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1 Using CATA tests to capture consumers' mental 2 representations elicited by images of pulse-based food 3 products with different levels of processing

4

5 **Juliana MELENDREZ RUIZ^{1*}, Stéphanie CHAMBARON¹, Erick SALDAÑA ²,**
6 **Sandrine MONNERY-PATRIS¹, Gaëlle ARVISENET¹**

7 1 Centre des Sciences du Goût et de l'Alimentation, AgroSup Dijon, CNRS, INRA,
8 Université Bourgogne Franche-Comté, F-21000 Dijon, France.

9 2 Facultad de Ingeniería Agroindustrial, Universidad Nacional de Moquegua
10 (UNAM), Calle Ancash s/n, 18001, Moquegua, Perú

11

12 * Correspondence: juliana.melendrezruiz@inrae.fr

13

14 **Abstract: 250 words.**

15 Consumption of pulses plays a key role in achieving a healthier and more
16 sustainable diet. Despite the increased availability of pulse-based foods on the French
17 market, pulse consumption in France remains below recommended levels. The objective of
18 this study was to capture French consumers' mental representations of various pulse-based
19 foods with different levels of processing, using a Check-All-That-Apply (CATA)
20 questionnaire with food images. We used CATA questionnaires, in two separate studies, to
21 capture two aspects: consumers' beliefs about the products presented in the study, and the
22 characteristics of those products, according to consumers. In Study 1, twelve images of
23 pulses were presented (unprocessed, processed, and ready-to-eat) to investigate whether
24 and how consumers differentiate between pulse-based products with different recipes and
25 levels of processing. In Study 2, parallel CATA questionnaires were used: one with images
26 of pulse-based products, and one with images of vegetables. We wanted to discover
27 whether the factors underlying different representations for pulse-based products were
28 specific to pulses, or were also observed with another family of food products. Results
29 showed that products were differentiated more by their level of processing than by their
30 main ingredient. Participants had more positive attitudes toward pulse products that were
31 unprocessed, processed, or "new ready-to-eat", than toward other ready-to-eat pulse
32 products (whether canned or frozen). Our results also highlighted that, in consumers'
33 mental representations of pulse-based products, packaging format is a negligible factor in
34 comparison with the nature of the product itself.

35

36 **Keywords:** CATA, mental representations, food choices, pulses, food processing

37

38

40 1. Introduction

41 Over the last few decades, there has been an increasing need to promote healthier
42 and more sustainable food choices. Pulses are considered to have many assets aligned with
43 this objective. The FAO defines pulses as a type of leguminous crop that is grown mainly
44 for human consumption, such as beans, chickpeas, lentils, and dried peas. This definition
45 excludes other leguminous crops, such as green peas, which are classified as green
46 vegetables, and crops used for oil extraction, such as soybeans (FAO, 2016). Pulses are
47 very nutritious and their consumption is associated with health and nutritional benefits.
48 Growing pulses helps to maintain the environmental sustainability of agriculture (Rawal &
49 Navarro, 2019). Despite the rising interest in pulses internationally, their consumption in
50 France remains low, at only 2 kg per person in 2018 (Agreste, 2019), well below the global
51 average consumption of 7.6 kg per person per year (Rawal & Navarro, 2019). A slightly
52 more recent study showed that, in France, there is no well-established social representation
53 of pulses as a food family (Melendrez-Ruiz et al., 2020). An earlier study had suggested
54 that, for French people, the difficulty of preparing pulses may be one of the main barriers to
55 their consumption (Melendrez-Ruiz, et al., 2019). In that study, French participants had to
56 compose a dish from photographs of food items, in different scenarios. Participants chose
57 pulses significantly more often when they were projected in a situation where they would
58 not have to be cooked. As the study used only photographs of raw products (lentils,
59 chickpeas, white beans, and red beans), it was not possible to infer how the consumer
60 would behave toward processed pulse-based products. In the more recent study, an
61 evocation task was carried out to understand the social representation of pulses among
62 French non-vegetarian participants (Melendrez-Ruiz et al., 2020). Respondents had to cite 5
63 words that came spontaneously to mind when they heard the word “pulses”. Words related
64 to culinary preparation were used quite frequently, and participants considered these words
65 of great importance. This result reveals that, even when there is no reference to any form of
66 processing in the questions asked, participants spontaneously think about preparation when
67 they think about pulses. For French people, the association between pulses and preparation
68 is anchored in the social representations of pulses; this association was not present among
69 Spanish people who carried out the same task (Melendrez-Ruiz et al., 2021).

70 Taking into account this consumer reticence concerning the preparation of pulses,
71 there has lately been an increase in the development of processed pulse products (Métayer
72 & Denhartigh, 2016). It is now possible to find, on the market, pulses with different levels
73 and types of processing, from unprocessed to ready-to-eat. Innovative ready-to-eat pulse-
74 based products are now available in France, which should help to overcome the difficulty of
75 preparation considered by many as a barrier to consumption. These ready-to-eat products
76 are often ultra-processed foods (UPFs), which means that they have undergone “excessive
77 processing” and contain ingredients and/or additives whose primary function is to modify
78 color, taste, and texture (Fardet, 2018a). Several classifications have been proposed to
79 distinguish the level and type of industrial processing that a food product undergoes:
80 NOVA (Monteiro et al., 2010), SIGA (Fardet, 2018c), the classifications proposed by IFIC

81 (Eicher-Miller et al., 2012), and by the University of North Carolina (Poti et al., 2015), etc.
82 Each of these classifications proposes a different number of classes and considers different
83 grouping criteria. A common point between these classifications is that unprocessed and
84 minimally processed foods are in the same group and are distinguished from processed
85 foods (processes meant to preserve or precook), and ready-to-eat foods (ready-to-eat, multi-
86 ingredient foods obtained by industrial processes, etc.). Pulse-based products exist at all
87 these levels of processing: unprocessed pulses (e.g., raw lentils, beans, etc.), processed
88 pulses (e.g., pulses cooked with water and salt, and sold in cans or glass jars, or vacuum-
89 packed) and ready-to-eat foods containing pulses (e.g., ready-to-eat dishes, such as
90 traditional recipes with meat and pulses, but also patties, meatballs, etc., where pulses are
91 no longer recognizable). Because of these multiple complex classifications, the differences
92 between processed and ready-to-eat foods may be less easily perceived by consumers. In
93 addition, it has been shown that an increase in the consumption of UPFs was associated
94 with a higher overall risk of cardiovascular disease (Srour et al., 2019), a higher mortality
95 risk among the adult population (Schnabel et al., 2019), and an increase in the risk of cancer
96 (Fiolet et al., 2018). These results have been widely communicated to consumers. The level
97 of processing applied to pulses could be considered negatively by consumers, and it is
98 therefore necessary to determine their mental representations of different types of pulse-
99 based products.

100

101 French consumers know what lentils, beans, and chickpeas are, and are quite well
102 informed about their properties (Melendrez-Ruiz, et al., 2019), but they tend to regard each
103 type of pulses differently. As a consequence, it seems necessary, when studying French
104 consumers' mental representations of pulses, to avoid the generic term "Pulses", and
105 instead to use examples of pulses. The great variety of types of pulses (i.e., red lentils,
106 green lentils, brown lentils, white beans, red beans, black beans, chickpeas, and dried peas)
107 together with the diversity of processing applied to these pulses may make it difficult to
108 untangle the many barriers to pulse consumption. In these conditions, studying consumers'
109 mental representations of pulse-based products is challenging. Mental representations are
110 defined as cognitive products and individual mental processes that come from the
111 interaction of individuals with their environment, allowing them to code the meaning of
112 stimuli and store this information in memory (Gallen, 2005). Traditional questionnaires
113 have been used to study mental representations, but a questionnaire would be overly long
114 and repetitive in the present case. Furthermore, social desirability bias is a known risk
115 during direct questioning. Indirect methodologies, such as word associations, sentence
116 completion, or projective techniques, have been developed to avoid this risk (Fisher, 1993).

117 The main objective of the present study was to capture French consumers' mental
118 representations of various pulse-based products with different recipes, and different levels
119 and types of processing. We used a Check-All-That-Apply (CATA) questionnaire. Within
120 sensory science, the CATA method is frequently used as a rapid sensory profiling
121 technique. It consists of asking assessors to select from a list (words or phrases) all the
122 attributes that they consider the most appropriate to describe a product (Valentin et al.,

123 2012). In the food domain, some studies have used a CATA test with images rather than
124 food products. For example, images have been used to characterize the expected sensory
125 characteristics of wine presented in different bottles (Puyares et al., 2010), and for apples
126 with different internal defects (Antúnez et al., 2019). Such CATA tests are easy to execute
127 for participants without any particular knowledge and do not require specific training.
128 Product characterization obtained from consumers using a CATA test is considered to be
129 reliable (Jaeger et al., 2013). Indeed, providing a list of characteristics to participants allows
130 them to understand rapidly the perceived sensory characteristics of a variety of products. In
131 the present study, we used the CATA questionnaire to capture how consumers characterize
132 products, using attributes related not to sensory characteristics, but to more general
133 characteristics, in order to access consumers' representations, beliefs, and attitudes, in
134 relation to the products presented.

135 Two separate studies were carried out to achieve our objective. In the first study, we
136 used a CATA test to measure whether and how consumers differentiate between pulse-
137 based products with different levels of processing. Comparing the attributes selected for
138 different products should allow us to understand the representations and beliefs about
139 different types of pulse-based products, and thus to identify possible barriers to their
140 consumption. In the second study, we compared the results obtained for pulses with the
141 results obtained for vegetables, in order to determine whether the factors underlying the
142 representations of pulse-based products were specific to pulses or could also be observed
143 with another family of products.
144

145 **2. Materials and methods**

146 Our study was divided into two steps. Study 1 and Study 2 were both conducted in
147 accordance with the Declaration of Helsinki and were approved by the ethical committee of
148 INSERM N°18-506. Institutional Review Board INSERM (CEEI/IRB) (IRB00003888,
149 IORG0003254, FWA00005831).

150 2.1. General organization for the two studies

151 People who agreed to take part in the two studies were asked to fill out a consent
152 form. Then they carried out a CATA test on a computer. The study began with an
153 explanation of the instructions. Then participants were asked to select all the attributes on
154 the CATA list that they considered the most representative of each image presented. The
155 image appeared at the top of the computer screen, in the center (one image at a time), and
156 the list of attributes was listed below, in five columns. The order of presentation for the
157 images and for the list of attributes was randomized between participants. For the same
158 participant, the order of the list of attributes was the same for all the images, as
159 recommended by Meyners & Castura (2016). At the end of CATA testing, participants
160 filled out a short questionnaire about their age, sex, and level of education. Redjade
161 software was used to build the test, and to collect the data. The total amount of time spent
162 by participants was around 15 to 20 minutes, on average.

163 2.2. Study 1

164 2.2.1. *Sample size and participants*

165 Participants were recruited on a voluntary basis, over three weeks, at a Cultural and
166 Social Center in Dijon, France. People attending the cultural center were approached by the
167 experimenter, who invited them to participate in a study “about food”. The real aim of the
168 study was not revealed, to avoid potential biases during the study. The inclusion criteria
169 were to be fluent in French, to be aged between 25 and 65, and not to have a specific,
170 restrictive diet (e.g., vegetarian or vegan).

171 In total, 73 participants were recruited; their characteristics are shown in Table 1.

172 **Table 1.** Characteristics of participants

Age	Women	Men	Total
25–34	17	5	22
35–44	20	11	31
45–54	7	3	10
55–64	9	1	10
Total	53	20	73

173

174 A bootstrapping resampling approach was used to determine the stability of the
175 samples in the perceptual space as a function of the number of consumers. For that purpose,
176 1000 random subsets were obtained, for 30, 43, and 73 consumers. A Correspondence
177 Analysis was then performed on each random subset from which the first two dimensions
178 were extracted, to compare them with the reference map (corresponding to 30, 43, or 73
179 consumers) via the Regression Vector (RV) coefficient.

180 The RV coefficient obtained from the correspondence analysis, plotted as a function
181 of the number of consumers, considering 0.95 as the cut-off point (Blancher et al., 2012).
182 The higher the RV coefficient, the greater the stability of the samples in the perceptual
183 space (Faye et al., 2006). All three sample sizes generated stable perceptual spaces, and the
184 results obtained are therefore valid, coherent with the recommended number of participants
185 (60–80) for a CATA questionnaire (Ares et al., 2014).

186 2.2.2. *Experimental design*

187 *Choice of a set of images*

188 After field observations in French supermarkets, twelve pulse-based products were
189 chosen. The products were selected by their main ingredient and level of processing. Three
190 types of pulses were selected as main ingredients: lentils, white beans, and chickpeas. For
191 each of these pulses, 4 products were chosen, according to their level of processing. Group
192 (I) is for unprocessed, i.e., dry pulses, in their raw state. Group (II) is for processed, i.e.
193 canned pulses, prepared with water and salt (which can be consumed as is, or used to
194 prepare a more complex dish). Group (III), for ready-to-eat pulses, was divided into two
195 sub-groups. Sub-group (IIIa) is for ready-to-eat main dishes, containing pulses combined

196 with a meat product, presented in a can. These images represent the most common way to
 197 consume pulses in France, and correspond to a well-established script: meat +
 198 accompaniment. For this reason, they will be described as “traditional - ready-to-eat”
 199 throughout this article. Sub-group (IIIb) was used for recipes that are seen as less traditional
 200 and more innovative in France, such as pulse-based “meatball substitutes”. These products
 201 are stand-alone meals, in which the main ingredient (pulses) is no longer recognizable.
 202 They will be described as “new - ready-to-eat” throughout this article (Figure 1).

203 The images used in Study 1 were obtained from French online supermarkets. They
 204 were chosen among many possible products to present a certain visual homogeneity
 205 (packaging format, with a limited number of colors...). For each image, the brand and all
 206 claims were erased (i.e., produced in France, rich in fiber, etc.), in order not to draw
 207 attention to specific products for reasons irrelevant to the objective of our study.
 208



209
 210 **Figure 1.** Images of pulse-based products used in the CATA questionnaire for Study 1,
 211 sorted by level of processing and type of pulses

212
 213 *List of terms used for the CATA questionnaire*

214 The attributes used in the CATA questionnaire were collated from previous studies,
 215 based on the characteristics of pulses considered most common by French consumers
 216 (Magrini et al., 2018; Melendrez-Ruiz, et al., 2019; Melendrez-Ruiz, et al., 2019;
 217 Melendrez-Ruiz et al., 2020). A total of 28 terms was selected (Table 2).

218 **Table 2.** List of attributes used in the CATA questionnaire for Study 1

List of attributes

It's for a solo meal (<i>C'est pour un repas en solo/ seul</i>)	It's chic (<i>C'est chic</i>)	I buy it (<i>Je l'achète</i>)	It's easy to find (<i>C'est facile à trouver</i>)	It's organic (<i>C'est bio</i>)
It's for a convivial meal (<i>C'est pour un repas convivial</i>)	I don't like it (<i>Je n'aime pas</i>)	I don't buy it (<i>Je ne l'achète pas</i>)	It's hard to find (<i>C'est difficile à trouver</i>)	I don't know it (<i>Je ne le connais pas</i>)
It's eaten mostly in winter (<i>Ça se mange plutôt en hiver</i>)	I really like it (<i>J'aime beaucoup</i>)	It's exotic (<i>C'est exotique</i>)	It's for vegetarians (<i>C'est pour les végétariens</i>)	It's natural (<i>C'est naturel</i>)
It's traditional (<i>C'est traditionnel</i>)	It's good for the environment (<i>C'est bon pour l'environnement</i>)	It's local (<i>C'est local</i>)	It's for sportsmen (<i>C'est pour les sportifs</i>)	It gives me stomach-ache (<i>Ça me donne mal au ventre</i>)
It's modern (<i>C'est moderne</i>)	It's cheap (<i>Ce n'est pas cher</i>)	It's difficult to prepare (<i>C'est difficile à préparer</i>)	It's good for the health (<i>C'est bon pour la santé</i>)	It's trendy (<i>C'est tendance</i>)
It's expensive (<i>C'est cher</i>)	It's easy to prepare (<i>C'est facile à préparer</i>)	It's outdated (<i>C'est vieillot</i>)		

219

220 2.3. Study 2

221 2.3.1. Sample size and participants

222 In Study 2, two different pools of participants voluntarily completed the CATA
 223 questionnaires online (one for vegetables and the other for pulses). Participants were
 224 recruited using snowball sampling by email, where a link was shared for over four months.
 225 In total, 108 participants began the CATA questionnaire for pulses, but only 69 completed
 226 it. From that number, 3 participants were eliminated because they followed a vegetarian or
 227 vegan diet; thus 66 participants were included in the study (Table 3). In total, 107
 228 participants began the CATA for vegetables, but only 81 completed it. From that number, 3
 229 participants were eliminated because they followed a vegetarian diet. The answers from 78
 230 participants were thus included in the analysis (Table 3). Of the participants, 82% were
 231 women and 18% were men. We also checked that participants spent a comparable amount
 232 of time on each of the two questionnaires: averaging around 15 to 20 minutes.

233 **Table 3.** Characteristics of participants who answered the CATA questionnaire
 234 about pulses or vegetables.

Age	CATA Pulses			CATA Vegetables		
	Women	Men	Total	Women	Men	Total
18–24	15	3	18	13	6	19

25–34	17	2	19	23	3	26
35–44	7	3	10	8	1	9
45–54	7	1	8	5	2	7
55–64	8	3	11	15	2	17
Total	54	12	66	64	14	78

235

236 *2.3.2. Experimental design*

237 *Choice of a set of images*

238 Different food images were chosen for each CATA questionnaire. For the CATA
 239 questionnaire about pulses (Figure 2), fifteen products were selected, to represent 3 types of
 240 pulses, with different levels of processing. Two of the three types of pulses were the same
 241 as in Study 1 (lentils and white beans), but red beans replaced chickpeas because only a
 242 limited number of processed chickpea products is available in French supermarkets. For
 243 each type of pulses, three levels of processing were selected: (I) unprocessed, consisting of
 244 raw dried pulses; (II) processed, consisting of pulses cooked with water and salt; and (III)
 245 ready-to-eat combining pulses with a meat product. For Group I, all three pulses shared the
 246 same packaging format. The pulses in both Group II and Group III were divided by
 247 packaging format into two sub-groups: a) canned, and b) frozen. Group III represents the
 248 most common way to consume pulses in France, corresponding to a well-established script:
 249 meat + accompaniment. The same recipe was presented in the two formats.

250

251 Figure 3 shows the food products used for the CATA questionnaire about vegetables.
 252 The selection process followed the same rules, except for the canned ready-to-eat group
 253 (IIIa), which is not readily available in France. In total, twelve images were selected with
 254 three different products: spinach, zucchini, and eggplant. Each vegetable was presented at
 255 the same three levels of processing: (I) unprocessed, (II) processed, and (III) ready-to-eat.
 256 Group I was represented by raw products; Group II (a) products were canned vegetables,
 257 cooked with water and salt (and with tomato for the eggplants). Products from Group II (b)
 258 were frozen vegetables. Group III was represented by ready-to-eat dishes, where a
 259 vegetable product was used as the main ingredient. For each image, both the brand and all
 260 claims were erased (i.e. produced in France, rich in fiber, etc.).

261



262

263 **Figure 2.** Images used in the CATA questionnaire on pulse products for Study 2. Dotted

264 lines indicate products also used for Study 1.



265

266 **Figure 3.** Images used in the CATA questionnaire on vegetable products for Study 2.

267

268 *Terms used for the CATA questionnaire*

269 Of the 28 attributes used in Study 1 (Table 2), we reused 27 and discarded one (*it's*
270 *local*). We added two attributes: *it's bad for the health* (c'est mauvais pour la santé) and *it's*
271 *eaten mostly in summer* (ça se mange plutôt en été) because participants in Study 1 had
272 mentioned that these attributes were missing from the initial list. The resulting list of 29
273 attributes was used for both CATA questionnaires in Study 2 (on pulse-based products, and
274 on vegetables).

275 2.3.3. Procedure

276 A single link was created for both questionnaires (pulses and vegetables), and the
277 program was set up in such a way that participants were automatically split into two
278 groups: one out of every two participants completed the CATA questionnaire for pulses,
279 while the next participant completed the CATA questionnaire for vegetables, and so on.
280 Each participant participated in only one questionnaire. Just after completing the CATA
281 questionnaire and before answering the sociodemographic questions, participants answered
282 the single-item Food Choice Questionnaire proposed by Onwezen et al. (2019), with a
283 seven-point scale, from 1: “not at all important” to 7: “very important”. At the end,
284 participants filled out a short questionnaire to indicate their age, sex, level of education,
285 whether they followed a specific diet, and their province (to check that they were living in
286 France).

287 2.4. Statistical analysis

288 For Study 1 and Study 2, a Cochran Q test was performed on the contingency table,
289 to determine if the frequencies of the attributes differed as a function of the image
290 presented. If the attributes used were significantly different across the images, multiple
291 pairwise comparisons were executed, using an exact McNemar test with Bonferroni
292 adjustment. Significant attributes identified by the Cochran Q test were then used to carry
293 out a Correspondence Analysis (CA) to visualize the relationships between the attributes
294 and the images.

295

296 In addition, in Study 2, we performed a t-test over the scores obtained for both
297 groups on each factor of the single-item Food Choice Questionnaire to compare the groups
298 of participants that completed the study for pulses and for vegetables.

299

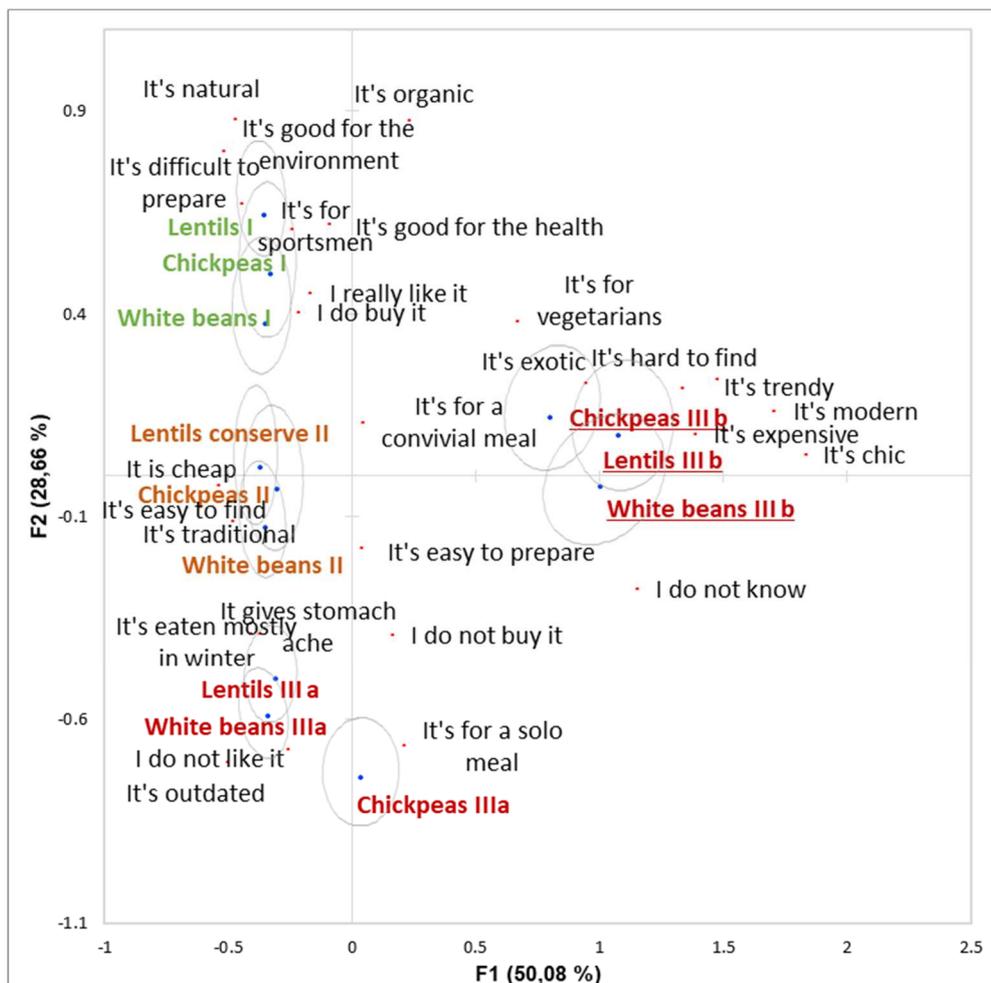
300 The XLSTAT software program for Windows (Addinsoft, version 2020-1) was used
301 for all statistical analyses. The confidence interval was set at 95%.

302

303 **3. Results**

304 3.1. Study 1

305 The Cochran Q test revealed that 27 out of the 28 attributes were used differently
 306 between the 12 images of pulse-based products (p -value < 0.05). The only attribute that was
 307 not used differently was “it’s local”. The Correspondence Analysis (CA) presented in
 308 Figure 4 shows the differences between the products. The first two axes explain 78% of the
 309 total variance. The CA shows associations between pulse-based products and attributes.
 310 Axis 1 divides products by novelty, while Axis 2 divides products by level of processing.
 311 Food products were divided by processing only: different pulses with the same type of
 312 processing were grouped together. All the products in Group I (raw, unprocessed products)
 313 were in the same group, mainly characterized by the attributes: *natural*, *good for health*,
 314 *good for the environment*, and *difficult to prepare*. Products in Group II (processed)
 315 also close to one another, and were considered to be *cheap*, *easy to find*, and *traditional*.
 316 Participants identified Group IIIa, composed of all the canned (traditional ready-to-eat)
 317 products, as *outdated*, *it gives me stomach-ache*, and *I don’t like it*. Group IIIb was
 318 composed of all the innovative (new ready-to-eat) products, and the attributes used by
 319 participants were: *it’s chic*, *it’s expensive*, and *it’s modern*. The attributes selected for the
 320 two sub-groups in Group III were very different: canned (traditional ready-to-eat) products
 321 had a more negative image than the innovative (new ready-to-eat) products.



322

323 **Figure 4.** Correspondence Analysis (CA) for the CATA questionnaire on pulses in
324 Study 1. Products (I) correspond to raw, unprocessed, (II) to processed, (IIIa) to traditional
325 ready-to-eat and (IIIb) to new ready-to-eat.

326 This study is the first evidence that representations of pulse-based products are not
327 the same, depending on the level of processing and the recipe. The difference between
328 pulse-based products is driven by their processing and/or recipe, and not by the type of
329 pulses (lentils, chickpeas, or white beans). It was not possible to draw precise conclusions
330 about the specific influence of the level of processing from the results of Study 1. Very
331 different attributes were associated with the two types of ready-to-eat products (traditional
332 vs new), which suggests that the level of processing may not be the only factor influencing
333 participants' mental representations. Considering that the packaging format and type of
334 processing were confounding variables in this sample of products, we cannot exclude the
335 possibility that packaging format may play a role in consumer representations of pulses. We
336 can also question whether the negative image of traditional ready-to-eat products is more
337 related to their recipe, to their presentation on the packaging (e.g., color and illustrations),
338 or their sensory properties. Study 1 highlighted a distribution of pulse-based products by
339 level of processing. It is unclear whether the level of processing is particularly important for
340 this specific family of food products, or if it would be also observed with other food
341 product families.

342 3.2. Study 2

343 Study 2 aimed to overcome the limitations observed in Study 1. In order to compare
344 two product-spaces, we used comparable CATA questionnaires to characterize pulse-based
345 products and another food product family (vegetables). In both product-spaces, the products
346 were selected as having either different packaging formats but the same level of processing
347 and the same recipe, or the same packaging format but different recipes and levels of
348 processing.

349 *3.2.1. Characterization of each set of respondents according to the food choice* 350 *questionnaire*

351 Table 4 shows the mean values obtained for each factor in the single-item Food
352 Choice Questionnaire. The Student t-test showed no significant differences for each factor
353 between the participants who answered the CATA on pulses and the participants who
354 answered the CATA on vegetables. Thus, both pools of participants in Study 2 were driven
355 by similar motivations.

356

357 **Table 4.** Mean values obtained for each factor of the Single-Item Food Choice
358 Questionnaire

Factors FCQ	Mean Pulses	Mean Vegetables	P-value
Familiarity	3.97	4.01	0.870
Convenience	3.98	4.23	0.333
Price	4.17	4.09	0.750
Mood	4.23	4.10	0.678
Weight control	4.39	4.56	0.528
Ethical concern	4.94	4.79	0.431
Natural content	5.52	5.56	0.824
Health	5.94	5.91	0.867
Sensory appeal	6.21	6.31	0.563

359

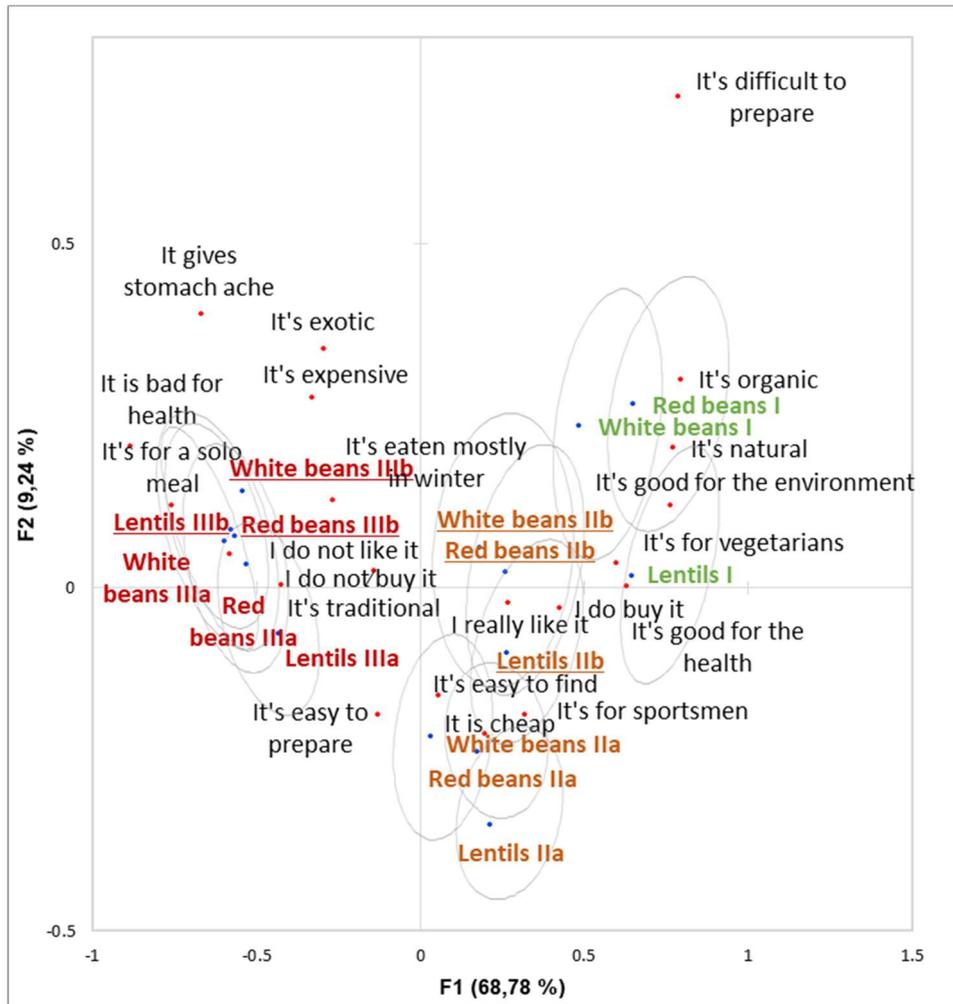
360 3.2.2. *Characterization of each set of respondents according to their personal*
361 *characteristics*

362 A Chi-square test was carried out for age, sex, and level of education between
363 participants who answered the CATA on pulses and those who answered the CATA on
364 vegetables. The results did not show any significant differences for age (p-value= 0.821),
365 sex (p-value= 0.971), or level of education (p-value= 0.591). Participants from each group
366 had similar personal characteristics.

367

368 3.2.3. *CATA questionnaire on pulses*

369 The Cochran Q test revealed that 21 attributes were used differently for the images
370 of pulse-based products (p-value < 0.05). The correspondence analysis presented in Figure
371 5 shows the differences between products. The first two axes explain 78% of the total
372 variance. Axis 1 mainly divides the pulse-based products into two groups: unprocessed and
373 processed are opposed to ready-to-eat products. Participants identified the unprocessed
374 products (I) and the processed frozen products (IIb) as more adapted for vegetarians, better
375 for health and for the environment, more natural and organic than the ready-to-eat products.
376 For the products from groups (I) and (II), participants more often selected the attribute *I buy*
377 *it*. All the ready-to-eat products, canned (IIIa) and frozen (IIIb) were grouped together, and
378 characterized by attributes such as *it gives me stomach-ache, it's exotic, it's bad for the*
379 *health, it's expensive, it's for a solo meal, it's eaten mostly in winter, it's traditional, I don't*
380 *like it, I don't buy it, and it's easy to prepare*. Unprocessed products (I) based on red beans
381 or white beans were considered more difficult to prepare than unprocessed lentils, and all
382 the processed products. By contrast, the canned processed products (IIa) were characterized
383 as *easy to prepare, easy to find, cheap, and adapted for sportsmen*.



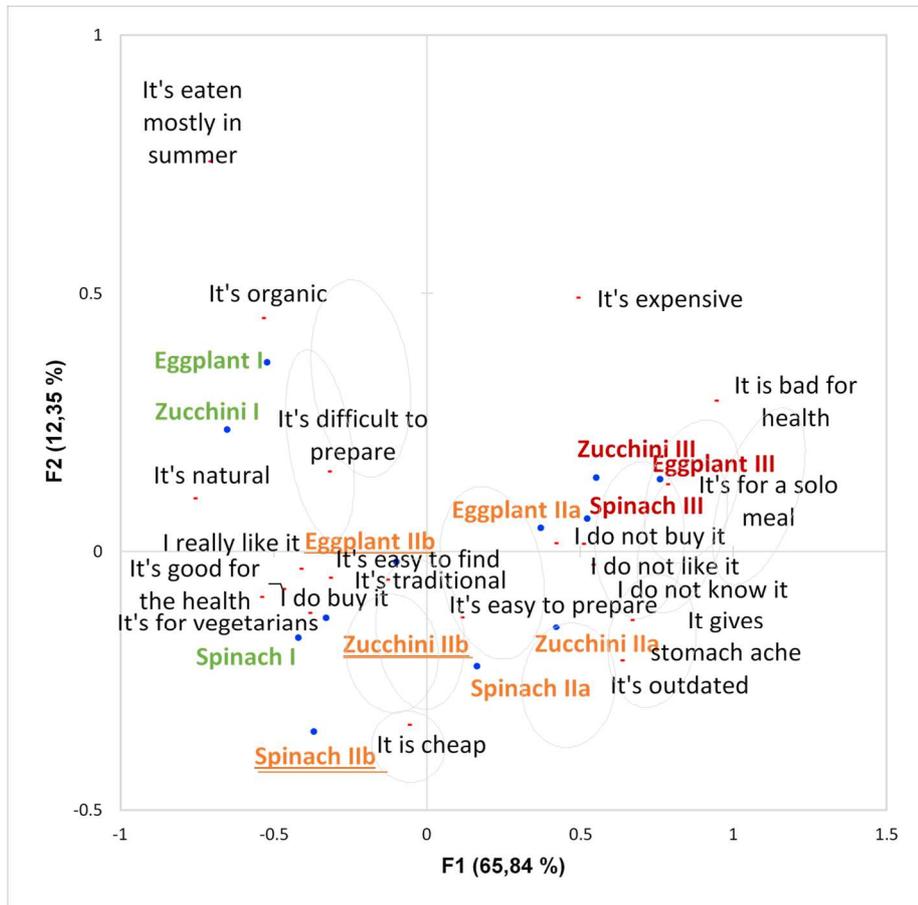
384

385 **Figure 5.** Correspondence Analysis (CA) for CATA on pulses in Study 2. Products
 386 (I) correspond to raw, unprocessed, (IIa) to processed canned, (IIb) to processed frozen,
 387 (IIIa) to ready-to-eat canned and (IIIb) to ready-to-eat frozen.

388 *3.2.4. CATA questionnaire on vegetables*

389 The results from the Cochran Q test showed that participants used 20 attributes
 390 differently across vegetable-based products (p-value < 0.05). The Correspondence Analysis
 391 (CA) presented in Figure 6 shows the differences between the vegetable-based products.
 392 The first two axes represent 78% of the total variance. Axis 1 opposes the (raw)
 393 unprocessed (I) and processed frozen vegetables (IIb) to the canned processed (IIa) and
 394 ready-to-eat vegetables (III). The attributes used by participants to characterize all the (raw)
 395 unprocessed products (I) and the processed frozen products (IIb) were: *it's natural*, *it's*
 396 *good for the health*, *it's for vegetarians*, and *I really liked it*. By contrast, the attributes
 397 more often used for the canned processed (IIa) and ready-to-eat vegetables (III) were: *it's*
 398 *bad for health*, *it's for a solo meal*, *it gives me stomach-ache*, *it's outdated*, *I don't buy it*, *I*
 399 *don't like it*, and *I don't know it*.

400 Axis 2 opposes raw eggplant and zucchini, associated with the attributes: *it's*
 401 *organic, it's expensive, and it's eaten mostly in summer*, to frozen spinach, considered as
 402 cheaper than the other products.



403
 404 **Figure 6.** Correspondence Analysis (CA) for the CATA on vegetables. Products (I)
 405 correspond to raw, unprocessed, (IIa) to processed canned, (IIb) to processed frozen, and
 406 (III) to ready-to-eat frozen.

407 **4. General discussion**

408 The main objective of this study was to capture consumers' mental representations
 409 of pulses with different levels of processing, using a Check-All-That-Apply (CATA)
 410 questionnaire. We used the results of two studies to verify if the level of processing affected
 411 consumers' representations of pulses. Study 1 highlighted new questions and we carried out
 412 Study 2 to check (i) if the different levels of processing were perceived similarly for two
 413 groups of food products; (ii) if the differences in representations between products
 414 depended only on their level of processing, or also on the type of recipe or packaging
 415 format.

416 *4.1. Does the level of processing affect mental representations, attitudes, and beliefs about*
 417 *products?*

418

419 One of our main findings from both Study 1 and Study 2 is that the differences in
420 representations, attitudes, and beliefs between various food products that belong to the
421 same food group (pulses or vegetables) are driven by their level of processing
422 (unprocessed, processed, or ready-to-eat), rather than by the fact that they contain the same
423 raw product (e.g. lentils, eggplant, beans, etc.).

424 Although not all the products included in Studies 1 and 2 were the same, and
425 although each study was carried out with different participants, the results from both studies
426 show similar tendencies. The descriptors used by participants reveal a more positive
427 attitude and beliefs toward products in their raw, unprocessed state, and in a processed
428 state, whatever their packaging format (cans or bags). By contrast, participants often
429 associated ready-to-eat pulses, whether canned and frozen, with attributes that reveal a
430 negative attitude and beliefs (*outdated, it gives me stomach-ache, I don't like it, and it's bad*
431 *for the health*). Our results are in accordance with a study carried out by the European Food
432 Information Council, in which UK residents showed a preference for unprocessed foods,
433 and perceived processed food negatively, arguing that there was a loss of nutritional and
434 health benefits in these products (EUFIC, 2016). In a previous study, we observed that
435 French non-vegetarian participants considered pulses as particularly difficult to
436 cook, compared to products from other food groups (Melendrez-Ruiz, et al., 2019). The
437 results from these two studies highlight a paradox. On the one hand, people who consider
438 pulses as difficult to cook may rarely prepare homemade dishes with raw pulses. On the
439 other hand, people who consider ready-to-eat pulse-based products negatively will probably
440 not consume them frequently. These two perceived properties of pulses may therefore
441 explain the low consumption of pulses by non-vegetarian French people. Yet the negative
442 attitude about ready-to-eat foods could be specific to the profile of the participants in our
443 study. For example, French vegetarian and vegan people tend to consume ultra-processed
444 plant-based meat and dairy substitutes to avoid animal-based products, and it has been
445 observed that their diet is richer in UPFs than that of meat-eaters or pescovegetarians
446 (Gehring et al., 2020). To confirm such results, it would be necessary for further study, to
447 compare consumers with different diets and/or socio-economic characteristics, to determine
448 if mental representations toward pulse products vary across different groups.

449

450 *4.2. Are mental representations of processed products the same for different food groups?*

451

452 Study 2 allowed us to compare pulse-based products and vegetable-based products. As
453 participants for both the CATA questionnaires had similar characteristics, it was possible to
454 compare results, to underline the common points and differences between pulse and
455 vegetable products. As already observed for pulse-based products, results for unprocessed

456 and ready-to-eat vegetable-based products were in direct opposition. Another similarity was
457 that unprocessed and processed frozen vegetables were characterized by attributes that
458 revealed a positive attitude and beliefs (e.g. *it's organic, it's natural, it's good for the*
459 *health, and I like it*) while the ready-to-eat frozen vegetables were characterized with
460 attributes that reveal a barrier to consumption (e.g. *it's bad for the health, and it's*
461 *expensive*). Nevertheless, we also found differences between the two groups of products.
462 Participants used similar attributes for processed canned vegetables and for ready-to-eat
463 vegetables. For pulses, processed products were characterized by attributes also used for
464 unprocessed products. Canned processed pulses have a positive image, while canned
465 processed vegetables have a negative image. This could explain buying behavior in France:
466 French adults declare that they most often buy canned pulse products (92%, ANSES, 2017).
467 By contrast, vegetables are mostly bought fresh (71%), and less often processed (29%),
468 whether canned or frozen (UNILET, 2015). This observation suggests that French people
469 are more familiar with canned pulses than with raw pulses, but with raw vegetables rather
470 than with canned vegetables. Their mental representations of canned pulses may thus be
471 better anchored than those for unprocessed pulses. There may also be a negative image of
472 canned vegetables in general, as revealed by a Swiss study showing that canned green
473 beans were perceived by participants to be harmful for the environment (Tobler et al.,
474 2011). Our hypothesis to explain our result is that French people, who are more used to
475 eating canned pulses, tend to consider this level of processing as the minimum required to
476 overcome the difficulty of preparation. Our results highlight that the mental representations
477 of products resulting from an industrial process are not perceived in the same way,
478 depending on the food group to which they belong. Mental representations seem to depend
479 on consumers' familiarity with products.

480

481 4.3. Three key points for mental representations of pulse-based products: the recipe, the 482 level of processing, and the packaging format

483

484 Among the main results of Study 1 are the differences in representations and beliefs
485 between traditional and new ready-to-eat products in France. Traditional ready-to-eat
486 products were mostly characterized by attributes such as *outdated, it gives me stomach-*
487 *ache, I don't like it*, that can be considered as a barrier to consumption. New ready-to-eat
488 products were characterized by very different attributes (e.g. *chic, modern, etc.*) that
489 revealed a positive attitude. This is in line with the literature showing that more innovative
490 ultra-processed foods were considered to have an image of “*good for the health*”, especially
491 for vegetarians and vegans (Fardet, 2017). Such differences in the representation of
492 traditional and innovative ready-to-eat foods could be related either to the recipe or to the
493 presentation and packaging format of the product. Traditional products contain whole
494 pulses that are recognizable to consumers, unlike meatball substitutes, where pulses are

495 mashed and mixed with other ingredients. As a consequence, consumers may find it hard to
496 distinguish pulses in the product. In addition, even though we eliminated all claims and
497 brands, the packaging of the innovating ready-to-eat products used in our study contained
498 images of unprocessed products (versus cooked products in traditional recipes). The
499 participants in our study may have perceived the image of unprocessed pulses as more
500 natural. As shown by Devia et al. (2021), the images of natural food on the labels of ultra-
501 processed products can have a positive effect on consumer perception, creating a belief that
502 a product is healthful, and thus having a positive effect on purchasing intention. To
503 disentangle whether the negative image of traditional ready-to-eat pulse-based products was
504 related to packaging or only dependent on the recipe, the products presented in Study 2
505 were all traditional recipes.

506 For each type of pulses, the same recipe was presented under two packaging
507 formats: frozen products and canned products. We found that consumers had quite negative
508 mental representations about both groups of ready-to-eat products (canned and frozen),
509 which apply to the product itself (the recipe) and not the packaging format. Consumers also
510 have a positive mental representation of the two processed pulse-based products with the
511 same recipe, whether frozen or canned.

512

513 *4.4. How to overcome the barriers to consumption of pulses*

514

515 Beside being considered as natural, good for the health, and for the environment, the
516 unprocessed pulses in our study were also characterized as *difficult to prepare*. These
517 findings confirm the results of a previous study on raw pulses for non-vegetarian French
518 consumers, based on a questionnaire (Melendrez-Ruiz, et al., 2019). Participants
519 characterized pulses with little processing, presented in a metal can, as *cheap*, and *easy to*
520 *find*, which reflects the French market reality. Canned pulses and ready-to-eat pulse
521 products shared the perceived characteristic of being *easy to prepare*. Generally speaking,
522 we observed a dichotomy between unprocessed products that have a positive image but are
523 considered difficult to prepare, and ready-to-eat products that have a more negative image
524 but are considered easy to prepare. This could be one of the main barriers to pulse
525 consumption.

526 One of the levers to encourage pulse consumption could be to enhance the
527 attractiveness of traditional processed products, and increase the availability of frozen
528 products. Participants identified frozen pulse-based products with little processing as: *for*
529 *vegetarians*, and *I do buy it*. This result could indicate new interest in frozen products
530 among French consumers, even if the pulses mainly consumed in France are canned
531 (Champ et al., 2015).

532 New recipes for pulse-based ready-to-eat foods also seem to be an interesting
533 opportunity to increase pulse consumption. Products presented in the form of “meatballs”
534 were related in our study to attributes like: *chic*, *modern*, but also *expensive*. It seems that
535 these innovative products do not suffer from a negative image among French consumers.
536 This could be explained by their novelty on the market, which makes them more attractive
537 than traditional pulse-based products. Yet it is important to highlight that some of these
538 ready-to-eat products can be classified as ultra-processed (e.g., additives, excessive
539 processing, high fat, sugar, and salt content) which may be consumed in small quantities
540 and limited to a maximum of 15% of the daily calorie intake (Fardet, 2017, 2018b). The
541 same ready-to-eat product from two different brands may have two completely different
542 compositions. Some of these products contain a large list of ingredients and additives, and
543 would be classified as ultra-processed, while others only contain a small number of
544 ingredients and very few or no additives. Research and development should focus on
545 creating new pulse-based products, that are ready-to-eat, combining pulses with other
546 ingredients (mostly cereals), not containing any additives or artificial flavors, and with a
547 good nutritional profile.

548 Finally, supplementary studies will be necessary to investigate whether the level of
549 processing of a pulse product would influence real-life consumer food choices in a retail
550 environment. As shown in the current study, French participants may have positive and/or
551 negative mental representations about a pulse-based product because of its level of
552 processing, but this does not necessarily mean that this product would not be chosen when
553 consumers are in a real-life buying context. Successfully targeted communication about
554 pulse-based foods can be a key element to highlight the positive features of these products.

555 **5. Conclusions**

556 Our results show that the industrial processing that a food product undergoes will
557 affect consumers’ mental representations. The use of the Check-All-That-Apply (CATA)
558 tests showed that pulse-based products are distinguished according to their processing, and
559 not by the type of pulses they contain. Whether in unprocessed state, processed (canned and
560 frozen), or new ready-to-eat products, pulses had a positive image. By contrast, pulse
561 products classified as traditional ready-to-eat (canned or frozen) were associated with a
562 more negative image. The study also indicated that positive or negative representations,
563 beliefs, and attitudes are related to the pulse-based product itself rather than to its
564 packaging. Our study allowed us to identify a major barrier to the consumption of pulses in
565 France. Indeed, French people consider pulses as products that are difficult to cook, yet
566 have quite a negative attitude toward traditional ready-to-eat pulse-based products. Overall,
567 the results of the present study highlight some levers that could be used by the pulse supply
568 chain to increase pulse consumption. These levers are the development of new ready-to-eat
569 pulse-based products, combining nutritional quality with an innovative image.

570 Communication on their good-for-health properties would probably improve the perception
571 of such products. Enhancing the attractiveness of canned processed pulses and improving
572 the availability of processed frozen products in French supermarkets could also be a way to
573 increase pulse consumption.

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579

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