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1 Importance of additional information, as a complement to information coming from packaging, to
2 promote meat substitutes: A case study on a sausage based on vegetable proteins.

3

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14 Abstract:

15 Scientific literature has shown that a partial replacement of meat-based foods with plant-based
16 foods would be beneficial for public health and the environment. However, both lack of sensory
17 attractiveness and lack of consumer awareness regarding benefits of rebalancing diets in favor of
18 plant protein partially explain the low market shares for meat alternatives. In the context of a
19 possible substitution of a meat product (pork-based sausage) by a visually very close counterpart
20 based on vegetable proteins, the objective of this work was to study the possibility of changing
21 consumer preferences towards the plant-based product by gradually providing information
22 concerning the health or environmental consequences of consuming both types of products. We
23 studied consumers' preferences after a blind tasting, after a tasting in the presence of the packaging,
24 and after the dissemination of two stages of information. The assessment of consumer preferences
25 was carried out using purchase preferences (PP) and willingness to pay (WTP). After the blind
26 tasting, PP were clearly oriented towards the meat product. After the tasting with packaging
27 information, the gap between the two products narrowed, but PP were still turned towards the
28 meat product. The dissemination of a first informative message about either health or the
29 environment was not enough to modify consumers' WTP. Adding a second message concerning
30 health led to an equivalence of the two products studied in terms of WTP and PP. The combination
31 of the two environmentally informative messages also made it possible to obtain an equivalence of
32 the WTP for both products, but the PP were still turned towards the pork product. This suggests that
33 the impact of additional information depends on the information disseminated. Overall, these
34 results militate in favor of the dissemination of information presenting the consequences of the
35 consumption of meat-based or vegetable protein-based products.

36

37

38 Keywords: Willingness to pay; purchase preference; meat substitute; information; taste

39

40

41 **1. Introduction**

42 **The production of meat and animal-based products is associated with a significant negative impact**
43 **on the environment (Hedenus et al., 2014, MacDiarmid et al., 2016).** Indeed, greenhouse gas
44 emissions from the agriculture sector account for approximately 22% of global total emissions, and
45 livestock production accounts for nearly 80% of this specific sector's emissions (McMichael et al.
46 2007). Moreover, excessive consumption of red meat, particularly processed meat, is associated
47 with an increased risk of total mortality, cardiovascular disease, colorectal cancer and type 2
48 diabetes in both men and women (Micha et al., 2010, McAfee et al., 2010, Richi et al., 2015).

49 A partial replacement of meat-based foods with plant-based foods is of dual interest. On the one
50 hand, changing the diet of animal-based foods to plant-based foods would reduce greenhouse gas
51 emissions and could therefore be more environmentally sustainable (Heller et al, 2013, Tilman and
52 Clark, 2014, Auestad and Fulgoni, 2015, GBD 2017 Diet Collaborators, 2017). On the other hand,
53 moderation of consumption of red meat and meat products, except for a specific population such as
54 the elderly, would be beneficial in terms of public health (Ricci et al., 2015, Willet et al, 2019).

55 One way to reduce the consumption of meat-based foods is to replace them with plant-based
56 alternatives. This strategy has the advantage of not radically changing dietary habits. The meat is
57 simply replaced by a product that mimics the sensory properties of meat (Siegrist and Hartmann,
58 2019). However, there is a general unwillingness to reduce meat consumption or substitute meat for
59 other foods among the vast majority of consumers, at least in various European countries (Hartmann
60 & Siegrist, 2017). The main barriers to this substitution are product novelty, the lower sensory
61 attractiveness of the substitutes compared to meat, and price (Hoek et al., 2011, Schösler et al.,
62 2012, Weinrich and Elshiewy, 2019). In addition, many consumers are unaware of the environmental
63 impacts of meat consumption and of the beneficial consequences of an overall reduction in the
64 consumption of meat and meat products. (Austgulen et al., 2018, Lacroix et al., 2019). Indeed, one
65 of the main conclusions of Hartmann and Siegrist's systematic literature review (2017) is that
66 consumer awareness of the environmental impact of meat production is surprisingly low (European
67 countries). Habits and beliefs regarding the positive health effects of meat could also prevent some
68 consumers from transitioning to lower meat consumption (Hartmann and Siegrist, 2020).

69 The most effective way to promote the transition to meat substitutes is probably to improve their
70 sensory attractiveness (Hoek et al., 2011, Slade, 2018). The perception of taste and appearance are
71 indeed one of the main obstacles to the consumption of meat substitutes (Weinrich, 2019).
72 However, major efforts in terms of research and development have already been made to propose
73 substitutes as similar as possible to their meat counterparts. For example, wheat and pea are two

74 plant species that are widely consumed and whose proteins can be used to produce processed
75 products that mimic meat-based sausages. These products are already available to consumers, and it
76 may be possible to promote their consumption by providing information and increasing awareness
77 of health and environmental benefits.

78 The overall objective of this study was to show that, in the context of substitution between a meat-
79 based product (pork sausage) and a vegetable protein-based counterpart (plant-based sausage), an
80 information concerning the consequences on health or the environment could be useful for
81 promoting the plant-based products. More specifically, the objective was to study the preferences of
82 consumers for these two products, according to taste, taste and packaging, and finally after the
83 dissemination of informative messages concerning the consequences for health or the environment
84 linked to the production and consumption of these two types of products. This information would
85 make it possible to know whether the information carried by the packaging is sufficient to promote
86 the herbal product and whether additional information concerning health or the environment would
87 allow additional promotion. The conclusions of this study could provide leads concerning possible
88 levers of action to promote a rebalancing of the origin of proteins in diets. We believe that our
89 objective addresses current concerns regarding food, health and the environment. In a recent review
90 of the literature, Weinrich (2019) suggests that more studies should be carried out combining
91 information treatment, purchase motivations and the calculation of WTP for meat.

92

93 **2. Materials and methods**

94 **2.1. Method**

95 To achieve our objective, we have determined consumers' purchase preferences (PP) for both
96 sausages, first according to "taste" (blind tasting), then according to taste and packaging and finally
97 according to taste, packaging and a series of information about **nutritional or environmental**
98 **consequences of consuming foods based on animal or plant proteins.** The PP collected after a blind
99 **tasting made it possible to evaluate consumers' preferences according to taste.** Our hypothesis was
100 **that the PP collected for the meat product would be higher than plant-based substitute (hypothesis**
101 **1), as often the case.** The PP collected after a second tasting of the products in the presence of their
102 **packaging makes it possible to assess consumer preferences in a context close to real consumption**
103 **conditions, that is by knowing the information carried by the packaging (first level of information).**
104 **Our hypothesis was that the comparison of the information carried by the two packages would allow**
105 **a first rebalancing of preferences, in favor of the plant-based product (hypothesis 2).** Finally, the PP
106 **collected after a series of additional information was intended to estimate the potential effect of an**

107 increase in the level of information concerning certain advantages and disadvantages linked to the
108 production and consumption of the two types of product. Our hypothesis was that consumers (at
109 least part of them) would be sensitive to the information and that the additional information would
110 allow a second rebalancing of PP of the two products, in favor of the plant-based product
111 (hypothesis 3). Indeed, according to Weinrich (2019), providing information on the benefits of meat
112 substitutes can influence consumer acceptance. Weinrich (2019) also specified that positive
113 persuasion drivers involve, among other things, arguments on health and environment.

114 Additionally, on three occasions, we collected the consumers' willingness to pay (WTP) for both
115 sausages, first after tasting in the presence of the packaging (i), then after a first (ii) and second (iii)
116 message concerning certain advantages and disadvantages linked to the production and
117 consumption of the two types of product. WTP is another method of understanding consumer
118 preferences from an economic perspective. The bonuses or penalties awarded by consumers reflect
119 the relative importance given to the various pieces of information given in this study. In particular,
120 the difference between the WTP given after tasting with the packaging and the WTP given after the
121 first informative message allows us to know more about the importance that given by consumers for
122 the information disseminated in this first message. Similarly, the WTP collected after the second
123 message makes it possible to deduce the effect of a further reinforcement of the information. Our
124 hypothesis was that the results obtained with WTP would be consistent with the results obtained
125 with PP, that is, that the initial WTP (tasting in the presence of the packaging) would be higher for
126 the meat product, and that the informative messages would gradually rebalance the WTP for the
127 two products (hypothesis 4).

128 The validation of hypothesis 1 would make it possible to verify that we have placed ourselves in a
129 favorable case for this study, that is, in the case where a plant-based substitute is less appreciated
130 than the reference product at the meat base. The validation of the other hypotheses would make it
131 possible to demonstrate the usefulness of additional information, in addition to the information
132 carried by packaging, in rebalancing consumer preferences in favor of the meat-based substitute.
133 Similar approaches have been used in several previous works (Lange et al. 2002, Combris et al.,
134 2006, Roosen et al., 2007, Ginon et al., 2009, Teuber et al., 2016) on different products (Champagne,
135 fish and bread), to study the impact of different information provided to consumers (brand, omega-3
136 fatty acids, methylmercury, bio, fiber and anthocyanins).

137 2.2. Experimental conditions

138 The experiment was conducted in March 2019 in a tasting room at the INRAE (National Research
139 Institute for Agriculture, Food and Environment, center of Dijon, France) that could accommodate 16

140 people simultaneously. Each participant was seated in an individual cabin equipped with data
141 collection software. All participants received an informative note describing the conditions for
142 participation in the study and signed a consent form. Each participant received 10 € indemnity for
143 his or her participation in a session lasting approximately 1 hour.

144 2.3. Participants

145 A sample of 122 regular consumers of pork (including occasional consumers) living in the
146 agglomeration of Dijon (France) was selected for this experiment. The statistics presented below
147 were based on the 102 participants for whom we obtained complete data. For the purposes of the
148 study, these 102 subjects were randomly divided into two groups. The Health group (n = 52)
149 received information regarding the health benefits of partially substituting meat-based foods for
150 plant-based foods. The Environment group (n = 50) received information regarding the
151 environmental interest of such a substitution (see paragraph 2.7). To simplify the text, we named
152 these two groups “Health group” and “Environment group”, even if the additional information given
153 in the form of messages referred only to some consequences for health¹ and the environment²
154 linked to the production and consumption of the products studied in this work (the exact content of
155 the messages is presented in paragraph 2.7).

156 Table 1 shows that the characteristics (sex, age, and level of education) of the panel and the two
157 groups were close to those observed for the French population in terms of age group, sex, incomes,
158 and level of education. The two groups were not different regarding these three criteria (age group:
159 $\chi^2(2, N = 102) = 0.08, p = .97$; sex: $\chi^2(1, N = 102) = 0.16, p = .69$, level of education: $\chi^2(3, N = 102) =$
160 $0.87, p = .83$). Moreover, a questionnaire completed at the end of the study made it possible to
161 characterize the consumption habits of the subjects and their knowledge about meat substitutes
162 based on vegetable proteins. Comparison of the two groups revealed that the subjects in the Health
163 group were more aware of the difference in composition between the two products ($\chi^2(1, N = 102)$
164 $= 27.69, p < .0001$), more aware of the benefit of balancing the sources of proteins ($\chi^2(1, N = 102) =$
165 $7.12, p = .01$), and slightly more buyers of meat substitutes based on vegetable proteins ($\chi^2(1, N =$
166 $102) = 5.54, p = .04$). On the other hand, the two groups did not differ on the other characteristics
167 (supplementary data, Table S1).

168

169 2.4. Products

¹ Balance of protein origin, fat, fatty acid and fiber intake

² Production of greenhouse gases, pollution, mobilization of cultivable areas

170 Two sausages belonging to the Herta brand were selected for this study: “Knacki Original” (pork) and
171 “Knacki Végétale” (plant-based). The pork sausage (original recipe) of this brand is very popular, with
172 a market share of 56% for the French market. The plant-based sausage, introduced in January 2018,
173 has been the subject of a long process of research and development to obtain a product close to the
174 original recipe in terms of **appearance**, taste and texture. Despite a similar appearance, the plant-
175 based sausage differs from the original pork recipe because of the nature of the raw materials (pork
176 versus wheat and peas) and their nutrient content. The plant-based product has a fat content of 19%
177 (23% for the pork product) and a protein level of 16% (12% for the pork product). The price of the
178 package of four plant-based sausages was higher than that of the package of four pork sausages
179 (average prices observed in Dijon, **France**: 1.50 € versus 1.00 €, respectively). However, the exact
180 prices and the price differences between the two variants varied slightly according to the point of
181 sale.

182 The packaging of both products was available to the subjects during several stages of the
183 experiment. The information on the packaging was as follows (both products): brand and name of
184 products, list of ingredients and nutritional information, advice on the preparation and preservation
185 of products, **how to recycle the packaging after use, and** other legal information (consumer service,
186 traceability elements, etc.). Several pieces of information were specific to one or more of the
187 products. The labels “100% pure pork” and “smoking on beech wood” were displayed on the front of
188 the pork sausage packaging. The back of this packaging also included “a quality meat, 100% pure
189 pork, without artificial colors, without polyphosphates, without plasma and without acidifier” and a
190 logo reading “taste and quality”. The front of the plant-based sausage packaging mentioned
191 “Végétale” (plant-based), “Wheat, egg, pea”, and “Smoked vegetarian based on wheat, egg, and
192 pea”. There was also a “vegetarian” logo (European vegetarian union). The back of the packaging of
193 this product included the slogan “the plant as we like it” and a logo in the shape of ears of wheat.

194 2.5. Timeline of the experiment

195 The sessions began with general information about the experiment. The participants were informed
196 that they would have to taste two samples of sausage (1/2 sausage per sample) three times and that
197 they should give their preference and their WTP for two sausages. The exact nature of the products
198 was not revealed at this stage. We insisted on the fact that no product would be sold or given at the
199 end of the experiment. The reason given was that we could not fully guarantee the chilling of
200 products from the lab to the participants’ refrigerators. We also insisted on the fact that all replies
201 were anonymous and that there were no “good” or “bad” replies but the possibility to freely

202 indicate choices reflecting their preferences. After the subjects signed a consent form, the
203 experiment began.

204 The experiment consisted of five stages (Figure 1). The first stage (Time-1) consisted of a blind
205 tasting of both products, followed by the PP. In the second stage (Time-2), the subjects first received
206 a package of each of the two sausages. The participants had a few minutes to observe them. Then,
207 the corresponding samples were brought for tasting. The correspondence between the packages
208 and the samples was ensured by coding the packages and samples with the same letter. After
209 tasting, the participants gave their PP for one or the other sausage. Then, they filled in the price
210 tables to give their WTP for the two sausages (one table per sausage). In the third stage (Time-3),
211 participants received the first informative message **on the environmental (Environment group) or**
212 **health consequences (Health group) linked to the production and consumption of the two types of**
213 **products** (paragraph 2.7). After being exposed to the information, the participants gave their WTP. In
214 the fourth stage (Time-4), participants received a second informative message, **reinforcing the first.**
215 After being exposed to the information, the participants gave their WTP one last time. Finally, in the
216 last stage of the experiment (Time-5), the participants gave their PP after having tasted the two
217 products one last time.

218 2.6. Purchase preference (PP)

219 **This measure indirectly assesses preferences by asking consumers which product they would be**
220 **most likely to buy. On three occasions (Figure 1),** participants had to give their PP for one or the
221 other sausage after having tasted them. To do so, they had to answer the following question:
222 "Imagine that you are in a purchase situation: after tasting both sausages, which one would you
223 purchase?" The participants gave their answer by making a mark on a continuous scale ranging from
224 "sausage A, without hesitation" (left bound) to "sausage B, without hesitation" (right bound).
225 Sausage A was always the pork sausage, and sausage B was always the plant-based sausage. The
226 label "one or the other, indifferently" was placed in the middle of the scale, reflecting an equivalent
227 preference for both sausages. The labels "sausage A, probably" and "sausage B, probably" were
228 positioned at 25 and 75% of the scale, respectively (Figure 2). It was possible for the subjects to click
229 anywhere on the scale. Participants also had the option of ticking a box "neither of them" to indicate
230 that they would not buy either of the two sausages. In this case, they should not make a mark on the
231 scale.

232 2.7. Willingness to pay (WTP)

233 **This measure indirectly assesses preferences from an economic point of view (economic value given**
234 **to products based on available information).** On three occasions (Figure 1), participants had to give

235 their WTP for each product. A multiple-price list was used for this purpose. Participants were asked
236 to choose whether they would **purchase** the product for prices varying from 0.40 to 2.10 € (Figure 3).
237 The average observed prices in Dijon were equal to 1.00 € for pork sausage and equal to 1.50 € for
238 plant-based sausage. The multiple price list was characterized by increments of 10 cents, with 6
239 prices lower than 1.00 € and 6 prices higher than 1.50 €.

240 2.8. Informative messages (health and environment)

241 **Information on the health and environmental consequences linked to the consumption of the two**
242 **types of products was given in two stages, resulting in two WTP measurements. The information was**
243 **given in two stages to study two levels of information. In fact, we do not know a priori the number of**
244 **pieces of information necessary to observe an impact on consumers' preferences.** The informative
245 messages were on a paper document given to the participants and were also read aloud by the
246 experimenter. The messages were written after studying articles coming from the nutrition,
247 agronomic and environmental fields.

248 Health group

249 Additional information n°1: "Plant-based sausage is made from wheat and peas. From a nutritional
250 point of view, it is advisable to combine the consumption of legumes, such as peas, with cereals,
251 such as wheat, for a complete supply of essential amino acids and equivalence to meat. The
252 consumption of more plant-derived proteins, e.g., from wheat and peas, and less animal protein
253 contribute to a recommended rebalancing of the diet."

254 Additional information n°2: "The combination of pea and wheat in plant-based sausage explains the
255 following composition differences compared to the pork sausage (original sausage). For the same
256 quantities, the plant-based sausage contains 18% less fat and 75% less saturated fat compared to
257 the pork sausage. In addition, it contains 8% more fiber. The decrease in fat and the increase in fiber
258 contribute to a rebalancing of the recommended diet."

259 Environment group

260 Additional information n°1: "The production of pork sausage leads to the emission of much more
261 greenhouse gases than the production of plant-based sausage. Nitrate pollution of groundwater and
262 surface water is higher in pig farming than in cereal production areas."

263 Additional information n°2: "To produce 1 kg of animal protein, the animal must be supplied with
264 approximately 4.9 kg of vegetable protein. The production of food for pigs utilizes large areas of
265 cultivated land. Direct consumption of vegetable proteins, such as plant-based sausages, would save
266 large areas of cropland and significantly reduce the use of pesticides and chemical fertilizers."

267 3. Data analysis

268 3.1. Data preparation

269 Missing data: Of the 122 initial participants, 20 were not considered for further analysis due to
270 missing data (WTP and/or PP). We finally had a dataset including 102 participants.

271 PP (Figure 2): the mark on the scale gives a score ranging from -10 (high preference for sausage A) to
272 +10 (high preference for sausage B). A score of zero indicates an equivalent preference for both
273 products. These scores were used without transformation.

274 WTP (figure 3): For each product, the WTP was determined by taking the highest price linked to a
275 choice "yes". If the boxes "no" or "maybe" were ticked for all lines, the WTP was fixed to 0.40 € (the
276 lowest value proposed). If for all lines the boxes "yes" were ticked, the WTP was fixed to 2.10 € (the
277 highest proposed value). For respondents switching twice at low and high prices, the highest price
278 corresponding to a "yes" was recorded as the WTP for the analysis.

279 3.2. Analyses

280 *Purchase preferences (PP) according to taste*

281 A t-test for one sample was carried out to determine whether the PP after blind tasting (scores
282 ranging from -10 to +10) were oriented towards one or the other of the two products studied
283 (comparison to a theoretical mean equal to zero). A PP score significantly less than zero would
284 validate hypothesis 1.

285 *Effect of packaging on purchase preferences (PP)*

286 A repeated measures ANOVA using restricted maximum likelihood (REML) (model: PP score ~
287 subject, time) followed by a post hoc test (Tukey HSD, threshold set at 5%) made it possible to
288 compare the PP obtained after blind tasting and after tasting with the packaging. The ANOVA was
289 set up as follows: the fixed effect was "time", the repeated factor was "time", and the subject factor
290 was "subject". A t-test for one sample was carried out to determine whether the PP after tasting
291 with packaging were oriented towards one or the other of the two products studied (comparison to
292 a theoretical mean equal to zero).

293 The differences observed between the two PPs (times 1 & 2, Figure 1) would be attributable to the
294 effect of the information carried by the packaging. A significant increase in PP scores following
295 tasting with the packaging would validate hypothesis 2.

296 *Effect of additional information on purchase preferences (PP)*

297 A repeated measures ANOVA using restricted maximum likelihood (REML) (model: PP score ~
298 subject, group, time, time*group) followed by a post hoc test (Tukey HSD, threshold set at 5%) made
299 it possible to compare the PP obtained after tasting with packaging and after the series of two
300 messages. The ANOVA was set up as follows: the fixed effects were “time”, “group” and
301 “time*group”, the repeated factor was “time”, and the subject factor was “subject”. A t-test for one
302 sample was carried out to determine whether the PP after tasting with packaging were oriented
303 towards one or the other of the two products studied (comparison to a theoretical mean equal to
304 zero).

305 For each group of subjects, the differences observed between the PP obtained after tasting with
306 packaging and after the series of two messages would be attributable to the cumulative effect of
307 both messages. For each group of subjects, a significant increase in PP following the two messages
308 would validate hypothesis 3.

309 *Effect of additional information on willingness to pay (WTP)*

310 For each product, a repeated measures ANOVA using restricted maximum likelihood (REML) (model:
311 WTP ~ subject, group, time, time*group) followed by a post-hoc test (Tukey HSD, threshold set at
312 5%) made it possible to compare the WTP obtained after tasting with packaging, after the first
313 informative message, and after the second informative message. The ANOVA was set up as follows:
314 the fixed effects were “time”, “group” and “time*group”, the repeated factor was “time”, and the
315 subject factor was “subject”. Finally, a series of t-tests (paired samples) was carried out in order to
316 conclude as to the equivalence or the difference in WTP between the two products, for each of the
317 stages and each of the two groups of subjects.

318 For each group of subjects, the difference observed between the average WTP after tasting with
319 packaging and after the first message was attributed to the effect of the first informative message.
320 In the same way, the difference observed between the average WTP after tasting with packaging
321 and after the second message was attributed to the cumulative effect of both informative messages.
322 An increase in WTP attributed to the plant-based product and/or a decrease in WTP attributed to
323 the meat-based product would validate hypothesis 4. A decrease in the differences between the
324 WTP obtained for the two products after dissemination of the informative messages would also
325 validate hypothesis 4.

326

327 **4. Results**

328 4.1. Consumer purchase preferences (PP) related to sensory characteristics

329 The PP collected after blind tasting made it possible to study consumers' preferences with regard to
330 the two sausages based on their sensory characteristics. The results show that consumers'
331 preferences were clearly turned to meat sausage (hypothesis 1). The preference score was -6.2 on a
332 scale from -10 (high preference for meat sausage) to +10 (high preference for vegetable protein
333 sausage). This value is significantly lower than 0 ($t(101) = -13.6, p < .001$).

334 4.2. Effect of packaging on purchase preferences (PP)

335 The PP assigned after blind tasting and after tasting with packaging made it possible to study the
336 effect of information carried by the packaging. The results of the ANOVA show that PP assigned
337 during the two stages were significantly different (time factor: $F(1,101) = 15.6, p = .0001$). Figure 4a
338 shows the average PP scores obtained after blind tasting (-6.2) and after tasting with packaging (-4.3)
339 and the result of the multiple comparison test. The information included on the packaging
340 influenced the PP towards a reevaluation of the plant-based product (hypothesis 2). The PP score
341 after tasting with the packaging, although higher than after blind tasting, remains significantly below
342 zero ($t(101) = -7.76, p < .001$), meaning that the pork product remained significantly preferred.

343 4.3. Effect of additional information on purchase preferences (PP)

344 The PP assigned after tasting with packaging and after the informative messages made it possible to
345 study the effect of information carried by the packaging. The ANOVA shows that, overall, after the
346 two informative messages, the PP were significantly different from the PP obtained after tasting
347 with the packaging (time factor: $F(1, 104) = 34.3, p < .0001$). In addition, belonging to one or the
348 other of the two groups of subjects, therefore the fact of having received information about health
349 or environmental concerns, seems to have had no influence (group factor: $F(1, 104) = 2.3, p = .13$).
350 However, this conclusion must be moderated because the time*group interaction was slightly
351 significant (time*group interaction: $F(1, 104) = 5.5, p = .021$), suggesting that the magnitude of the
352 effect of informative messages was slightly different from one group of subjects to another. Figure
353 4b shows the average PP scores obtained after tasting with packaging (Health group: -3.9;
354 Environment group: -4.7) and after informative messages (Health group: -0.9; Environment group: -
355 3.4) and the results of the multiple comparison test. The results of the multiple comparison test of
356 means confirm the time*group interaction. For the Health group, after the informative messages,
357 the PP scores are significantly higher than after the tasting with the packaging ($p = .001$) (hypothesis
358 3). For the Environment group, although the value of the PP score obtained after the additional
359 information was higher than after tasting with packaging, the difference was not significant
360 according to the Tukey's test ($p = .31$). For Environment group, the PP score after informative
361 messages remained significantly below zero ($t(49) = -4.1, p = .0002$), meaning that the pork product,

362 remained significantly preferred. On the other hand, for the Health group, the PP obtained after the
363 informative messages were not significantly different from zero ($t(51) = -0.99, p = .33$), meaning that
364 the PP for the two products were equivalent.

365

366 4.4. Effect of informative messages on willingness to pay (WTP)

367 The WTP given after tasting with packaging, after the first information, and after the second
368 informative message made it possible to study the effect of the first informative message and the
369 cumulative effect of the two informative messages.

370 *WTP to pay for the pork product*

371 The results of the ANOVA performed show that, overall, the WTP for the pork product depends on
372 the different steps of the protocol (time factor: $F(2, 208) = 13.6, p < .001$). Moreover, WTP was
373 globally equivalent from one group to another (group factor: $F(1, 104) = 2.07, p = .15$), and the
374 group*time interaction was not significant ($F(2, 208) = 2.38, p = .10$). Thus, overall, having received
375 information about health or environmental concerns seems to have had no influence. However, this
376 conclusion should be moderate since the p value associated with the group factor is relatively close
377 to the threshold. In addition, the post hoc multiple comparison tests of means show some
378 differences between the two groups. Figure 5a shows the average WTP obtained for the pork
379 sausage after tasting with packaging (Health group: 1.25 €; Environment group: 1.47 €), after the
380 first message (Health group: 1.25 €; Environment group: 1.31 €), and after the second message
381 (Health group: 1.12 €; Environment group: 1.19 €), and the results of the multiple comparison test.

382 The first message about health did not cause any change regarding the WTP for the pork product (p
383 = 1.00), and the averages were even strictly identical. The second message about health caused a
384 decrease in WTP but the difference with WTP after tasting with the packaging was still not significant
385 ($p = .54$). Therefore, for the Health group, the cumulative effect of the two messages was not
386 sufficient to cause a significant decrease in WTP.

387 The first message about the environment caused a first decrease in the WTP for the pork product,
388 but, the difference with the WTP obtained after tasting with packaging was not significant ($p = .37$).
389 However, the cumulative effect of both messages about environment caused a further decrease in
390 WTP for pork sausage and, this time, the difference with the WTP obtained during the tasting with
391 the packaging was significant ($p = .01$). Therefore, for the Environment group, the cumulative effect
392 of the two messages was sufficient to cause a significant decrease in WTP.

393 *WTP for plant-based product*

394 The results of the ANOVA performed show that, overall, the WTP for the plant-based product
395 depended on the different steps of the protocol (time factor: $F(2, 208) = 28.4, p < .001$). Moreover,
396 WTP was globally equivalent from one group to another (Group factor: $F(1, 104) = .17, p = .69$), and
397 the Group*Time interaction was not significant ($F(2, 208) = .21, p = .81$). Thus, the fact of having
398 received information about health or environmental concerns had no influence. Figure 5b show the
399 average WTP for the plant-based sausage, after tasting with packaging (Health group: 0.94 €;
400 Environment group: 0.91 €), after the first message (Health group: 1.08 €; Environment group: 1.02
401 €), and after the second message (Health group: 1.14 €; Environment group: 1.09 €), and the results
402 of the multiple comparison test.

403 For both groups, the first message about the environment caused a first increase in WTP for the
404 plant-based sausage, but the difference with the WTP obtained after tasting with the packaging was
405 not significant (Health group: $p = .08$; Environment group: $p = .31$). However, for the two groups, the
406 WTP after the second message was significantly higher than during the tasting with packaging
407 (Health group: $p = .002$; Environment group: $p = .01$). Therefore, for both groups, the cumulative
408 effect of the two messages caused a significant increase in WTP.

409 *Difference between the WTP of the two products*

410 The comparison of the WTP obtained during the different stages made it possible to study the
411 differences between the two products under the different information conditions. After tasting with
412 packaging, the WTP of the two products were significantly different (delta: +0.43 euro for the meat
413 product, $t(101) = 6.41, p < .001$). After the first and second health informative messages, the WTP of
414 the two products were not significantly different (first message: delta: +0.17 euro for the meat
415 product, $t(51) = 1.69, p = .10$; second message: delta: +0.02 euro for the plant-based product, $t(51) = -$
416 $0.19, p = .85$). After the first environmentally informative message, the WTP of the two products
417 were still different (delta: +0.30 euro for the meat product, $t(49) = 2.85, p = .006$). On the other
418 hand, after the second message concerning the environment, the WTP of the two products were not
419 different (delta: +0.10 euro for the meat product, $t(49) = 0.81, p = .42$).

420 In summary, for the two groups, the WTP after tasting with the packaging was significantly in favor
421 of pork-based sausage and the combined effect of the two messages made it possible to achieve an
422 equivalence between the WTP assigned to the two products (hypothesis 4).

423 **5. Discussion**

424

425 *Purchase preferences (PP) according to sensory characteristics*

426 Food choices and preferences result from a complex process involving many factors, including
427 sensory characteristics. This is why the first step of this work was to measure blind PP, i.e., only by
428 the appearance, texture, and flavors of both products. The analysis of PP based on blind tasting
429 indicates that consumer preferences remain focused on the pork product. **This result validates our**
430 **first hypothesis (hypothesis 1), namely, that the vegetable protein substitute is less appreciated. The**
431 **choice concerning the products of this study was therefore relevant, especially since the difference**
432 **between the two products, according to taste, is important. This situation was therefore ideal to see**
433 **to what extent information could revalue the vegetable protein product or at least reduce the gap**
434 **between the meat product and its vegetable counterpart.** Although no descriptive task was
435 conducted during this experimentation, we can suppose that the sensory characteristics of the plant-
436 based product are slightly atypical compared to the pork sausages currently available on the market.
437 It is difficult to compare these results with the existing literature because the products studied and
438 the methods for estimating the appreciation are rarely the same from one study to another.
439 However, some studies have focused on the evaluation of meat and meat substitutes by consumers
440 and have shown that meat substitutes lagged behind in the overall evaluation and in particular in
441 sensory appreciation (McIlveen et al., 1999).

442 *Influence of the packaging information on purchase preferences (PP)*

443 Food choices and preferences are also guided by non-sensory characteristics, such as information
444 included in packaging. In this experiment, the effect of the information included on the packaging of
445 the two studied products could be evaluated by comparing the PP given after tasting with and
446 without packaging information. Specifically, the revelation of the packaging information has allowed
447 consumers to know, or perhaps for some of them to confirm, that one of the two sausages was
448 made from vegetable ingredients. The effect of the information on both packages resulted in a
449 significant increase in PP for the plant-based product, but it did not reverse preferences. Indeed, the
450 PP collected after tasting with packaging information remained clearly focused on the pork sausage.
451 **This result validates our second hypothesis (hypothesis 2), namely, that the packaging allows a slight**
452 **revaluation of the product based on vegetable proteins. However, this effect is not enough to**
453 **reverse consumers' preferences. This suggests that the information on the packaging of these**
454 **sausages is not sufficient to encourage consumers to consume the plant version rather than the**
455 **animal version.**

456 **The differences between the PP given after the blind tasting and after the tasting with packaging**
457 **information reflect the consumer interest in the non-sensory properties of the two products,**
458 **specifically that of the plant-based product.** The novelty of the product and/or the nutritional claims

459 on the packaging of the plant-based sausage may explain the increase in preference observed for
460 this product. It can also be envisaged that the revelation of the true nature of the plant-based
461 sausage clearly differentiated this product from the meat product universe, thereby changing the
462 way in which the consumer compared the two products and causing a positive shift in consumer
463 perception. Indeed, the atypical sensory characteristics of the plant-based sausage may be more
464 easily accepted when it is clearly identified as a plant product. In addition, faced with current
465 technological constraints to mimic a meat-like taste and texture, some authors propose to develop
466 radically new meat substitutes, the so-called novel protein foods, which are not necessarily meat-
467 like (Hoek et al., 2011). A recent work by Lemken et al. (2019) has shown that some German and
468 New Zealand consumers would accept processed pulses if the products were not marketed as an
469 alternative to meat. Another consumer group would prefer to replace meat directly with specific
470 legumes rather than having highly processed products.

471 *Influence of additional information*

472 The information provided on the packaging of the plant-based product informs consumers about the
473 ingredients used and their nutritional value. However, the level of knowledge of consumers
474 regarding the impact on the health of a rebalancing of diets in favor of vegetable proteins is very
475 variable. Moreover, the packaging of the plant-based sausage also displays a Vegetarian logo whose
476 meaning and scope may vary from one consumer to another. Therefore, this experiment consisted
477 of two consecutive information phases designed to study the reactions of the panelists to
478 information concerning **certain consequences for health and the environment linked to the**
479 **production and consumption of these two types of products. We hypothesized that additional**
480 **information (in addition to the information written on the packaging) about the health and**
481 **environmental benefits of rebalancing diets in favor of plant protein could add value to the plant-**
482 **based sausage and that this added value would result in an increase in the PP (hypothesis 3) and**
483 **WTP (hypothesis 4) for the planted-based product (or at least a reduction in the differences**
484 **observed between the two products).**

485 **Our results validate our hypotheses (3 & 4). In fact, the WTP for the plant-based product was**
486 **significantly higher after the two informative messages. This result is valid for both groups. The**
487 **results obtained also show an evolution in PP in favor of the vegetable protein product, but this**
488 **increase is significant only for the group having received health-related information. The conclusions**
489 **obtained with the two methods therefore differ slightly.** Both approaches make it possible to study
490 the impact of informative messages on the overall assessment of the two products studied.
491 However, they do not measure exactly the same thing. The WTP reflects an overall appreciation of

492 each of the two products, while the PP are more likely to directly demonstrate a preference for
493 either of the two products. It is not necessarily surprising that the results differ slightly. Despite
494 these differences concerning one of the two groups, we can consider that the results are in general
495 agreement. The differences between the two groups concerning the cumulative effect of the two
496 informative messages on PP could be explained by a group effect. Indeed, the questionnaire
497 completed at the end of the study made it possible to show that consumers of the Health group
498 were initially more aware of the differences in composition between the two products studied, more
499 aware of the importance of the balance of protein sources and more buyers of vegetable protein-
500 based meat substitutes. Their knowledge of the Health group about plant-based products was
501 therefore greater than that of the Environment group, which perhaps explains their greater
502 receptivity or acceptance of the information disseminated. It is also conceivable that health
503 information has had more impact than environmental information. The consequences for health are
504 perhaps perceived as being more direct for consumers (and therefore more impactful) than the
505 consequences for the environment. As the composition of the two groups varied on the three
506 characteristics mentioned above and the information disseminated varied from one group to
507 another, it is difficult to conclude definitively on the origin of the differences observed between both
508 Health and Environment groups.

509 We also showed that, overall, it was necessary to combine two informative messages to observe a
510 change in consumer preferences. Indeed, the increase in WTP and PP following the first message
511 (environmental or health-related information) was not significant. This result suggests that the
512 subjects involved in the study were not convinced by the information constituting the first message
513 (health and environment) and therefore that they did not respond mechanically in the direction of
514 the information given. On the other hand, they were convinced by the combination of the two
515 messages. This suggests that the effectiveness of additional information depends on the nature of
516 the information and/or the amount of information disseminated. As part of a communication
517 campaign, it would therefore be necessary to test beforehand the impact of the information
518 disseminated on consumers.

519 It is important to emphasize that after the distribution of the two informative messages, the WTP of
520 the two products were equivalent (for the two groups) and that the PP of the Health group was not
521 significantly different from zero. This is an encouraging sign because it shows that the type of
522 messages used in this study makes it possible to obtain equality of products in terms of consumer
523 preferences, whereas the meat product was preferred according to blind tasting and after tasting
524 with packaging. This suggests that the establishment of consumer preferences results from a trade-
525 off between the intrinsic and extrinsic characteristics of products and that the information provided

526 by the packaging is not sufficient to encourage consumers to orient themselves towards plant
527 variants. Even if the diffusion of scientific information is often slow and imperfect in real contexts,
528 this work underlined an important sensitivity of the participants, indicating potential evolutions and
529 suggesting future possibilities of substitution between the two types of products. This means that in
530 the long term, information campaigns could significantly influence preferences for plant-based
531 products and change consumption habits. However, the most suitable mode of communication and
532 the exact nature of the information to be disseminated remain to be determined. The information
533 must be understandable by all and, if possible, not be added to the numerous information written
534 on the packaging.

535 *Limitations of the study*

536 This study has several limitations. First, the choices made by consumers did not involve actual
537 purchases. This limit is valid for most experiments involving hypothetical choices. The health risks
538 linked to the transport of products from the laboratory to the home of the panelists have indeed led
539 us to limit the protocol to hypothetical choices. On the other hand, we cannot exclude the possibility
540 of social desirability bias. In a systematic review of recent literature, Cerri et al. (2019) point out that
541 social desirability is one of the causes of common method biases social desirability bias in research
542 using self-reported measures, including research on consumer responses to more sustainable foods.
543 However, consumers were clearly informed at the start of the session that all responses were
544 anonymous. We also insisted on the absence of good or bad replies and on the fact that participants
545 had to try to answer as if they were buying from a supermarket. In addition, the panelists were
546 installed in cabins, isolating the other participants and preserving their privacy. They could therefore
547 express themselves freely by giving their answers. Anonymous data collection is considered by Cerri
548 et al. (2019) as a possible procedural remedy to limit the bias of social desirability. To go further, we
549 could have measured the need for social approval of each panelist and used this measure as a
550 variable characterizing the panelists. The fact that the study relates to a single exposure is another
551 limitation of this work. Even if the results obtained supplement current knowledge, it would be
552 interesting to carry out a complementary study involving repeated measurements. Such measures
553 are also recommended by Weinrich (2019). It is possible that over time and repeated exposures,
554 preferences for plant-based sausage may increase. A study by Hoeck et al. (2013) has shown that the
555 preferences of a group of consumers exposed twice a week over a period of 10 weeks to dishes
556 containing meat or meat substitutes evolve gradually. Initially, the meat products were considered
557 tastier, but as the exposures progressed, the differences between the meat and plant-based product
558 diminished until they were no longer significant.

559

560 6. Conclusion

561

562 This case study based on a meat-based sausage and a vegetable protein-based counterpart shows
563 that the information carried by the packaging makes it possible, to a certain extent, to orient
564 consumers' PP towards plant-based sausage. However, consumers' preferences (PP and WTP) after
565 tasting in the presence of the packaging remain focused on the meat-based product. We have
566 shown that additional information, in addition to that carried by the packaging, relating to health or
567 the environment would make it possible to promote the plant-based even more. We have shown
568 that the dissemination of a first informative message concerning health or the environment was not
569 enough to modify consumers' WTP. However, the combination of the two informative messages
570 concerning the health consequences linked to the consumption of the two types of product made it
571 possible to modify consumer preferences in favor of the plant-based product. These two messages
572 made it possible to obtain an equivalence of the two products studied in terms of PP and WTP. The
573 combination of the two environmentally informative messages also made it possible to obtain an
574 equivalence of the two products studied in terms of WTP. On the other hand, the PP after these
575 informative messages were not different from that expressed after the tasting with the packaging
576 and still turned towards the pork product. This suggests that the impact of additional information
577 depends on the information disseminated in the messages. It is also possible that the initial level of
578 knowledge of the subjects has an influence on the receptiveness to the information disseminated. As
579 part of a communication campaign, it would therefore be advisable to test the effectiveness of the
580 information used before disseminating it on a large scale. Overall, these results militate in favor of
581 the dissemination of information presenting the consequences of the consumption of meat-based or
582 vegetable protein-based products. The appropriate medium to disseminate this information remains
583 to be determined.

584

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591

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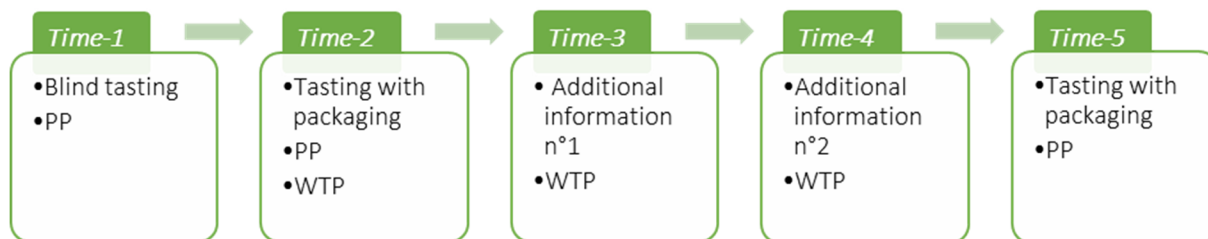


Figure 1: Timeline of the experiment. Both sausages were tasted at Time-1, Time-2, and Time-5. Purchase preferences (PP) were collected at Time-1, Time-2, and Time-5. Willingness to pay (WTP) were collected at Time-2, Time-3, and Time-4.

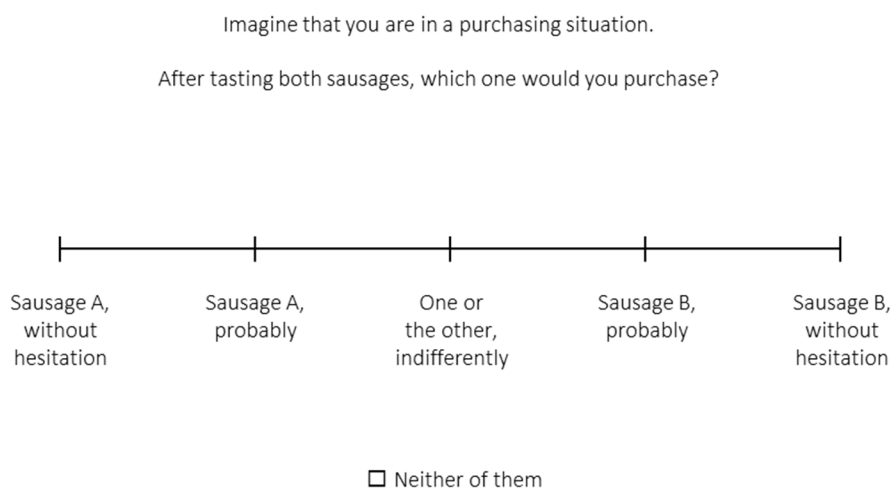


Figure 2: Scale used for measuring purchase preference (PP). Sausage A was always the pork sausage, and sausage B was always the plant-based sausage.

Would you purchase "sausage A at the following prices?

For each line, check off either "yes", "no", or "maybe".

Price	Yes	No	Maybe
0,40 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0,50 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0,60 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0,70€	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0,80 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0.90€	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.00 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.10 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.20 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.30 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.40 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.50 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.60€	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.70 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.80 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.90 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.00 €	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 3: Multiple-price list used for measuring willingness to pay (WTP) for each product

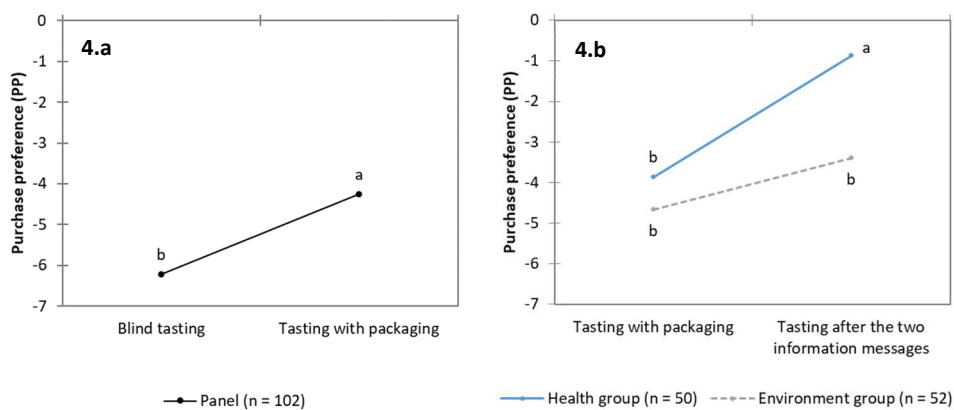


Figure 4: Effect of packaging information (4.a) and cumulative effect of both information messages (4.b) on purchase preferences (PP). PP scores ranged from -10 (pork product preferred) to 10 (plant-based product preferred). Zero indicates an equivalent preference for both products. For each graph, dots with different letters correspond to significantly different averages (Tukey's HSD test, $p < 0.05$).

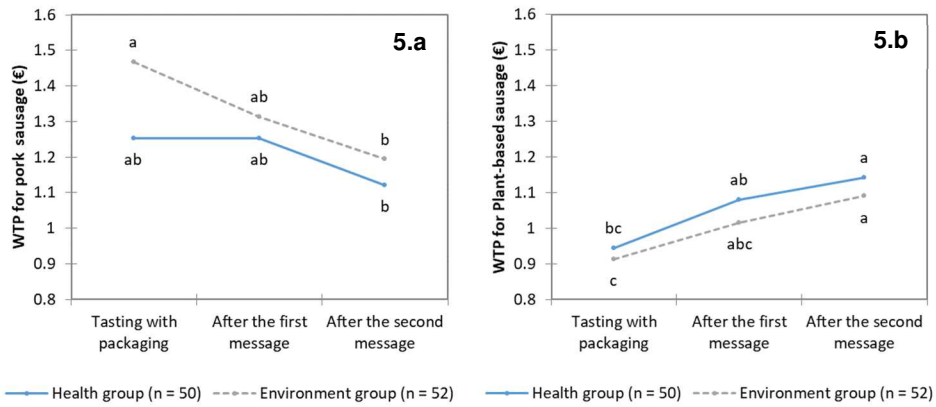


Figure 5: Cumulative effect of information messages on willingness to pay (WTP) for the pork (5.a) and plant-based products (5.b). Dots with different letters correspond to significantly different averages (Tukey's HSD test, $p < 0.05$). Multiple comparison of means concerns the six points of each graph (one analysis)

Table 1: Panel, sociodemographic characteristics

		Health (n = 50)	Environment (n = 52)	All (n = 102)	French population ¹
Sex	Women (%)	48.1	54.0	51.0	51.6
	Men (%)	51.9	46.0	49.0	48.4
Age (year)	20-39 (%)	34.6	32.0	33.3	31.2
	40-59 (%)	32.7	30.0	31.4	34.4
	60 and over (%)	32.7	38.0	35.3	34.4
Level of education	< Baccaulaureate ² (%)	19.2	24.0	21.6	28.4
	Bac and bac + 2 (%)	40.4	44.0	42.2	40.3
	Higher than bac + 2 (%)	40.4	32.0	36.2	31.3

¹ 2018 figures, INSEE (National Institute of Statistics and Economic Studies)

² Baccaulaureate (bac): French high school diploma