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1 **Horsemeat consumption in France: determinants and sustainable**
2 **market perspectives**

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22 Abstract:

23 In France, the horsemeat market has been declining for about 50 years and has become a specialized
24 market. Our study aims to understand this decline with regard to the drivers and practices of consumers
25 and non-consumers of this meat, in order to estimate the potential for this market development. To study
26 horsemeat consumption, we analyze two sets of data: two large-scale surveys carried out on the French
27 general population, and one ad-hoc survey focusing more specifically on the representations of horses
28 and horsemeat. Our results underline the potential for increasing horsemeat consumption from a
29 sustainability perspective. The question of moral acceptance remains a determining factor in the
30 consumption of this meat. Once this factor is taken into account, horsemeat appears relevant in the
31 diversification of animal protein consumption because of its particular nutritional and environmental
32 properties and similar culinary use to that of other red meats. Horsemeat can thus lay claim to becoming
33 a sustainable alternative to beef consumption.

34 Key words: Horse meat; meat acceptance; sustainability; consumer surveys; nutritional values.

35

36 **1. Introduction**

37 Considering the issues involved in the production and consumption of meat, horsemeat has a particular
38 status, combining several advantages but also disadvantages.

39 From a nutritional quality perspective, horsemeat contains more iron and zinc than other meats, and
40 has a low fat content with a good lipid profile due to the equine digestive physiology that allows the
41 transfer of n-3 polyunsaturated fatty acids (PUFAs) from pasture to meat (Belaunzaran et al., 2015;
42 Lorenzo et al., 2019). Consequently, horsemeat consumption increases the status of PUFA content in
43 the erythrocytes of consumers (Del Bò et al., 2013).

44 From an environmental point of view, horse breeding has ecological benefits linked to the inherent
45 nature of equines as non-ruminant herbivores (equine grazing), and to their specific land use in areas
46 where other livestock are currently absent. In terms of equine grazing specificities, the absence of
47 rumination leads to lower methane emissions compared to cattle (117.9 kg CH₄/dairy cow/year and 20.7
48 kg CH₄/horse/year in France) (Rzekęć et al., 2020). In addition, the breeding of heavy horses for meat

49 in France allows the maintenance of nine threatened local heavy breeds and keeps areas open through
50 grazing or agrotourism (Bigot et al., 2018).

51 Moreover, the maintenance of horse slaughter (and consequently horsemeat consumption) enables the
52 avoidance of food waste as well as the possibility of ending horses' lives in respectful conditions, instead
53 of keeping them in poor conditions without any care (Saastamoinen, 2015).

54 We understand the term "sustainable market" to mean the set of production modes and commercial
55 practices that fulfill the needs of current generations without compromising those of future generations,
56 taking into account the environmental, economic, social and health impacts of these activities.

57 All these aspects imply that in sustainability terms, horsemeat could be a good substitute for beef. It
58 would thus be desirable to increase its consumption (Belaunzaran et al., 2015). Nevertheless, any
59 increase in this consumption is conditional upon its acceptance (Belaunzaran et al., 2015). For instance,
60 Popoola et al. (2021) show that horsemeat is not associated with food among Canadian consumers and
61 that its consumption would be unacceptable to them. By contrast, hippophagy was legally authorized in
62 France in 1866 and is still practiced in the country (Lamy et al., 2020).

63 All meat consumption is strongly modulated by psychological determinants, personal convictions and
64 beliefs. The concept of the "meat paradox" reflects the internal conflict within the meat eater, divided
65 between the pleasure of eating animal flesh and the moral discomfort of killing the animal (Loughnan et
66 al., 2010, 2014). This cognitive conflict is stimulated by the phenomenon of anthropomorphism and the
67 rise in empathy toward animals, which have a deterrent effect on meat consumption in general
68 (Niemyjska et al., 2018; Zickfeld et al., 2018). Eaters who are most uncomfortable then use strategies
69 to reduce the dissonance between these contradictory cognitions (Séré de Lanauze & Siadou-Martin,
70 2016). These strategies include the denial or downplaying of the emotional and moral capacities of
71 livestock (Bastian et al., 2012; Bratanova et al., 2011) and, conversely, the attribution of such capacities
72 to non-consumable animals. From this point of view, horses are then perceived as being mentally gifted,
73 and their meat is perceived as non-consumable, according to a survey conducted in Australia, for
74 example (Bastian et al., 2012).

75 As Belaunzaran et al. (2015) point out, there are strong cultural differences between countries
76 concerning the consumption of horsemeat and consequently strong differences in the quantities
77 consumed. The present article focuses on the consumption of horsemeat in France. Indeed, France

78 weighs significantly in the international horsemeat market, since it is one of the main importing and
79 exporting countries (Belaunzaran et al., 2015). It is also one of the countries where per capita availability
80 is higher than the world average (Belaunzaran et al., 2015). However, national horsemeat consumption
81 was divided by 10 between 1980 and 2018, while over the same period, the population increased by
82 25%. Per capita consumption dropped from 1.67 kg/capita/year to 0.15 kg/capita/year, which suggest
83 an irreversible trend in consumption.

84 Analyzing the determinants and practices of horsemeat consumers and non-consumers could provide
85 additional information to help to understand the situation, as well as levers to increase horsemeat
86 consumption with the aim of furthering the sustainable development of the equine sector within a
87 sustainable market perspective. Thus, we examine horsemeat consumption in the French context. To
88 this end, we propose a short literature review on the specific status and acceptance of horsemeat. Next,
89 we analyze the individual characteristics of horsemeat consumers and non-consumers through two
90 large-scale surveys (INCA2, Kantar WorldPanel). Finally, through an ad-hoc quantitative survey, we
91 study the representations that consumers and non-consumers have of horses, as well as potential levers
92 for and obstacles to increasing horsemeat consumption, in particular among current non-consumers.

93 **2. Literature review: Horsemeat status, history and market**

94 **2.1. Specific features of horses linked to their status and utilizations**

95 The horse is an animal with a particular status stemming from its various uses: domestic animal for
96 leisure and sport, working animal for transportation, tourism or agriculture, and livestock for meat and
97 milk.

98 From a historical point of view, the use of horses for working activities has long been dominant, while
99 their use in leisure and sports activities is more recent and has become extensive. Finally, their use as
100 food has always existed, although with notable spatio-temporal differences.

101 Regarding the cultural dimension, societies differ in terms of the (real and symbolic) status that they
102 bestow upon horses. For example, Ferret (2010) compares Yakutia (Russian republic in the Far East)
103 with France. This author shows that the Yakuts (semi-nomadic people) are horse people, and the animal
104 is also the emblem of their nation. This animal is venerated and has a multi-purpose role, as it is used
105 as a worker, for transportation, and for the production of milk, meat, fat, horsehair and fur. Ferret reports
106 the more unidirectional purpose of horses in France, mainly oriented towards leisure activities.

2.2. Short overview of the history of horsemeat consumption in France

From the Middle Ages, French people rejected the consumption of horsemeat for symbolic, religious and health reasons, and this lasted for a long period of the country's history. Nevertheless, the availability of horsemeat following the slaughter of an old or injured animal gave rise to opportunistic consumption. Consequently, horsemeat consumption was negatively perceived: it was seen as unmentionable, taboo, only acceptable in times of crisis like famine or war. Gradually, the consumption of horsemeat took on an immoral, or even shameful character.

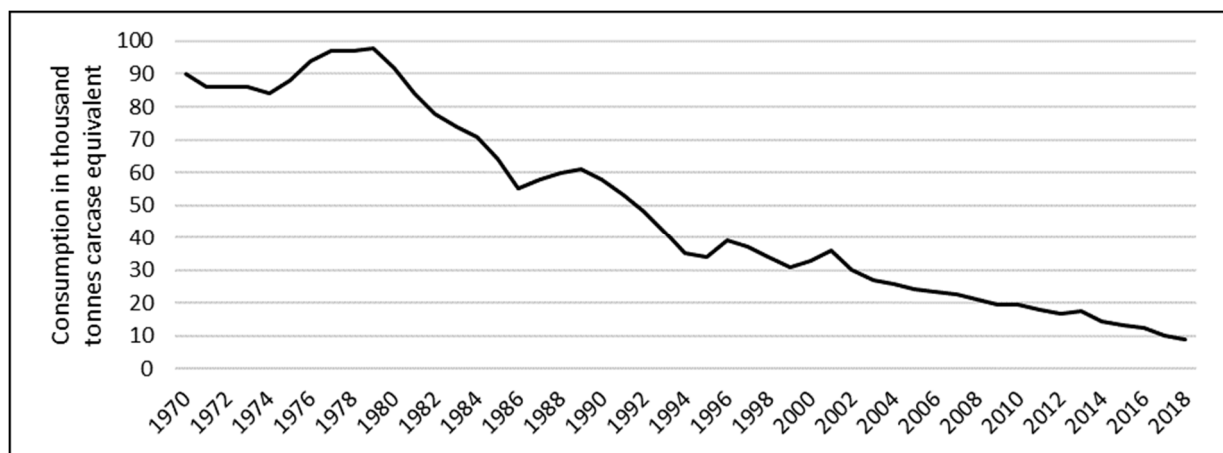
A change occurred in the 19th century. Some European countries bordering France, such as Germany and Belgium, took the decision to legalize the consumption of horsemeat (Gade, 1976). Part of the medical, hygienist and naturalist scientific community at that time seized upon this issue and positioned themselves in favor of hippophagy. Two individuals actively promoted horsemeat consumption in France: Isidore Geoffroy Saint-Hilaire (1805-1861), administrator and professor at the Museum of Natural History in Paris, and Emile Decroix (1821-1901), chief veterinarian for the French army and president of the French association for the protection of animals (Gade, 1976; Leteux, 2012; Otter, 2011; Pierre, 2003). After demonstrating that horsemeat was safe, healthy and nutritious, both sought to promote its consumption among populations that were deprived of regular protein intakes. Among the working classes, horsemeat could provide a nutritious and high-quality protein intake at a lower cost, as it was less expensive than other meats. They also encouraged the consumption of horsemeat for ethical reasons linked to the animal. In the 19th century, considerations about animal suffering were still limited, and horse owners pushed their animals to work to their limits. In such conditions, slaughter seemed to be a better fate for these horses than death from exhaustion (Roche, 2015). The promotional work was done through the organization of banquets, scientific presentations, and the distribution of free meat to people in need (Leteux, 2012). This challenging approach succeeded in increasing the acceptance of hippophagy. The Administrative Police Court of Paris legally authorized the practice for human consumption in 1866 (Digard, 2012; Leteux, 2012; Lizet, 2010; Pierre, 2003).

At the end of the 19th and the beginning of the 20th centuries, the medical community recommended the consumption of horsemeat for its flesh and blood, in order to prevent and fight against prevalent diseases such as tuberculosis (Pierre, 2003). The sector then became more professional with the arrival of a specific venue for trading in horsemeat: the horse butcher's shop. Unlike traditional butchers, they could sell only horsemeat to customers. The sector quickly got organized through a professional

137 syndicate. Demand for horsemeat rose to the point that imports became necessary from 1904 (Pierre,
 138 2003). The number of shops increased, especially in Paris and in the large and medium-sized towns of
 139 France. In 1913, there were more than 300 horse butcher shops in the city of Paris alone (Roche, 2015).
 140 From the second half of the 20th century, the consumption of horsemeat gradually declined (Figure 1),
 141 due to the convergence of several factors.

142 First, the perception of its health benefits regressed, particularly following several health crises such as
 143 salmonellosis (1967) and trichinosis (between 1975 and 2000) (Ancelle et al., 1998; Pozio et al., 2001;
 144 Simoons, 1994; Touratier, 2001). Nutritional trends in the scientific literature of the time also argued in
 145 favor of a more plant-based and less meat-based diet (Darmon, 2015).

146 Second, on the economic and social levels, horsemeat reflected a low social status, contrasting with the
 147 strong symbolic status that remained associated with the animal (Simoons, 1994). The socio-
 148 professional category of workers that consumed more horsemeat than the other social categories in
 149 France declined sharply (Marchand, 2010).

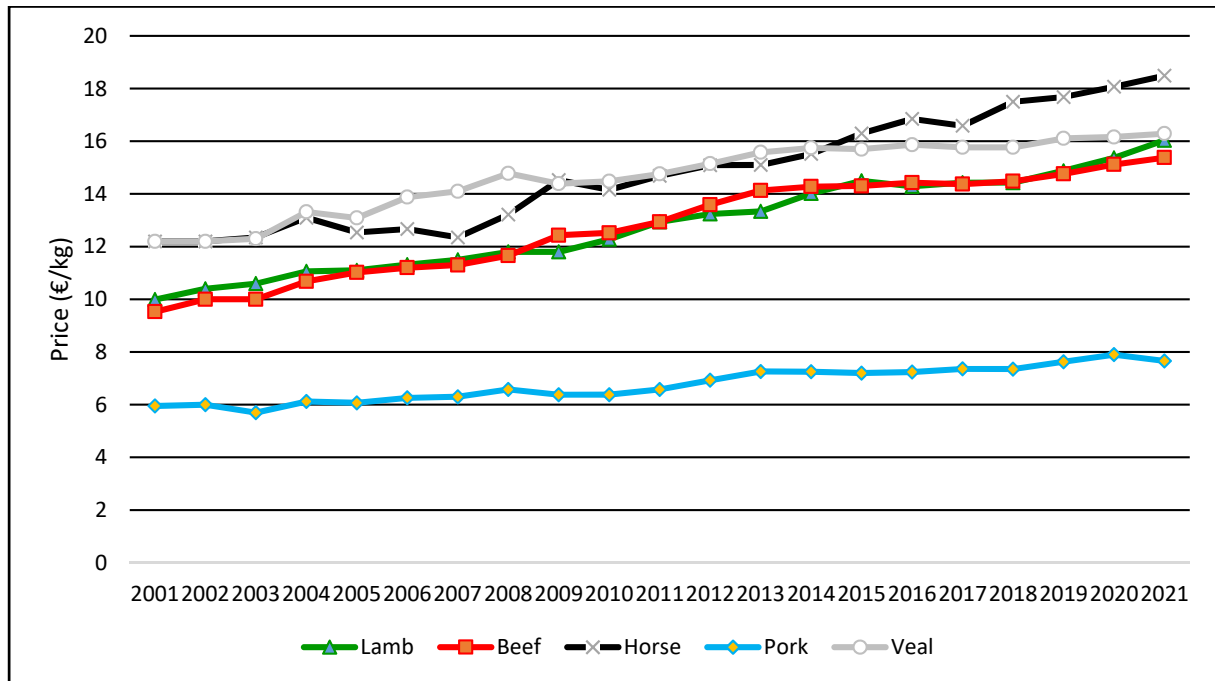


150
 151 Figure 1: Evolution of horsemeat consumption in France since 1970 (IFCE)

152 Third, even if horsemeat consumption is decreasing, imports continue to be necessary to meet national
 153 demand, because horse slaughter has been steadily declining, with a fall of 40% between 2010 and
 154 2020 in France.

155 Fourth, the number of horse butcher's shops has decreased dramatically whereas half of the supply of
 156 horsemeat relies on them. The other half is distributed through supermarkets, direct sales and small
 157 local markets representing a very small part of the market (Cazes-Valette, 2008).

158 Fifth, horsemeat is now among the most expensive meats per kilo, with the price exceeding that of veal
 159 in 2014 (Figure 2). Even though the data represented in Figure 2 are overall prices (including all types
 160 of meat), horsemeat has remained comparatively the most expensive over the last 7 year period.



161
 162 Figure 2: Evolution of retail meat prices since 2001 (IFCE)

163 Finally, on the cultural level, horsemeat consumption has struggled to gain a foothold elsewhere than in
 164 already established areas (Centre - North of France). French cuisine shows little interest in the product,
 165 and horsemeat is rarely served in restaurants. Finally, the number of defenders of the practice had
 166 diminished, unlike its detractors, such as animal protection and welfare associations (Lizet, 2010).

167 The rapprochement between animals and man brings us back to the question of the moral acceptability
 168 of meat consumption and the anthropological categories of edible animals according to their proximity
 169 to humans (Leach, 1980; Merdji, 2002). The consumption of horsemeat is a particularly pertinent
 170 example. Over the course of the 20th century, horses gradually shifted from working activities to leisure
 171 activities, thus developing a more hedonic and sentimental relationship with humans (Digard, 2012). In
 172 their work on horsemeat consumption in the Finnish context, Leipämaa-Leskinen et al. (2018) show that
 173 the meanings related to a living horse can be transferred to those of horsemeat, influencing cultural
 174 barriers that determine whether this meat is suitable or not for food consumption.

175 Although horsemeat has followed the general structural downward trend in the same way as other
176 meats, it clearly has its own specific characteristics. Compared to other types of animal production that
177 are only dedicated to food consumption (such as cattle, sheep and pork), the moral acceptability of
178 horsemeat consumption is socially disputed. The historical perspective testifies to the fragility of this
179 acceptability.

180 **3. Methodology**

181 This paper relies on three complementary analyses. Two of them use pre-existing large-scale surveys,
182 one on households' food purchases and the other on food consumption. These datasets have a certain
183 number of limits. First, there is a risk that people may consume horsemeat outside of the survey and
184 are considered as non-consumers whereas they are in fact consumers. Second, people may hide their
185 horsemeat consumption as it can be considered socially unacceptable. These two biases could thus
186 lead to an underestimation of horsemeat consumers. However, we consider these biases to be relatively
187 weak. The third is an ad-hoc survey enabling us to study horse and horsemeat representations among
188 consumers and non-consumers.

189 3.1. Kantar survey

190 3.1.1. *Kantar data*

191 The data used come from the "Kantar WorldPanel" surveys of 2015 and 2017, enrolling respectively
192 5031 and 5131 French household panellists. They reported their purchases for at least 22 weeks and
193 provided their socio-demographic and economic variables: age, sex, height, weight, education level,
194 income, occupation status, presence or not of a child in the household, information on potential
195 production of food at home in terms of the presence of a garden or fruit trees, and location of the family
196 home (rural versus urban, North versus South of France).

197 The dataset provides detailed information on all purchases of food products, including products without
198 a bar code and fresh products (meat, fish, fruits and vegetables). This database contains quantities and
199 expenditures for several food products and therefore provides information on food consumption at home.
200 Note that this database does not provide information on food consumption outside the home, nor on
201 self-made product consumption.

202

3.1.2. Probability estimation

Since the households included in the sample were observed over a variable number of consecutive weeks (at least 22 weeks), we first standardized the quantity of horsemeat purchased by each household. We computed the average yearly quantity of horsemeat purchased per consumption unit (according to the Organization for Economic Co-operation and Development (OECD) definition) for each household as:

$$qmean_i = \frac{\sum_{k=1}^{w_i} q_{i,k}}{w_i * UC_i}$$

Where

$q_{i,k}$ is the quantity of horsemeat purchased by household i during week k

w_i is the total number of consecutive weeks observed for household i ($w_i \geq 22$)

UC_i is the size of household i expressed in consumption units (UC) according to the OECD definition (1 UC for the first adult in the household + 0.5 UC for other persons aged 14 or over + 0.3 UC for children under 14).

The overwhelming majority of households never purchased horsemeat within the time window selected for the study: 88.7% (respectively 90.5% in 2017) of households did not buy horsemeat over the 22 consecutive weeks surveyed. This implies that we have an over-representation of zero values in our horsemeat purchase data. This is why we cannot use the Ordinary Least Squares method (Greene, 2002) to analyze the household's propensity to buy horsemeat: this method will not yield consistent estimates due to the over-representation of zero values. Importantly, it would lead to an underestimation of predictions of purchased quantities, and would bias the estimation of the coefficients associated with the explanatory variables. Several alternatives are commonly used to counteract such biases. One of the most widely used is the Tobit model, developed by Tobin in the 1950s (Tobin, 1958). However, this model assumes that the variables involved in the probability of purchasing horsemeat are also those that determine the quantity of meat purchased. Furthermore, the Tobit model assumes that the explanatory variables exert the same influence (i.e.: increase vs decrease) on the quantity of horse meat and on the probability of buying horse meat. However, it turns out that in our case, we cannot rule out the possibility that both decision-making processes are supported by different determinants. Therefore, we cannot hypothesize that they will have the same impact on each decision. Under these conditions, the Cragg model (Cragg, 1971) would be more appropriate than the Tobit model. Indeed, it removes the

232 twofold constraint of the Tobit model. The Cragg model, also known as the double-hurdle model,
 233 proceeds in two stages. First, the probability of buying horsemeat is estimated with a Probit model (the
 234 selection model). Next, the impact of the individual determinants on the quantity of meat purchased is
 235 estimated with a truncated regression (the decision model: only quantities > 0 are taken into account).
 236 Thus, the Cragg model consists of the following components:

237 The selection equation:

238

$$239 \quad P_i = 1 \quad \text{if } P_i^* > 0 \quad \text{with } P_i^* = \alpha z_i + u_i \quad \text{and } u_i \sim N(0, 1) \quad (1)$$

$$240 \quad 0 \quad \text{otherwise}$$

241

242 Where P^* is a latent variable that takes the value 1 if the household buys horsemeat at least once in the
 243 year and 0 otherwise, z a vector of household characteristics and α a vector of parameters.

244

245 The decision model:

246

$$247 \quad y_i = y_i^* \quad \text{if } y_i^* > 0 \quad \text{and } P_i^* > 0 \quad \text{with } y_i^* = x_i \beta + \varepsilon_i \quad \text{and } \varepsilon_i \sim N(0, \sigma^2) \quad (2)$$

$$248 \quad 0 \quad \text{otherwise}$$

249

250 Where y_i is the Napierian logarithm of the extrapolation of the yearly quantity of horsemeat purchased
 251 by consumption unit (according to the OECD definition), x is a vector of household characteristics and
 252 β is a vector of parameters.

$$253 \quad y_i = \ln(qmean_i * 52) \quad \text{if } qmean_i > 0, y_i = 0 \quad \text{if } qmean_i = 0$$

254 Finally, we also estimated the Tobit model, as the successive steps of the analysis led us to hold the
 255 same explanatory variables in both equations. Then we tested which model was the more appropriate.
 256 We proceeded to a Chi-square test based on the likelihood ratio. The LR statistic is the following
 257 (Greene, 2002):

258

$$259 \quad LR = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \sim \chi^2(k)$$

260

261 Where L_T is the likelihood of the Tobit model, L_P is the likelihood of the Probit model, L_{TR} is the likelihood
262 of the truncated regression model and k is the number of independent variables in the equations.
263 Finally, the Chi-square test elected the Cragg model (p-value = 0.000) for both samples (2015 and 2017)
264 and confirmed our first assumption.

265 *3.1.3. Kantar explanatory variables*

266 The explanatory variables are: age of the panellist (person responsible for household purchases) (3
267 classes), education level of the panellist (4 levels), occupational status of the panellist (6 categories),
268 income per consumption unit (in monthly euros), size of the municipality (3 categories, region (North
269 versus South of France), availability of an orchard (in the main or secondary residence), availability of a
270 vegetable garden (in the main or secondary residence), body mass index of the panellist (6 categories),
271 and presence or not of a child in the household.

272 *3.2. INCA2 survey*

273 The data come from the cross-sectional survey INCA2 carried out by ANSES (French Agency for Food,
274 Environmental and Occupational Health & Safety) in 2006 and 2007
275 (<https://www.anses.fr/fr/system/files/PASER-Sy-INCA2EN.pdf>).

276 Only adult meat consumers were considered in our study, resulting in a sample of 1006 men and 1430
277 women, among whom 1595 adults declared never consuming horsemeat (hereafter, "non-consumers
278 (NC)"), 841 were raw or cooked horsemeat consumers (hereafter, "declared consumers (DC)"), among
279 them 60 reported having consumed horsemeat during the surveyed week (hereafter, "factual consumers
280 (FC)"). Our INCA2 sample is divided into three sub-samples such that 65.5% are NC, 34.5% are DC
281 among them 2.5% are FC (due to the very short period - one week - of dietary reporting). To compare
282 the profiles of individuals between samples, we run non-parametric tests such as Wilcoxon's test and
283 χ^2 tests.

284 *3.3. Quantitative exploratory analysis of horsemeat representations*

285 This work relies on an ad-hoc quantitative survey. First, the aim is to explore consumers' and non-
286 consumers' representations of horses. Then the rationale for non-consumption of horsemeat (as
287 reported by non-consumers) provides a glimpse of potential future consumption. The last sub-section
288 focuses on how non-consumers perceive the mental capacities of horses (Bastian et al., 2012).

289 The quantitative survey was conducted in December 2018 through an online sampling company (Survey
290 Sampling International). The sample includes 1005 people representative of the French adult population
291 in terms of age, gender and socio-professional category.

292 Before starting the investigation, we asked participants to tell us what horses mean to them by
293 spontaneously giving us 3 representative words (see Appendix 2). This question was asked before
294 questioning people on their consumption of meat and horsemeat, such that participants' representations
295 would not be influenced by the purpose of the survey. Finally, the last part of the study aims to measure
296 participants' perceptions of the emotional and cognitive capabilities of horses. We use the 10-item scale
297 of Bastian et al., 2012: "In your opinion, are horses capable of feeling hunger / fear / pleasure / pain /
298 anger" and "In your opinion, are horses capable of self-control / moral sense / memory / empathy /
299 planning". Answers were given on a 5-level Likert scale from "strongly disagree" to "strongly agree".

300 **4. Results**

301 4.1. Horsemeat purchases

302 According to the Kantar surveys, 11.25% of households bought horsemeat in 2015. This proportion
303 decreased to 9.5% in 2017.

304 Among buyers, the average quantity was 1.36 kg/year/CU in 2015 and 1.20 kg/year/CU in 2017. These
305 quantities differ according to the socio-demographic and economic characteristics of households. In
306 2015, the average quantities purchased by households whose panellists were in the 18-44 y-old
307 category were 18% and 27.7% lower than the 45-64 y-old and >65 y-old categories, respectively.
308 Households with an education level below the baccalaureate bought 5% more than those with a higher
309 education level (Bachelors' degree and above).

310 All these descriptive results were confirmed by econometric estimates to quantify the specific effects of
311 each variable on the probability of buying horsemeat (Probit models) and on the quantity purchased
312 (truncated models). Both models (2015 – table 1 and 2017 – table 2) highlight the fact that panellists
313 under 44 years are less likely to purchase horsemeat and that they purchase lower quantities per year
314 than others. Both models also show that the proportion of northern French households buying
315 horsemeat is significantly higher than that among southerners. But there is no significant difference
316 between northerners and southerners regarding the quantities bought by horsemeat consumers. In
317 2015, the results show that households owning a vegetable garden were more likely to consume

318 horsemeat. Both models also provide evidence that households whose panellists are overweight are
319 more inclined to buy horsemeat. But weight has no impact on the quantities purchased, except in 2015
320 for severe and morbid obese panellists who purchased more horsemeat.

321 In both the 2015 and 2017 models, the presence of one or more children in the household seems to
322 increase the probability of consuming horsemeat. Moreover, the 2015 results also indicate that
323 households with an income below the poverty level have a higher probability of buying horsemeat, but
324 at the same time, that high-income horsemeat consumers buy higher quantities than the former. Both
325 models (2015 and 2017) show that intermediate professions have a lower probability of buying
326 horsemeat than the reference category of "employees/workers". The results are more ambiguous
327 regarding "senior executives" and "students and unemployed people". On the one hand, the 2015 M3
328 model shows that a level of education above baccalaureate + 1 year (or more) is negatively associated
329 with the probability of purchasing horsemeat, and on the other hand, the level of education below the
330 baccalaureate is positively associated horsemeat consumption.

331

332 **Table 1**333 Impact of sociodemographic and economic variables on purchases of horsemeat in 2015 (estimated
334 coefficients with the Cragg model)

Variables	M1 Truncated	Probit	M2 Truncated	Probit	M3 Truncated	Probit
<i>Age</i>						
18-44*	-0.22 ⁺ (0.125)	-0.37** (0.060)	-0.20 (0.125)	-0.35** (0.060)	-0.20 (0.133)	-0.29** (0.063)
45-64 (Ref : reference)	Ref	Ref	Ref	Ref	Ref	Ref
65+	0.38** (0.121)	0.08 (0.065)	0.40** (0.122)	0.07 (0.065)	0.35** (0.124)	0.05 (0.065)
<i>Country size</i>						
Rural areas		-0.04 (0.063)		-0.04 (0.063)		-0.05 (0.063)
Urban areas of 2000 to 199,999 inhabitants		Ref		Ref		Ref
Urban areas of 200,000 inhabitants and more + Paris		0.10 ⁺ (0.058)		0.10 ⁺ (0.058)		0.12* (0.058)
<i>Region of residence</i>						
North	0.18 (0.112)	0.20** (0.052)	0.19 ⁺ (0.112)	0.19** (0.052)	0.19 ⁺ (0.112)	0.18** (0.052)
South	Ref	Ref	Ref	Ref	Ref	Ref
<i>Orchard owner</i>						
Yes		0.01 (0.058)		0.01 (0.057)		0.02 (0.058)
No		Ref		Ref		Ref
<i>Vegetable garden</i>						
Yes		0.11 ⁺ (0.058)		0.11 ⁺ (0.058)		0.10 ⁺ (0.058)
No		Ref		Ref		Ref
<i>Monthly income €/CU</i>						
Poverty line	0.14 (0.159)	0.15 ⁺ (0.078)				
Poverty line to median income	0.08 (0.135)	0.08 (0.065)				
Median income to 7th decile	Ref	Ref				
>7th decile	0.35* (0.152)	-0.05 (0.071)				
<i>Body Mass Index</i>						
Thinness	-0.17 (0.350)	-0.11 (0.151)	-0.08 (0.351)	-0.11 (0.152)	-0.16 (0.353)	-0.11 (0.152)
Normal weight	Ref	Ref	Ref	Ref	Ref	Ref
Overweight	-0.07 (0.117)	0.17** (0.055)	-0.08 (0.116)	0.17** (0.055)	-0.08 (0.117)	0.16** (0.056)
Moderate obesity	0.20 (0.154)	0.28** (0.077)	0.16 (0.154)	0.29** (0.077)	0.17 (0.155)	0.27** (0.077)
Severe and morbid obesity	0.39 ⁺ (0.210)	0.31** (0.108)	0.35 ⁺ (0.209)	0.32** (0.108)	0.36 ⁺ (0.210)	0.30** (0.108)
No answer	-0.54	0.28	-0.55	0.27	-0.53	0.28

	(0.384)	(0.189)	(0.384)	(0.190)	(0.386)	(0.190)
<i>Child(ren) in household</i>						
Yes		0.10 (0.061)		0.13* (0.059)		0.15* (0.059)
No		Ref		Ref		Ref
<i>Socio-professional status</i>						
Farmer		-1.04 (1.183)		-0.51 (0.489)		
Senior executive		0.17 (0.248)		-0.16 (0.113)		
Student/Unemployed person		0.28+ (0.172)		0.04 (0.085)		
Employee/Manual worker		Ref		Ref		
Associated professionals		-0.04 (0.122)		-0.13* (0.056)		
Self-employed		-0.35 (0.272)		-0.02 (0.131)		
<i>Education level</i>						
< Post-secondary qualifications					0.14 (0.128)	0.13* (0.062)
Baccalaureate					Ref	Ref
Bac +1st, 2nd, 3rd year university					0.16 (0.159)	-0.14* (0.073)
Bachelor's degree +					0.10 (0.174)	-0.18* (0.077)
Constant	6.08** (0.157)	-1.50** (0.086)	6.19** (0.135)	-1.43** (0.077)	6.12** (0.147)	-1.48** (0.084)
Observations	5,031	5,031	5,031	5,031	5,031	5,031

335 Standard errors in brackets; ** p<0.01, * p<0.05, + p<0.10; M1: model with monthly income;
336 M2: model with socio-professional status; M3: Model with education level.
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341 **Table 2**342 Impact of sociodemographic and economic variables on purchases of horsemeat in 2017 (estimated
343 coefficients with the Cragg model).

Variables	M1		M2		M3	
	Truncated	Probit	Truncated	Probit	Truncated	Probit
<i>Age</i>						
18-44*	-0.35** (0.128)	-0.29** (0.063)	-0.36** (0.132)	-0.26** (0.063)	-0.34* (0.135)	-0.24** (0.065)
45-64	Ref	Ref	Ref	Ref	Ref	Ref
65+	0.20 (0.124)	0.13+ (0.066)	0.19 (0.127)	0.11+ (0.067)	0.19 (0.125)	0.10 (0.067)
<i>Country size</i>						
Rural		0.03 (0.064)		0.01 (0.064)		0.01 (0.064)
UB 2,000 to 199,999 inhabitants		Ref		Ref		Ref
UB of 200,000 inhabitants and Paris		0.14* (0.060)		0.15* (0.061)		0.15* (0.061)
<i>Region of residence</i>						
North	0.10 (0.114)	0.15** (0.054)	0.11 (0.115)	0.15** (0.054)	0.11 (0.114)	0.14** (0.054)
South	Ref	Ref	Ref	Ref	Ref	Ref
<i>Orchard owner</i>						
Yes		0.02 (0.058)		0.03 (0.058)		0.02 (0.058)
No		Ref		Ref		Ref
<i>Vegetable garden</i>						
Yes		0.03 (0.059)		0.02 (0.059)		0.03 (0.059)
No		Ref		Ref		Ref
<i>Monthly income €/CU</i>						
Poverty line	-0.13 (0.181)	0.10 (0.089)				
Poverty line to median income	-0.17 (0.155)	-0.06 (0.074)				
Median income to 7th decile	Ref	Ref				
>7th decile	-0.05 (0.170)	-0.06 (0.082)				
<i>Body Mass Index</i>						
Thinness	-0.38 (0.304)	0.10 (0.143)	-0.38 (0.304)	0.10 (0.143)	-0.38 (0.304)	0.10 (0.143)
Normal weight	Ref	Ref	Ref	Ref	Ref	Ref
Overweight	0.08 (0.122)	0.14* (0.058)	0.09 (0.122)	0.13* (0.058)	0.08 (0.122)	0.13* (0.058)
Moderate obesity	0.26 (0.162)	0.17* (0.078)	0.26 (0.161)	0.16* (0.078)	0.22 (0.161)	0.16* (0.078)
Severe and morbid obesity	0.16 (0.201)	0.38** (0.106)	0.17 (0.202)	0.38** (0.106)	0.14 (0.201)	0.38** (0.105)
No answer	0.51 (0.661)	-0.34 (0.264)	0.49 (0.662)	-0.37 (0.267)	0.47 (0.663)	-0.37 (0.268)

<i>Child(ren) in household</i>						
Yes		0.11 ⁺		0.12 [*]		0.14 [*]
		(0.063)		(0.061)		(0.061)
No		Ref		Ref		Ref
<i>Socio-professional status</i>						
Farmer		-0.23		-0.34		
		(1.142)		(0.481)		
Senior executive		0.15		-0.34 ^{**}		
		(0.287)		(0.124)		
Student/Unemployed person		-0.13		0.12		
		(0.183)		(0.092)		
Employee/Manual worker		Ref		Ref		
Associated professionals		0.04		-0.20 ^{**}		
		(0.127)		(0.058)		
Self-employed		-0.10		-0.15		
		(0.338)		(0.153)		
<i>Education level</i>						
< Post-secondary qualifications				0.09		0.09
				(0.130)		(0.064)
Baccalaureate				Ref		Ref
Bac +1st, 2nd ,3rd year university				0.05		-0.07
				(0.156)		(0.073)
Bachelor's degree +				0.01		-0.20 [*]
				(0.176)		(0.079)
Constant	6.32 ^{**}	-1.53 ^{**}	6.21 ^{**}	-1.50 ^{**}	6.16 ^{**}	-1.55 ^{**}
	(0.173)	(0.097)	(0.129)	(0.079)	(0.146)	(0.086)
Observations	5,031	5,031	5,031	5,031	5,031	5,031

344 Standard errors in brackets; ** p<0.01, * p<0.05, + p<0.10; M1: model with monthly income;
345 M2 model with socio-professional status; M3: Model with education level

346

347 4.2. Horsemeat consumption

348 Table 3 summarizes the characteristics of individuals from the INCA2 survey. People are between 45
349 and 47 years old on average (no significant differences were found between Non-Consumers NC and
350 Declared Consumers DC that include Factual Consumers FC). Men are significantly more represented
351 in the sub-sample of horsemeat consumers (47% of DC sub-sample) than in the whole sample (41.3%).
352 Chi² tests highlight the differences among genders, socio-professional categories and regions of
353 residence. Furthermore, the majority of NC of horsemeat are senior executives and higher intellectual
354 professions, whereas consumers of horsemeat are employees (21%), pensioners (20%) and people
355 without a professional activity (17%), or manual workers (15%). Last, horsemeat eaters are much more
356 represented in the northern regions of France.

357

358 **Table 3**

359 Individual characteristics from INCA2 survey (2006-2007).

360

Characteristics		Whole sample (n = 2436)	Non-consumer (n=1595)	Declared consumer (n= 841)	Factual consumer (n= 60)
Age		45,44 (+/- 15,28)	45,69 (+/- 15,31)	44,98 (+/- 15,24)	47,5 (+/- 15,50)
Gender	1: Men	1006 (41.3%)	38,31 %	46,97 % (*)	40 %
	2: Women	1430 (58.7%)	61,69 %	53,03 % (*)	60 %
Socio- Professional Category (SPC)	1: Farmers	33 (1,36%)	1,63 %	0,83 %	3,33 %
	2: Craftsmen, traders, business leaders	67 (2,75%)	2,26 %	3,69 %	3,33 %
	3: Executives, higher intellectual professions	227 (9,32%)	10,28 %	7,5 % (*)	5 %
	4: Intermediate Professions	410 (16,84%)	17,74 %	15,12 %	13,33 %
	5: Employees	549 (22,55%)	23,45 %	20,83 %	16,67 %
	6: Manual workers	289 (11,87%)	10,47 %	14,52 % (*)	15 %
	7: Retired	490 (20,12%)	19,94 %	20,48 %	23,33 %
	8: No professional activity	370 (15,20%)	14,23 %	17,02 %	20 %
Zone	0: North West	369 (15,15%)	12,16 %	20,81 % (*)	26,67 % (*)
	1: East	260 (10,67%)	10,85 %	10,34 %	6,67 %
	2: Ile de France	328 (13,46%)	13,04 %	14,27 %	23,33 % (*)
	3: West	375 (15,39%)	17,18 %	12,01 % (*)	6,67 % (*)
	4: Centre	265 (10,88%)	11,16 %	10,34 %	5 %
	5: Central East	297 (12,19%)	12,48 %	11,65 %	8,33 %
	6: South West	238 (9,77%)	10,72 %	7,97 % (*)	8,33 %
	7: South East	304 (12,48%)	12,41 %	12,6 %	15 %

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364

365 *Characterization of horsemeat consumption among adults*

366 FC report consuming horsemeat mainly during meals taken at home (87.5%), with the family (66.7%),
367 generally at lunch (79%) rather than dinner (21%), with an average of 133g per meal.

368 *What about the consumption of other meats?*

369 The INCA2 survey reveals that DC and FC of horsemeat eat more meat of all types than those who
370 reported never eating horsemeat. The proportion of consumers of beef, pork, veal and lamb is higher
371 among consumers of horsemeat (91.1%) than among non-consumers (70%), and consumers also
372 consume more rabbit meat (no significant difference with pork and lamb). DC of horsemeat had a higher
373 consumption of beef than those who did not consume horsemeat during the survey week. Moreover,
374 FC of horsemeat consumed less beef (43.3% did not eat it during the survey week) than DC.

375 4.3. Horsemeat representations

376 Concerning the perception of cognitive and emotional capacities, an exploratory factor analysis led to a
377 two-axis structure: the first one deals with emotions, the second one with intellectual capacities. Both
378 have good statistical properties (see Appendix 3). Factor 1 includes 5 items (hunger, fear, pleasure,
379 pain, anger), and factor 2 includes 3 items (self-control, moral sense, planning). This analysis led to the
380 description of two variables: An "emotions" variable corresponding to the average of the 5 items in the
381 "emotions" factor, and a "capacities" variable corresponding to the average of the 3 items in the
382 "capacities" factor.

383 Statements on meat and horsemeat consumption (see Appendix 1) show that currently 91% of the
384 sample are meat eaters, and 37% have already consumed horsemeat several times. Women and people
385 aged 18-34 years are statistically less likely to consume horsemeat (respectively $\chi^2=24,3$, $p<0,0001$
386 and $\chi^2=41,6$, $p<0,0001$). Fifty-four percent of the whole sample have never eaten horsemeat but
387 report eating other meats. However, among them, 331 respondents state that they cannot imagine
388 eating horsemeat, either because they love the animal too much or for other moral reasons (33 % of the
389 whole sample). For those who do not currently consume horsemeat, the respondents indicated that
390 possible consumption of this kind of meat could be envisaged in the future. Thus 162 persons (16% of
391 the whole sample) do not eat horsemeat because it is too expensive, it is too hard to find, it is not French-
392 produced meat or they do not instinctively think about buying this kind of meat (16% of the whole
393 sample). All these reasons might be related to production, marketing and retailing strategies. 49 other

394 respondents do not buy horsemeat because they do not like the taste or the color of this meat (4,9% of
 395 the whole sample).

396 An analysis of the representations of horses was first carried out for the whole sample. The responses
 397 are grouped into 12 different categories, which are detailed in Appendix 2.

398 **Table 4**

399 Number of citations of horse representations by category (quantitative exploratory survey, 2018).

	Category	Number	%
401	Animality	269	9%
	Abilities, character	235	8%
402	Racing	381	13%
	Physical features	67	2%
403	Elite	45	2%
	Leisure	290	10%
404	Nature	105	4%
	Emphatic physical description	632	22%
405	Relationship	216	7%
	Senses	248	9%
406	Meat	32	1%
	Other	278	10%
407	Nothing	109	4%
	Total	2907	100%

408 The "meat" category is poorly represented, with only 32 occurrences (see Table 4). Representations
 409 related to the concrete physical features of the animal (67 occurrences) are in the minority compared to
 410 the qualifiers and attributes of horses (physical qualification: 632 occurrences), with a lexical field that
 411 is more complete and abstract. The vast majority of these terms have a positive connotation, highlighting
 412 the beauty, nobility or grace of horses. These qualifiers contribute to a form of idealization of the animal,
 413 testifying to an imagery that is still present in the lineage of the aristocratic status of the horse (Leteux,
 414 2012). Among the categories of occurrences, a macro-category (887 occurrences) can be created by
 415 grouping together three categories linked by the interaction between man and animal (racing with 381
 416 occurrences, leisure with 290 occurrences, relationship with 216 occurrences). Finally, the results
 417 obtained underline the ambivalent status of the horse, which oscillates in a continuum with man at one
 418 pole and the animal at the opposite pole. The "animality" category (269 terms) brings the horse closer
 419 to the animal pole, while the anthropomorphic category of "abilities and characters" (235 terms) brings

420 the horse closer to the human pole. Thus, the status and position of the horse within the human-animal
 421 relationship remains undecided.

422 Representations do not differ between horsemeat consumers and non-consumers. However, among
 423 non-consumers, the representations are significantly different between those who express affective and
 424 moral reasons and those who have other reasons for not eating horsemeat ($\chi^2=62,7$; $p=2,8 \cdot 10^{-9}$), see
 425 table 5.

426 **Table 5**

427 Number of citations of horse representations by category, depending on the reasons for not eating
 428 horsemeat (quantitative exploratory survey, 2018).

Category	Number		%	
	Love and moral	Other reasons	Affective and moral reasons	Other reasons
Animality	90	62	9	11
Other	72	69	7	12
Ability, personality	82	40	9	7
Racing	106	98	11	17
Physical features	15	19	2	3
Elite	17	7	2	1
Leisure	101	66	10	11
Nature	34	22	4	4
Emphatic physical description	247	99	26	17
Relationship	77	21	8	4
Nothing	29	41	3	7
Senses	93	43	10	7
Meat	1	3	0	1
Total	964	590	100	100

429

430 The next part focuses on current non-consumers who do not invoke affective and moral arguments for
 431 not consuming horsemeat. Actually, the greatest potential for an increase in the consumption of
 432 horsemeat relies on this category. In terms of representations, these survey participants cite emphatic
 433 physical descriptions less often and horseraces more often, showing more utilitarian representations of
 434 horses than affective and moral non-consumers do. They also talk less often about horses' abilities and
 435 characters and more often about "animal" attributes, which reflects a status closer to the animal for these
 436 individuals (compared to affective and moral non-consumers). Now turning to the perception of the
 437 emotional and cognitive abilities of horses, these people credit horses with significantly fewer emotional

438 and cognitive abilities than those who maintain affective and moral reasons for non-consumption (table
 439 6). We may then assume that the consumption of horsemeat might be morally acceptable (Bastian et
 440 al., 2012) for these people. Their reasons for non-consumption are mainly related to supply, whereby it
 441 would be possible to increase their consumption if the supply changed, including changes in the places
 442 where products are sold, their prices and the visibility of products on the shelves. Some of them,
 443 however, do not want to eat horsemeat because of its taste or its color (some participants say they don't
 444 like red meat). To convince these consumers to consume horsemeat, it would be necessary to further
 445 develop communications on the nutritional benefits of horsemeat and to propose recipes that hide the
 446 taste and color, due to their preferences.

447 **Table 6.**

448 Attribution of emotional and intellectual capacities to horses by horsemeat non-consumers (for affective
 449 and moral reasons, or other reasons) and consumers (quantitative exploratory survey, 2018).

	Horsemeat non-consumers		Horsemeat consumers (3)	Comparison (1) to (2) tvalue (p)	Comparison (2) to (3) tvalue (p)
	Affective and moral reasons (1)	Other reasons (2)			
Emotions	4.62 (0.72)	4.41 (0.82)	4.51 (0.76)	-3.03 (p=0.0026)	-1.42 (p=0,15)
Intellectual capacity	3.55 (1.06)	3.13 (1.10)	3.19 (1.01)	-4.41 (p<.0001)	-0.67(p=0.5)

450

451 **5. Discussion**

452 From a sustainability perspective, horsemeat could be a good substitute for beef because of its
 453 environmental and nutritional benefits, provided that its consumption tallies with consumer preferences.
 454 Our results show that the development of the horsemeat market is not only possible, but also that it can
 455 easily be steered in a sustainable direction.

456 **5.1. Possible horsemeat market increase**

457 Two groups of consumers have been identified as being likely to increase their consumption of
 458 horsemeat. On the one hand, households and individuals who already consume small quantities of

459 horsemeat, and on the other hand, non-consumers of horsemeat who do not consume it for supply
460 reasons. The potential for increasing horsemeat consumption through its current consumers is
461 substantial. Indeed, Study 1 shows that horsemeat-buying households buy horsemeat only infrequently
462 (on average they buy horsemeat one week in ten), and, according to the results of Study 2, only one-
463 sixth of reported consumers of horsemeat consumed it during the week of the survey.

464 Furthermore, according to the results of Study 3, a significant proportion (30%) of respondents who do
465 not consume horsemeat would be likely to consume it. These consumers do not eat horsemeat because
466 they do not think about it, or cannot find it. The potential for growth in the horsemeat market therefore
467 appears to be considerable, once this rate of "potential consumers" is extrapolated to the proportion of
468 non-consumers observed in Study 2.

469 5.2. How can such an increase in the consumption of horsemeat respond to
470 sustainability issues?

471 As highlighted in the introduction, horsemeat is nutritionally and environmentally attractive as a
472 substitute for large ruminant meat. Moreover, it is a red meat with a taste which is quite similar to beef
473 and is usually identified as a substitute for beef by French consumers (Lamy et al, 2020). In France,
474 adult bovines (mainly beef) represent around a quarter of total meat consumption in France. The
475 substitution of part of beef consumption by horsemeat would thus meet the sustainability challenges
476 facing French food systems. Moreover, due to its nutritional qualities, eating horsemeat instead of beef
477 could lead to a reduction in the total quantity of meat consumed, as consumers do not need to eat as
478 much horsemeat as beef to get the same amount of iron, for example. Furthermore, horsemeat eaters
479 have a lower socio-economic status (study1 and study 2), which is commonly associated with
480 overweight (Vernay et al, 2009). From a nutritional point of view, our results show that current consumers
481 of horsemeat are heavy consumers of beef (study 2) and are rather overweight (study 1). Substituting
482 some of the beef consumed by horsemeat among these populations is therefore particularly beneficial
483 from a nutritional point of view, thanks to its low fat content and high fat quality. This nutritional
484 perspective, added to the fact that horsemeat is more environmentally friendly than beef, means that a
485 substitution of beef by horsemeat would lead to a reduction in the environmental impact of food systems,
486 and an improvement in the nutritional quality of the diet.

487 The sustainability of food systems requires, among other things, food and nutrition security. One of the
488 conditions for food security is that food should respect individual preferences. Thus, imposing the
489 consumption of horsemeat on consumers or populations for whom it is not acceptable for affective,
490 moral or taste preference reasons (aversion to red meat) would ultimately be contrary to the spirit of
491 sustainability. Our results (study 3) show that a significant proportion of current non-consumers do not
492 consume and do not buy horsemeat for affective and moral reasons. The market development plan for
493 horsemeat must therefore respect these preferences and target other consumers. Thus, the targets
494 identified in this research are either already consumers of horsemeat or non-consumers for whom the
495 consumption of horsemeat is acceptable. Based on the results of Study 1 and Study 3, we estimate that
496 these consumers would represent about 30-40% of the population.

497 5.3. What policies and strategies are needed to make this increase in consumption
498 possible and sustainable?

499 A critical element of the effects of horsemeat consumption on sustainability is the meat it replaces. For
500 horsemeat to substitute beef as much as possible, communication actions should emphasize the
501 benefits associated with this substitution.

502 But, the strategy to be adopted should differ according to the target.

503 Current non-consumers who would be prepared to eat it do not do so at present because they do not
504 think about it and because they cannot find it (study 3). This underlines the need for a policy to promote
505 this meat, and a distribution strategy to make it more visible, which includes increasing supply. The
506 promotion of the consumption of horsemeat could be achieved on the one hand by a communication
507 policy targeting the nutritional and environmental qualities of this meat, associated with a larger
508 distribution making it possible to find horsemeat in all meat outlets. Moreover, it would be useful to
509 develop and promote recipes and prepared dishes. On the other hand, an increase in the supply of
510 horsemeat in the catering sector (commercial or collective) could encourage those who have never
511 eaten it to try it.

512 Most current horsemeat eaters have a low socio-economic status and live in the north of France. Such
513 characteristics suggest a cultural heritage of food traditions inherited from the emergence of hippophagy
514 in France (Digard, 2012; Leteux, 2005; Roche, 2015). Horsemeat preferences could also be due to a
515 collective imagery that associates this meat with strength and virility. Promoting the image of strength

516 and virility of horsemeat would reinforce its attractiveness among the working class and low socio-
517 economic status groups, which is one target. Nevertheless, its relatively high price may be an obstacle
518 to increased consumption among these people. It is possible to find a high diversity of meats between
519 beef, veal and lamb, with a high price variance depending on the cut of meat, whereas the choice
520 between horsemeat cuts marketed at present is narrow, with only the most noble ones, so the most
521 expensive, on offer. A diversification of cuts of horsemeat marketed would thus lead to a wider range of
522 prices for this meat, and a more diversified use. An increase in consumption among people with a low
523 socio-economic status would then be easier. For current consumers with a higher economic status,
524 pricing will not be decisive whereas environmental and nutritional arguments could be.

525 **6. Conclusion**

526 In conclusion, the three studies performed in this research show that it is possible to increase the
527 consumption of horsemeat in France. Given the targets identified, this increase could be achieved by
528 substituting beef, thus leading to environmental and nutritional benefits. The principle of respect for
529 individual preferences, which is necessary for a sustainable diet, would entail the targeting of consumers
530 who are willing to consume horsemeat. This research thus identifies two targets (current consumers and
531 non-consumers willing to consume it), and discusses the policies to be put in place to make this increase
532 in consumption effective and sustainable.

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