e. information about legumes environmental and health benefits  
360 increased hedonic responses and expectations of pulses-enriched formulations, the effect of  
361 information was different depending of consumers’ FN level and FN was negatively correlated to  
362 commitment with sustainability.

363

#### 364 **4.1 | Overall liking of whole corn-based formulations added with legumes**

365 The outcome of the present study suggests that the use of 20% chickpea or red lentil flour is a  
366 promising strategy to enrich whole-corn polenta samples since liking scores were always above the  
367 midpoint of the liking scale and no significant differences were found between the added samples and  
368 the control. This result is supported by previous studies suggesting that pulses are a versatile  
369 ingredient whose addition can be implemented in different food formulations. For instance, for  
370 gluten-free biscuits based on rice flour and tapioca starch, the addition of 20% yellow pea flour did  
371 not lead to changes in acceptability and texture, as well as the addition of 30% lentil flour to crackers  
372 was acceptable and comparable to the control (Malcolmson et al. 2013). Han and colleagues (2010)  
373 showed that the addition of legumes to gluten-free crackers was positively evaluated by consumers  
374 in terms of color, texture and taste. In another study (Yang et al. 2020), Bambara groundnut, which  
375 is a legume of African origin, was used to enrich both crackers and biscuits; in both cases, the results  
376 showed no significant differences in liking compared to control samples.

377

#### 378 **4.2 | Effect of information on consumer's acceptance (whole consumers group)**

379 The outcome of the present study showed a positive and significant effect of the information about  
380 legumes health and environmental benefits on consumer overall liking. Considering the total sample  
381 of consumers, food formulations added with legumes were less liked than expected, however, the  
382 information led to an assimilation effect meaning that consumers tended to increase their liking score  
383 in the real condition to reduce the gap between expectation and actual perception. These results are  
384 consistent with previous research showing that information about health and sustainability of a  
385 specific food product or ingredient led to increased expectations by increasing consumer's hedonic  
386 responses. For instance, consumers from Finland, Germany and the United Kingdom tended to  
387 increase their perception of healthiness and their intention to try functional foods if these products  
388 were accompanied by health claims (Saba et al. 2010). Accordingly, when consumers were aware  
389 about the environmental and health benefits of using by-products from the wine chain as ingredients

390 in beetroot puree, their expectations of these products increased (Proserpio et al. 2020). In a similar  
391 way, information about environmental and nutritional properties of Bambara groundnut had a positive  
392 impact on consumers' emotional responses (Yang et al. 2020).

393 However, our results showed an incomplete assimilation for samples containing pulses, indicating  
394 that information was not strong enough to compensate for the loss in sensory appeal of the legume  
395 added formulations. In other words, the information had a positive effect on consumer hedonic  
396 response but sensory appeal prevailed over information about health and environmental legumes  
397 benefit. This result suggests that although consumers may be interested in healthy and sustainable  
398 products, they are not willing to consume them if sensory properties are not satisfying. This outcome  
399 is commonly found in similar studies that explored the effect of health and environmental information  
400 on consumer liking and expectation. For instance, Lima et al. (2019) investigated both the effect of  
401 traffic light system in grape nectars and nutritional warnings in chocolate flavored milk to reduce  
402 sugar consumption in these drinks. In both cases, the sample with small sugar reduction was the most  
403 frequently chosen in the blind and informed evaluations, while in the expected ones, participants  
404 selected the sample with large sugar reduction showing that consumers were only potentially willing  
405 to reduce their sugar consumption. Likewise, Proserpio et al. (2020) showed that the sustainable  
406 information conveyed does not always lead to increased liking scores in real conditions for beetroot  
407 puree enriched added with winemaking by-products. Taken together, these results indicate that food  
408 products sensory characteristics play a predominant role over the information conveyed and  
409 consumers are unlikely to compromise their hedonic experience for potential health and sustainability  
410 benefits (Lima et al. 2019).

411

#### 412 **4.3 | Effect of information on consumer's acceptance (according to FN level)**

413 To the best of our knowledge, no studies investigated health and environmental information effect on  
414 consumers grouped according to their level of food neophobia. Interestingly, the conveyed health and  
415 environmental information about pulses - intended as alternative proteins to meat with a low

416 environmental impact that can increase the nutritional level of food to which they are added - had a  
417 different effect on consumer liking and expectation depending on the FN level. For neophilic and  
418 neutral groups, the information had a positive influence on liking and was associated with a complete  
419 assimilation effect in some cases (chickpea for neophilics and red lentil for neutrals) indicating that  
420 the lower the neophobia level the more consumers are responsive to health and environmental  
421 information, so much so that information can fill the liking gap. On the contrary, no effect of  
422 information was observed on neophobic groups. In this group, even no significant differences were  
423 found between the blind and the expected conditions. This indicates that individuals with higher  
424 degree of FN are completely insensitive to information about nutritional and environmental benefit  
425 of food to the extent that this information does not create even an expectation in them. We hypothesize  
426 that this result is attributable to the fact that neophobic subjects not only are individuals with low  
427 responsiveness toward innovative food products (Tuorila and Hartmann, 2020; van den Heuvel et al.  
428 2019) such as, for instance, functional foods or nutritionally modified foods but they are, in general,  
429 people with low interest in food (Jaeger et al., 2017), even when such food is accompanied by positive  
430 information. In agreement with our assumption, Yang et al. (2020) found that neophobic subjects  
431 showed a lower emotional response to snacks enriched with pulses than neophilic ones.

432

#### 433 **4.4 | Association between sustainability commitment and food neophobia (FN)**

434 The lack of information effect on neophobic subjects can be supported and explained by the negative  
435 association found between FN and current sustainable behavior expressed through a sustainability  
436 index (SUS index), which suggests that the higher the FN the lower the commitment to a series of  
437 sustainable actions. In general, another interesting result is that neophobic subjects tend to have a  
438 negative opinion about sustainable products claiming, for instance, that sustainability is more a matter  
439 of image rather than something concrete. In addition, neophobic subjects showed a distrustful attitude  
440 towards sustainable products believing that they are less safe than traditional ones and that  
441 information about these products is poor and unclear. Finally, neophobic subjects also have the

442 feeling that these products are difficult to be found on the market and that it is difficult to distinguish  
443 between products that protect the environment and those that harm it. The same cannot be said,  
444 however, regarding awareness of the environmental impact of both sustainable and non-sustainable  
445 foods. Indeed, in this case, the participants in our study demonstrated a good knowledge of food  
446 environmental impact and this knowledge seems to be independent of everyone's level of neophobia.  
447 This may be attributable to mass media, which since the early 2000s have played an increasing role  
448 in consumers' education (Russo et al. 2012). In this context, Russo and Simeone (2017) have shown  
449 that social media facilitate the acquisition of knowledge about ethical issues and contribute to the  
450 creation of an individual value system in which awareness of environmental impact is a strong  
451 determinant of the product, sometimes even more so than the price.  
452 Given that, to the best of our knowledge, no studies have investigated the relationship between food  
453 neophobia and sustainability commitment, further research is recommended in order to confirm and  
454 extend our findings.

455

## 456 **5 | CONCLUSION**

457 In this work, chickpeas and red lentil flours were successfully used as an ingredient in polenta  
458 formulations as samples added with these pulses were well appreciated by consumers. The  
459 exploitation of these ingredients in gluten free formulations can contribute to increase food  
460 companies' products portfolio providing consumers with new acceptable options.

461 The present results show that, in general, associating new sustainable ingredients with beneficial  
462 health and environmental information can be a strategy to improve consumer liking and expectation  
463 potentially contributing to promote their consumption. However, findings showed that sensory  
464 characteristics remain one of the main determinants of food acceptance highlighting the importance  
465 of optimizing sensory quality of products added with new sustainable ingredients.

466 Furthermore, health and environmental information is completely ineffective with a specific target of  
467 consumers, i.e. individuals with a higher food neophobia level. These subjects are also those that

468 behave less sustainably and are less confident and trustful about food sustainability. This indicates  
469 the need to consider consumers' individual characteristics and to develop appropriate and  
470 personalized communication strategies when specific innovations are launched on the market.  
471 Finally, the limitations of the present study should be mentioned. First, the number of individuals  
472 involved is not so large to be considered representative of a wider community; secondly, the choice  
473 of experimental food employed, which is a typical Italian product not widely consumed, except in  
474 some Italian regions. Hence, further research is recommended using more widely consumed foods to  
475 confirm and extend our findings.

476

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483

#### 484 **CONFLICT OF INTEREST STATEMENT**

485 The authors declare no conflict of interest. The funders had no role in the design of the study; in the  
486 collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to  
487 publish the results.

488

#### 489 **DATA AVAILABILITY STATEMENT**

490 Data will be made available upon reasonable request to the corresponding author.

491

#### 492 **INFORMED CONSENT**

493 Informed consent was obtained from all subjects involved in the study.

494 **REFERENCES**

- 495 Adámek, M., Adámková, A., Mlček, J., Borkovcová, M., & Bednářová, M. (2018). Acceptability  
496 and sensory evaluation of energy bars and protein bars enriched with edible insect. *Potravinárstvo:  
497 Slovak Journal of Food Sciences*, 12(1), 431-437. <https://doi.org/10.5219/925>
- 498 Appiani, M., Rabitti, N. S., Proserpio, C., Pagliarini, E., & Laureati, M. (2021). Tartary buckwheat:  
499 a new plant-based ingredient to enrich corn-based gluten-free formulations. *Foods*, 10(11), 2613.  
500 <https://doi.org/10.3390/foods10112613>
- 501 Ares, G., & Deliza, R. (2010). Studying the influence of package shape and colour on consumer  
502 expectations of milk desserts using word association and conjoint analysis. *Food Quality and  
503 Preference*, 21(8), 930-937. <https://doi.org/10.1016/j.foodqual.2010.03.006>
- 504 Bazzano, L. A., He, J., Ogden, L. G., Loria, C., Vupputuri, S., Myers, L., & Whelton, P.K. (2001)  
505 Legume consumption and risk of coronary heart disease in US men and women: NHANES I  
506 epidemiologic follow-up study. *Archives of Internal Medicine*, 161(21), 2573-2578.  
507 <https://doi.org/10.1001/archinte.161.21.2573>
- 508 Bland, J. M., & Altman, D. G. (1997). *Cronbach's alpha*. *BMJ (Clinical research ed.)*, 314(7080),  
509 572. <https://doi.org/10.1136/bmj.314.7080.572>
- 510 Boye, J., Zare, F., & Pletch, A. (2010). Pulse proteins: Processing, characterization, functional  
511 properties and applications in food and feed. *Food Research International*, 43(2), 414-431.  
512 <https://doi.org/10.1016/j.foodres.2009.09.003>
- 513 Bresciani, A., & Marti, A. (2019). Using pulses in baked products: lights, shadows, and potential  
514 solutions. *Foods*, 8(10), 451. <https://doi.org/10.3390/foods8100451>
- 515 Cardo, A., Churruga, I., Lasa, A., Navarro, V., Vázquez-Polo, M., Perez-Junkera, G., & Larretxi, I.  
516 (2021). Nutritional imbalances in adult celiac patients following a gluten-free diet. *Nutrients*,  
517 13(8), 2877. <https://doi.org/10.3390/nu13082877>
- 518 Circus, V. E. & Robinson, R. (2019). Exploring perceptions of sustainable proteins and meat  
519 attachment. *British Food Journal*, 121(2), 533-545. <https://doi.org/10.1108/BFJ-01-2018-0025>
- 520 Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectation by external cues and its  
521 effect on sensory perception and hedonic ratings: A review. *Journal of Sensory Studies*, 11(2),  
522 103-128. <https://doi.org/10.1111/j.1745-459X.1996.tb00036.x>
- 523 Di Cairano, M., Galgano, F., Tolve, R., Caruso, M. C., & Condelli, N. (2018). Focus on gluten free  
524 biscuits: ingredients and issues. *Trends in Food Science & Technology*, 81, 203-212.  
525 <https://doi.org/10.1016/j.tifs.2018.09.006>
- 526 Food and Agriculture Organization of the United Nations. (2017). *The future of food and agriculture:  
527 Trends and challenges*. Fao.
- 528 Figueira, N., Curtain, F., Beck, E., & Grafenauer, S. (2019). Consumer understanding and culinary  
529 use of legumes in Australia. *Nutrients*, 11(7), 1575. <https://doi.org/10.3390/nu11071575>
- 530 Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., Pierrehumbert, R. T.,  
531 Scarborough, P., Springmann, M. & Jebb, S. A. (2018). Meat consumption, health, and the  
532 environment. *Science*, 361(6399), eaam5324. <https://doi.org/10.1126/science.aam5324>
- 533 Hajas, L., Sipos, L., Csobod, É. C., Bálint, M. V., Juhász, R., & Benedek, C. (2022). Lentil (*Lens  
534 culinaris* Medik.) flour varieties as promising new ingredients for gluten-free  
535 cookies. *Foods*, 11(14), 2028. <https://doi.org/10.3390/foods11142028>
- 536 Hall, C., Hillen, C., & Garden Robinson, J. (2017). Composition, nutritional value, and health benefits  
537 of pulses. *Cereal Chemistry*, 94(1), 11-31. <https://doi.org/10.1094/CCHEM-03-16-0069-FI>

- 538 Han, J., Janz, J. A., Gerlat, M. (2010). Development of gluten-free cracker snacks using pulse flours  
539 and fractions. *Food Research International*, 43(2), 627–633.  
540 <https://doi.org/10.1016/j.foodres.2009.07.015>
- 541 Hartmann, C. & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable  
542 protein consumption: A systematic review. *Trends in Food Science & Technology*, 61, 11-25.  
543 <https://doi.org/10.1016/j.tifs.2016.12.006>
- 544 Higa, F., Koppel, K., & Chambers, E. (2017). Effect of additional information on consumer  
545 acceptance: An example with pomegranate juice and green tea blends. *Beverages*, 3(3), 1-13.  
546 <https://doi.org/10.3390/beverages3030030>
- 547 Hughes, J., Pearson, E., & Grafenauer, S. (2022). Legumes—A comprehensive exploration of global  
548 food-based dietary guidelines and consumption. *Nutrients*, 14(15), 3080.  
549 <https://doi.org/10.3390/nu14153080>
- 550 Jaeger, S. R., Rasmussen, M. A., & Prescott, J. (2017). Relationships between food neophobia and  
551 food intake and preferences: Findings from a sample of New Zealand adults. *Appetite*, 116, 410–  
552 422. <https://doi.org/10.1016/j.appet.2017.05.030>
- 553 Jenkins, D. J., Kendall, C. W., Augustin, L. S., Mitchell, S., Sahye-Pudaruth, S., Blanco Mejia, S.,  
554 Chiavaroli, L., Mirrahimi, A., Ireland, C., Bashyam, B., Vidgen, E., de Souza, R. J., Sievenpiper,  
555 J. L., Coveney, J., Leiter, L. A., & Josse, R. G. (2012). Effect of legumes as part of a low glycemic  
556 index diet on glycemic control and cardiovascular risk factors in type 2 diabetes mellitus: a  
557 randomized controlled trial. *Archives of Internal Medicine*, 172(21), 1653–1660.  
558 <https://doi.org/10.1001/2013.jamainternmed.70>
- 559 Jnawali, P., Kumar, V., & Tanwar, B. (2016). Celiac Disease: Overview and Considerations for  
560 Development of Gluten-Free Foods. *Food Science and Human Wellness*, 5(4), 169–176.  
561 <https://doi.org/10.1016/j.fshw.2016.09.003>
- 562 Laureati M., & Proserpio C. (2021). Consumer perception and acceptance of healthy and sustainable  
563 food: trends, challenges and mitigatory strategies. In *Consumer Acceptance and Sensory*  
564 *Evaluation of New Food Products: Principles and Applications*; de Almeida Costa, A. I.,  
565 Monteiro, M. J. P. & Lamy E., Eds. Royal Society of Chemistry.
- 566 Laureati M., Proserpio C., Jucker C., & Savoldelli S. (2016). New sustainable protein sources:  
567 consumers' willingness to adopt insects as feed and food. *Italian Journal of Food Science*, 28(4),  
568 652-667. <https://doi.org/10.14674/1120-1770/IJFS.V476>
- 569 Laureati, M., Jabes, D., Russo, V., & Pagliarini, E. (2013). Sustainability and organic production:  
570 How information influences consumer's expectation and preference for yogurt. *Food Quality and*  
571 *Preference*, 30(1), 1-8. <https://doi.org/10.1016/j.foodqual.2013.04.002>
- 572 Laureati, Spinelli, S., Monteleone, E., Dinnella, C., Prescott, J., Cattaneo, C., Proserpio, C., De  
573 Toffoli, A., Gasperi, F., Endrizzi, I., Torri, L., Peparario, M., Arena, E., Bonello, F., Condelli, N.,  
574 Di Monaco, R., Gatti, E., Piasentier, E., Tesini, F., & Pagliarini, E. (2018). Associations between  
575 food neophobia and responsiveness to “warning” chemosensory sensations in food products in a  
576 large population sample. *Food Quality and Preference*, 68, 113–124.  
577 <https://doi.org/10.1016/j.foodqual.2018.02.007>
- 578 Lawless, H.T. & Heymann, H. (2010) Sensory Evaluation of Food. Principles and Practices. 2nd  
579 Edition, Springer Verlag, New York. <https://doi.org/10.1007/978-1-4419-6488-5>

580

581 Lemken, D., Knigge, M., Meyerding, S., & Spiller, A. (2017). The value of environmental and health  
582 claims on new legume products: A non-hypothetical online auction. *Sustainability*, 9(8), 1340.  
583 <https://doi.org/10.3390/su9081340>

584 Lima, M., Alcantara, M., Ares, G., & Deliza, R. (2019). It is not all about information! Sensory  
585 experience overrides the impact of nutrition information on consumers' choice of sugar-reduced  
586 drinks. *Food Quality and Preference*, 74, 1-9. <https://doi.org/10.1016/j.foodqual.2018.12.013>

587 MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of  
588 order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory*  
589 *Studies*, 4(2), 129-148. <https://doi.org/10.1111/j.1745-459X.1989.tb00463.x>

590 Malcolmson, L., Boux, G., Bellido A.-S., & Fröhlich P. (2013). Use of Pulse Ingredients to Develop  
591 Healthier Baked Products. *Cereal Foods World*, 58(1), 27–32. [https://doi.org/10.1094/CFW-58-](https://doi.org/10.1094/CFW-58-1-0027)  
592 [1-0027](https://doi.org/10.1094/CFW-58-1-0027)

593 Manohar, S., Rehman, V., & Sivakumaran, B. (2021). Role of unfamiliarity and information on  
594 consumers' willingness to try new healthy foods. *Food Quality and Preference*, 87, 104037.  
595 <https://doi.org/10.1016/j.foodqual.2020.104037>

596 McCrory M. A., Hamaker B. R., Lovejoy J. C., & Eichelsdoerfer P. E. (2010). Pulse consumption,  
597 satiety, and weight Management. *Advances in Nutrition*, 1(1), 17–30.  
598 <https://doi.org/10.3945/an.110.1006>

599 Melendrez-Ruiz, J., Buatois, Q., Chambaron, S., Monnery-Patris, S., & Arvisenet, G. (2019). French  
600 consumers know the benefits of pulses, but do not chose them: An exploratory study combining  
601 indirect and direct approaches. *Appetite*, 141, 104311. <https://doi.org/10.1016/j.appet.2019.06.003>

602 Menozzi, D., Sogari, G., Veneziani, M., Simoni, E., & Mora, C. (2017). Eating novel foods: An  
603 application of the theory of planned behaviour to predict the consumption of an insect-based  
604 product. *Food quality and Preference*, 59, 27-34. <https://doi.org/10.1016/j.foodqual.2017.02.001>

605 Migliavada, R., Coricelli, C., Bolat, E. E. Uçuket, C., & Torri, L. (2022). The modulation of  
606 sustainability knowledge and impulsivity traits on the consumption of foods of animal and plant  
607 origin in Italy and Turkey. *Scientific Reports*, 12, 20036. [https://doi.org/10.1038/s41598-022-](https://doi.org/10.1038/s41598-022-24325-z)  
608 [24325-z](https://doi.org/10.1038/s41598-022-24325-z)

609 Mollard, R. C., Luhovyy, B. L., Panahi, S., Nunez, M., Hanley, A., & Anderson, G. H. (2012).  
610 Regular consumption of pulses for 8 weeks reduces metabolic syndrome risk factors in overweight  
611 and obese adults. *British Journal of Nutrition*, 108(S1), S111–S122.  
612 <https://doi.org/10.1017/S0007114512000712>

613 Næs, T., Brockhoff, P.B., & Tomic, O. (2010). Statistics for Sensory and Consumer Science  
614 Naqash, F., Gani, A., Gani, A., & Masoodi, F.A. Gluten-free baking: combating the challenges—A  
615 Review. (2017). *Trends in Food Science & Technology*, 66, 98–107.  
616 <https://doi.org/10.1016/j.tifs.2017.06.004>

617 Nemecek, T., Von Richthofen, J.-S., Dubois, G., Casta, P., Charles, R., & Pahl, H. (2008).  
618 Environmental impacts of introducing grain legumes into European crop rotations. *European*  
619 *Journal of Agronomy*, 28(3), 380–393. <https://doi.org/10.1016/j.eja.2007.11.004>

620

- 621 Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory* (McGraw-Hill Series in Psychology,  
622 Vol. 3). New York, NY: McGraw-Hill.
- 623 Papanikolaou, Y., & Fulgoni V. L. 3rd. (2008). Bean consumption is associated with greater nutrient  
624 intake, reduced systolic blood pressure, lower body weight, and a smaller waist circumference in  
625 adults: results from the National Health and Nutrition Examination Survey 1999–2002. *Journal of*  
626 *the American College of Nutrition*, 27(5), 569–576.  
627 <https://doi.org/10.1080/07315724.2008.10719740>
- 628 Pliner, P., & Hobden, K (1992). Development of a scale to measure the trait of food neophobia in  
629 humans. *Appetite*, 19, 105–120. [https://doi.org/10.1016/0195-6663\(92\)90014-W](https://doi.org/10.1016/0195-6663(92)90014-W)
- 630 Poore, J., & Nemecek, T. (2018). Reducing food’s environmental impacts through producers and  
631 consumers. *Science*, 360(6392), 987-992. <https://doi.org/10.1126/science.aag0216>
- 632 Preissel, S., Reckling, M., Schläfke, N., & Zander, P. (2015). Magnitude and farm-economic value  
633 of grain legume pre-crop benefits in Europe: A review. *Field Crops Research*, 175, 64–79.  
634 <https://doi.org/10.1016/j.fcr.2015.01.012>
- 635 Proserpio, C., Bresciani, A., Marti, A., & Pagliarini, E. (2020). Legume Flour or Bran: Sustainable,  
636 Fiber-Rich Ingredients for Extruded Snacks?. *Foods*, 9(11), 1680.  
637 <https://doi.org/10.3390/foods9111680>
- 638 Proserpio, C., Fia, G., Bucalossi, G., Zanoni, B., Spinelli, S., Dinnella, C., Monteleone, E., &  
639 Pagliarini, E. (2020). Winemaking byproducts as source of antioxidant components: Consumers’  
640 acceptance and expectations of phenol-enriched plant-based food. *Antioxidants*, 9(8), 661.  
641 <https://doi.org/10.3390/antiox9080661>
- 642 Rebello, C. J., Greenway, F. L., & Finley, J.W. (2014). A review of the nutritional value of legumes  
643 and their effects on obesity and its related co-morbidities. *Obesity reviews*, 15(5), 392-407.  
644 <https://doi.org/10.1111/obr.12144>
- 645 Russo, C., & Simeone, M. (2017). The growing influence of social and digital media: Impact on  
646 consumer choice and market equilibrium. *British Food Journal*, 119(8), 1766-1780.  
647 <https://doi.org/10.1108/BFJ-05-2017-0283>
- 648 Russo, V., Milani, L., Re, A., Crescentini, A., & Sciangula, C. (2012). The sustainability and the role  
649 of the mass media: representation, values and behaviours among consumers in Italy.
- 650 Saba, A., Vassallo, M., Shepherd, R., Lampila, P., Arvola, A., Dean, M., Winkelmann, M., Claupein,  
651 E., & Lähteenmäki, L. (2010). Country-wise differences in perception of health-related messages  
652 in cereal-based food products. *Food Quality and Preference*, 21(4), 385-393.  
653 <https://doi.org/10.1016/j.foodqual.2009.09.007>
- 654 Sabbe, S., Verbeke, W., Deliza, R., Matta, V., & Van Damme, P. (2009). Effect of a health claim and  
655 personal characteristics on consumer acceptance of fruit juices with different concentrations of  
656 açai (*Euterpe oleracea* Mart.). *Appetite*, 53(1), 84–92. <https://doi.org/10.1016/j.appet.2009.05.014>
- 657 Schlup, Y., & Brunner, T. (2018). Prospects for insects as food in Switzerland: A tobit regression.  
658 *Food Quality and Preference*, 64, 37-46. <https://doi.org/10.1016/j.foodqual.2017.10.010>
- 659 Schneider, A. V. C. (2002). Overview of the market and consumption of pulses in Europe. *British*  
660 *Journal of Nutrition*, 88(S3), 243-250. <https://doi.org/10.1079/BJN2002713>
- 661 Sharma, S., Thind, S. S., & Kaur, A. (2015). In vitro meat production system: why and how?. *Journal*  
662 *of Food Science and Technology*, 52(12), 7599-7607. <https://doi.org/10.1007/s13197-015-1972-3>
- 663 Siret, F., & Issanchou, S. (2000). Traditional process: Influence on sensory properties and on  
664 consumers’ expectation and liking. Application to ‘pâte de campagne’. *Food Quality and*  
665 *Preference*, 11(3), 217–228. [https://doi.org/10.1016/S0950-3293\(99\)00058-0](https://doi.org/10.1016/S0950-3293(99)00058-0)

- 666 Slade, P. (2018). If you build it, will they eat it? Consumer preferences for plant-based and cultured  
667 meat burgers. *Appetite*, 125, 428–437. <https://doi.org/10.1016/j.appet.2018.02.030>
- 668 Śmiglak-Krajewska, M., Wojciechowska-Solis, J., & Viti, D. (2020). Consumers' purchasing  
669 intentions on the legume market as evidence of sustainable behaviour. *Agriculture*, 10(10), 424.  
670 <https://doi.org/10.3390/agriculture10100424>
- 671 Sogari, G., Menozzi, D., & Mora, C. (2016). Exploring young foodies' knowledge and attitude  
672 regarding entomophagy: A qualitative study in Italy. *International Journal of Gastronomy and*  
673 *Food Science*, 7, 16-19. <https://doi.org/10.1016/j.ijgfs.2016.12.002>
- 674 Tuorila, H., & Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Current*  
675 *Opinion in Food Science*, 33, 1-8. <https://doi.org/10.1016/j.cofs.2019.09.004>
- 676 Van den Heuvel, E., Newbury, A., & Appleton, K. M. (2019). The psychology of nutrition with  
677 advancing age: Focus on food neophobia. *Nutrients*, 11(1), 151.  
678 <https://doi.org/10.3390/nu11010151>
- 679 Vanhonacker, F., Van Loo, E. J., Gellynck, X., & Verbeke, W. (2013). Flemish consumer attitudes  
680 towards more sustainable food choices. *Appetite*, 62, 7-16.  
681 <https://doi.org/10.1016/j.appet.2012.11.003>
- 682 Verbeke, W. (2015). Profiling consumers who are ready to adopt insects as a meat substitute in a  
683 Western society. *Food Quality and Preference*, 39, 147-155.  
684 <https://doi.org/10.1016/j.foodqual.2014.07.008>
- 685 Vidigal, M. C. T. R., Minim, V. P. R., Carvalho, N. B., Milagres, M. P., & Gonçalves, A. C. A.  
686 (2011). Effect of a health claim on consumer acceptance of exotic Brazilian fruit juices: açai  
687 (*Euterpe oleracea* Mart.), camu-camu (*Myrciaria dubia*), cajá (*Spondias lutea* L.) and umbu  
688 (*Spondias tuberosa* Arruda). *Food Research International*, 44(7), 1988–1996. <https://doi.org/10.1016/j.foodres.2010.11.028>
- 690 Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman,  
691 D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk,  
692 R., Rivera, J. A., De Vries, W., Majele Sibanda, L., Afshin, A., ... & Murray, C. J. L. (2019). Food  
693 in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems.  
694 *Lancet*, 393(10170), 447–492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)
- 695 Yang, Q., Shen, Y., Foster, T., & Hort, J. (2020). Measuring consumer emotional response and  
696 acceptance to sustainable food products. *Food Research International*, 131, 108992.  
697 <https://doi.org/10.1016/j.foodres.2020.108992>
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705 **Table 1.** Mean hedonic scores under the 3 experimental conditions (B = Blind; E = Expected; R =  
 706 Real) and expectation effect on samples liking

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Samples	Scores			E–B		R–B		R–E	
	B	E	R	Mean	p-value	Mean	p-value	Mean	p-value
CONTROL	62.7	76.2	65.0	13.5	*** (Disconf.)	2.3	n.s.		
20% CHICKPEAS	60.2	73.2	67.3	13.0	*** (Disconf.)	7.1	** (Assim.)	–5.9	* (Incomplete)
20% RED LENTILS	58.9	72.2	65.4	13.3	*** (Disconf.)	6.5	** (Assim.)	–6.8	** (Incomplete)

708 (n.s., not significant; \*, p<0.05; \*\* p<0.01; \*\*\*, p<0.001) Disconf. = negative disconfirmation,

709 Assim. = assimilation

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725 **Table 2.** Mean hedonic scores provided by Neophilic, Neutral and Neophobic consumers under the  
 726 3 experimental conditions (B = Blind; E = Expected; R = Real) and expectation effect on samples  
 727 liking.

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FNS groups	Samples	Ratings			E-B		R - B		R - E	
		B	E	R	Mean	p-value	Mean	p-value	Mean	p-value
Neophilic	CONTROL	63.2	78.0	66.2	14.8	** (Disconf.)	3.0	n.s.		
	20% CHICKPEAS	64.6	79.8	71.1	15.2	*** (Disconf.)	6.5	n.s.		
	20% RED LENTILS	60.5	78.7	70.3	18.2	*** (Disconf.)	9.8	* (Assim.)	-8.4	n.s. (Complete)
Neutral	CONTROL	60.3	76.9	64.6	16.6	*** (Disconf.)	4.3	n.s.		
	20% CHICKPEAS	58.7	72.0	66.7	13.3	*** (Disconf.)	8.0	* (Assim.)	-5.3	n.s. (Complete)
	20% RED LENTILS	58.6	72.5	65.2	13.9	*** (Disconf.)	6.6	* (Assim.)	-7.3	* (Incomplete)
Neophobic	CONTROL	67.8	72.7	64.8	4.9	n.s.	-3.0	n.s.		
	20% CHICKPEAS	59.7	69.3	65.0	9.6	n.s.	5.3	n.s.		
	20% RED LENTILS	57.9	65.2	61.0	7.3	n.s.	3.1	n.s.		

729 (n.s., not significant; \*, p<0.05; \*\* p<0.01; \*\*\*, p<0.001) Disconf. = negative disconfirmation,  
 730 Assim.= assimilation

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743 **Table 3.** Mean frequency of answers provided by the total sample of participants and by participants  
744 grouped according to FN level to the question: “Recently, how often have you performed the  
745 following actions?” (“Never = 0 times”, “Rarely = 2-3 times a month”, “Sometimes = 1-2 times a  
746 week”, “Often = 3-4 times a week”, “Always = every day”). In the last column, Pearson’s correlation  
747 coefficients (r) between FN and each action is reported. Significant correlations are emboldened. S=  
748 sustainable actions; NS= non-sustainable actions.  
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Items	Total group (n=127)	Neophilic (N=29)	Neutrals (N=69)	Neophobic (N=29)	FNS index (r)
1. Eating meat (NS)	2.6	2.7	3.0	2.5	-0.05
2. Buying local food (S)	3.0	3.0	3.1	2.6	- <b>0.21</b> *
3. Buying fair trade products (S)	2.2	2.2	2.2	2.2	- 0.10
4. Eating seasonal food (S)	4.1	4.0	4.2	3.9	- <b>0.19</b> *
5. Mixing waste (NS)	1.3	1.2	1.3	1.5	0.16
6. Recycling (S)	4.9	5.0	4.8	4.9	- 0.11
7. Buying clothes from ethical fashion (S)	2.0	2.0	2.0	1.8	- 0.09
8. Shopping in supermarkets (NS)	3.6	3.6	3.6	3.7	-0.01
9. Saving electric energy (S)	3.9	3.9	3.9	3.8	- 0.08
10. Buying regional food (S)	3.1	3.2	3.2	2.8	- 0.17
11. Buying 0 Km products (S)	2.3	2.2	2.4	2.2	- 0.07
12. Using public transportation (S)	4.0	4.2	4.1	3.8	- 0.11
13. Eating exotic food (NS)	2.4	2.5	2.4	2.2	-0.15
14. Eating organic food (S)	2.9	2.8	3.0	2.6	- 0.10
15. Leaving the lights on when unnecessary (NS)	1.6	1.3	1.6	1.8	<b>0.18</b> *

750 (\*, p<0.05; \*\* p<0.01; \*\*\*, p<0.001)

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755 **Table 4.** Mean frequency of answers provided by the total sample of participants and by participants  
 756 grouped according to FN level to the question: “In your opinion, does the consumption of the  
 757 following food harm the planet or cause environmental damage in any way?” (1=strongly disagree;  
 758 4=Neither agree nor disagree; 7=strongly agree). S= sustainable food item; NS= non-sustainable food  
 759 item.  
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Items	Total group (n=127)	Neophilic (N=29)	Neutrals (N=69)	Neophobic (N=29)
1. Chicken meat	4.3	4.2	4.5	3.8
2. Beef	5.1	5.0	5.2	4.9
3. Cheese	3.6	3.6	3.5	3.9
4. Seasonal fruits	1.9	1.9	1.7	2.2
5. Vegetables	2.0	2.0	1.8	2.4
6. Nuts	2.4	2.6	2.3	2.6
7. Legumes	2.0	2.0	1.8	2.4
8. Eggs	3.2	3.6	3.1	3.2
9. Farmed fish	4.1	4.3	4.0	4.1
10. Tofu	2.8	2.8	2.6	3.1
11. Exotic fruit	3.9	4.3	3.9	3.7

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769 **Table 5.** Mean frequency of answers provided by the total sample of participants and by participants  
770 grouped according to FN level to the question: “How much do you agree with the following  
771 statements?” (1=strongly disagree; 4=Neither agree nor disagree; 7=strongly agree). In the last  
772 column Pearson’s correlation (r) for each item of consumers’ opinions and beliefs on sustainability  
773 questionnaire and FN index in the total samples of the subjects is reported. Significant correlations  
774 are emboldened.  
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Items	Total group (n=127)	Neophilics (N=29)	Neutrals (N=69)	Neophobic (N=29)	FNS index (r)
1. These products are too expensive for me	4.5	4.4	4.5	4.6	0.06
2. It is difficult to find these products on the market	3.5	2.9	3.5	3.9	<b>0.28 **</b>
3. There is little information about these products	4.8	4.3	4.7	5.4	<b>0.22 *</b>
4. The information about these products is not clear	4.0	3.9	3.8	4.5	<b>0.20 *</b>
5. There is little choice among sustainable products	3.9	3.9	3.7	4.4	0.17
6. These products seem less safe than traditional ones	2.2	2.1	2.0	3.0	<b>0.21 *</b>
7. Sustainable products are of low quality	1.9	2.1	1.6	2.7	0.14
8. It is difficult to distinguish between food products that harm the environment and food products that respect the environment	3.6	3.5	3.3	4.1	<b>0.20 *</b>
9. I am not sure about the reliability of some eco-labels	4.1	4.2	3.9	4.6	0.14
10. Sustainability is just an image choice and there is nothing concrete in the actions of companies	2.8	2.6	2.6	3.6	<b>0.24 **</b>

776 (\*, p<0.05; \*\* p<0.01; \*\*\*, p<0.001)