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Abstract:

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

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

1. Introduction

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

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

From an environmental point of view, horse breeding has ecological benefits linked to the inherent nature of equines as non-ruminant herbivores (equine grazing), and to their specific land use in areas where other livestock are currently absent. In terms of equine grazing specificities, the absence of rumination leads to lower methane emissions compared to cattle (117.9 kg CH_4/dairy cow/year and 20.7 kg CH_4/horse/year in France) (Rzekęć et al., 2020). In addition, the breeding of heavy horses for meat

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

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

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

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

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

As Belaunzaran et al. (2015) point out, there are strong cultural differences between countries concerning the consumption of horsemeat and consequently strong differences in the quantities 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

syndicate. Demand for horsemeat rose to the point that imports became necessary from 1904 (Pierre, 2003). The number of shops increased, especially in Paris and in the large and medium-sized towns of France. In 1913, there were more than 300 horse butcher shops in the city of Paris alone (Roche, 2015).

From the second half of the 20th century, the consumption of horsemeat gradually declined (Figure 1), due to the convergence of several factors.

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

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

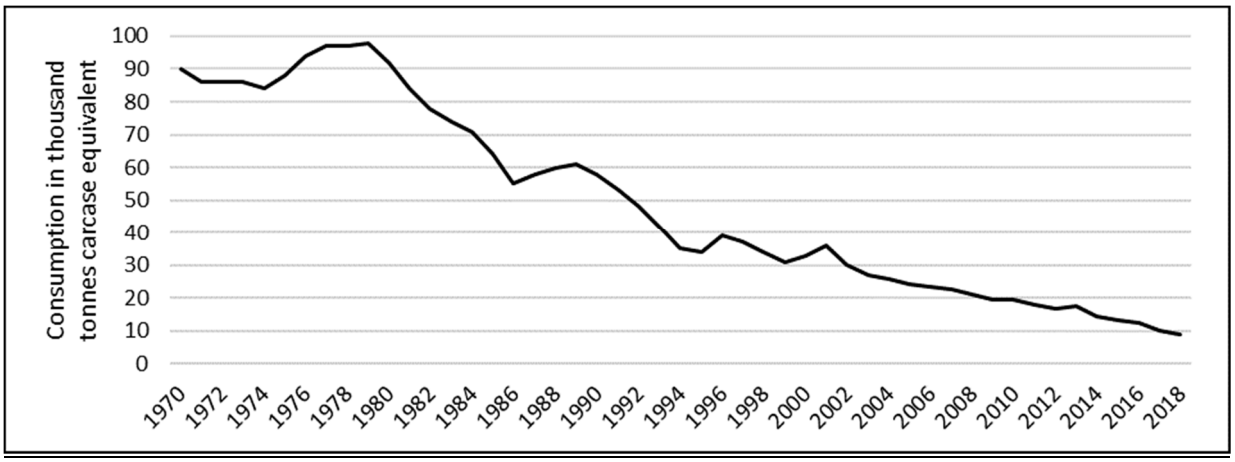

Figure 1: Evolution of horsemeat consumption in France since 1970 (IFCE)

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

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

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

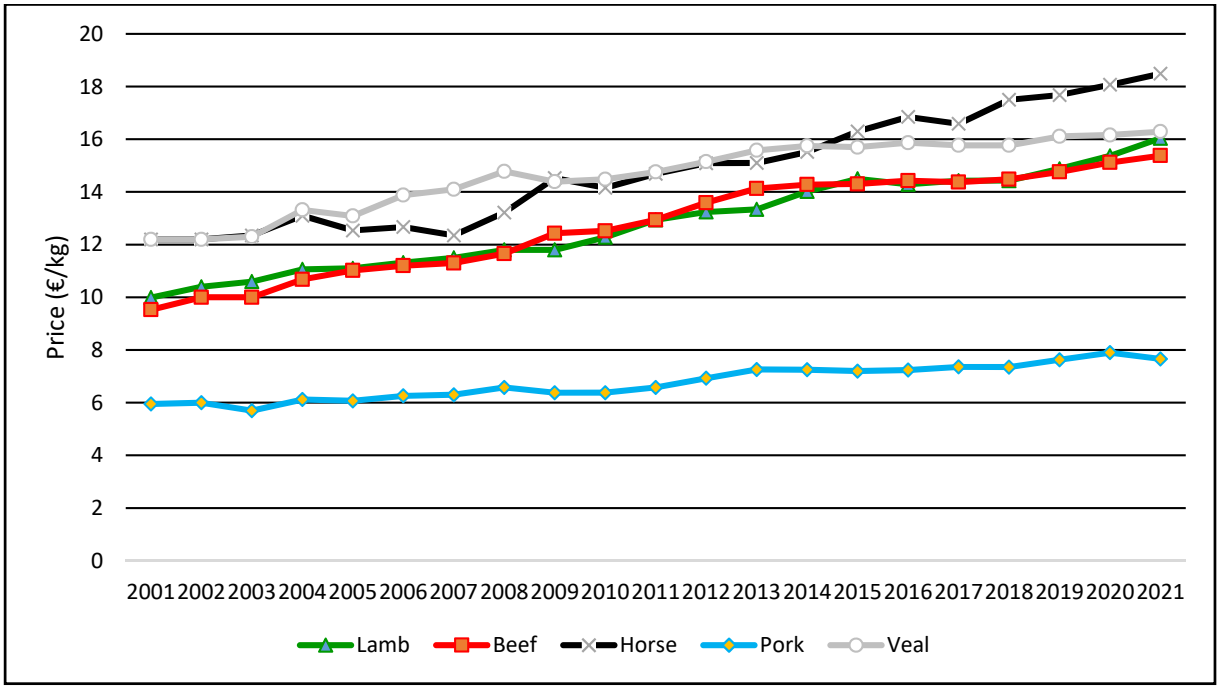

Figure 2: Evolution of retail meat prices since 2001 (IFCE)

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

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

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

3. Methodology

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

3.1. Kantar survey

3.1.1. Kantar data

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

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

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

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

The selection equation:

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

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

The decision model:

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

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

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

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

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

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

3.1.3. Kantar explanatory variables

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

3.2. INCA2 survey

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

Only adult meat consumers were considered in our study, resulting in a sample of 1006 men and 1430 women, among whom 1595 adults declared never consuming horsemeat (hereafter, "non-consumers (NC)"), 841 were raw or cooked horsemeat consumers (hereafter, "declared consumers (DC)"), among them 60 reported having consumed horsemeat during the surveyed week (hereafter, "factual consumers (FC)"). Our INCA2 sample is divided into three sub-samples such that 65.5% are NC, 34.5% are DC among them 2.5% are FC (due to the very short period - one week - of dietary reporting). To compare the profiles of individuals between samples, we run non-parametric tests such as Wilcoxon's test and Chi² tests.

3.3. Quantitative exploratory analysis of horsemeat representations

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

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

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

4. Results

4.1. Horsemeat purchases

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

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

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

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

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

Table 1

Impact of sociodemographic and economic variables on purchases of horsemeat in 2015 (estimated coefficients with the Cragg model)

	M1		M2		M3	
Variables	Truncated	Probit	Truncated	Probit	Truncated	Probit
Age						
18-44*	-0.22^{+}	-0.37**	-0.20	-0.35**	-0.20	-0.29**
	(0.125)	(0.060)	(0.125)	(0.060)	(0.133)	(0.063)
45-64 (Ref : reference)	Ref	Ref	Ref	Ref	Ref	Ref
65+	0.38**	0.08	0.40**	0.07	0.35**	0.05
	(0.121)	(0.065)	(0.122)	(0.065)	(0.124)	(0.065)
Country size						
Rural areas		-0.04		-0.04		-0.05
		(0.063)		(0.063)		(0.063)
Urban areas of 2000 to 199,999 inhabitants		Ref		Ref		Ref
Urban areas of 200,000 inhabitants and more + Paris		0.10^{+}		0.10^{+}		0.12*
		(0.058)		(0.058)		(0.058)
Region of residence						
North	0.18	0.20**	0.19^{+}	0.19**	0.19^{+}	0.18**
	(0.112)	(0.052)	(0.112)	(0.052)	(0.112)	(0.052)
South	Ref	Ref	Ref	Ref	Ref	Ref
Orchard owner						
Yes		0.01		0.01		0.02
		(0.058)		(0.057)		(0.058)
No		Ref		Ref		Ref
Vegetable garden						
Yes		0.11^{+}		0.11^{+}		0.10^{+}
		(0.058)		(0.058)		(0.058)
No		Ref		Ref		Ref
Monthly income €/CU						
Poverty line	0.14	0.15^{+}				
	(0.159)	(0.078)				
Poverty line to median income	0.08	0.08				
	(0.135)	(0.065)				
Median income to 7th decile	Ref	Ref				
>7th decile	0.35*	-0.05				
	(0.152)	(0.071)				
Body Mass Index						
Thinness	-0.17	-0.11	-0.08	-0.11	-0.16	-0.11
	(0.350)	(0.151)	(0.351)	(0.152)	(0.353)	(0.152)
Normal weight	Ref	Ref	Ref	Ref	Ref	Ref
Overweight	-0.07	0.17**	-0.08	0.17**	-0.08	0.16**
	(0.117)	(0.055)	(0.116)	(0.055)	(0.117)	(0.056)
Moderate obesity	0.20	0.28**	0.16	0.29**	0.17	0.27**
	(0.154)	(0.077)	(0.154)	(0.077)	(0.155)	(0.077)
Severe and morbid obesity	0.39^{+}	0.31**	0.35^{+}	0.32**	0.36^{+}	0.30**
	(0.210)	(0.108)	(0.209)	(0.108)	(0.210)	(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)
Child(ren) in household						
Yes		0.10		0.13*		0.15*
		(0.061)		(0.059)		(0.059)
No		Ref		Ref		Ref
Socio-professional status						
Farmer			-1.04	-0.51		
			(1.183)	(0.489)		
Senior executive			0.17	-0.16		
			(0.248)	(0.113)		
Student/Unemployed person			0.28+	0.04		
			(0.172)	(0.085)		
Employee/Manual worker			Ref	Ref		
Associated professionals			-0.04	-0.13*		
			(0.122)	(0.056)		
Self-employed			-0.35	-0.02		
			(0.272)	(0.131)		
Education level						
< Post-secondary qualifications					0.14	0.13*
					(0.128)	(0.062)
Baccalaureate					Ref	Ref
Bac +1st, 2nd, 3rd year university					0.16	-0.14*
					(0.159)	(0.073)
Bachelor's degree +					0.10	-0.18*
					(0.174)	(0.077)
Constant	6.08**	-1.50**	6.19**	-1.43**	6.12**	-1.48**
	(0.157)	(0.086)	(0.135)	(0.077)	(0.147)	(0.084)
Observations	5,031	5,031	5,031	5,031	5,031	5,031

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

340

341 **Table 2**
342 Impact of sociodemographic and economic variables on purchases of horsemeat in 2017 (estimated
343 coefficients with the Cragg model).

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

Child(ren) in household						
Yes		0.11+		0.12*		0.14*
		(0.063)		(0.061)		(0.061)
No		Ref		Ref		Ref
Socio-professional status						
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)		
Education level						
< 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

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

4.2. Horsemeat consumption

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

Table 3

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

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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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Characterization of horsemeat consumption among adults

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

What about the consumption of other meats?

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

4.3. Horsemeat representations

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

Statements on meat and horsemeat consumption (see Appendix 1) show that currently 91% of the sample are meat eaters, and 37% have already consumed horsemeat several times. Women and people aged 18-34 years are statistically less likely to consume horsemeat (respectively Khi2=24,3, p<0,0001 and Khi2=41,6, p<0,0001). Fifty-four percent of the whole sample have never eaten horsemeat but report eating other meats. However, among them, 331 respondents state that they cannot imagine eating horsemeat, either because they love the animal too much or for other moral reasons (33 % of the whole sample). For those who do not currently consume horsemeat, the respondents indicated that possible consumption of this kind of meat could be envisaged in the future. Thus 162 persons (16% of the whole sample) do not eat horsemeat because it is too expensive, it is too hard to find, it is not French-produced meat or they do not instinctively think about buying this kind of meat (16% of the whole sample). All these reasons might be related to production, marketing and retailing strategies. 49 other

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

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

Table 4

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

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

The "meat" category is poorly represented, with only 32 occurrences (see Table 4). Representations related to the concrete physical features of the animal (67 occurrences) are in the minority compared to the qualifiers and attributes of horses (physical qualification: 632 occurrences), with a lexical field that is more complete and abstract. The vast majority of these terms have a positive connotation, highlighting the beauty, nobility or grace of horses. These qualifiers contribute to a form of idealization of the animal, testifying to an imagery that is still present in the lineage of the aristocratic status of the horse (Leteux, 2012). Among the categories of occurrences, a macro-category (887 occurrences) can be created by grouping together three categories linked by the interaction between man and animal (racing with 381 occurrences, leisure with 290 occurrences, relationship with 216 occurrences). Finally, the results obtained underline the ambivalent status of the horse, which oscillates in a continuum with man at one pole and the animal at the opposite pole. The "animality" category (269 terms) brings the horse closer 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 (Khi2=62,7; $p=2,8.10^{-9}$), 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

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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

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

Table 6.

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

	Horsemeat non-consumers		Horsemeat consumers (3)	Comparison (1) to (2)	Comparison (2) to (3)
	Affective and moral reasons (1)	Other reasons (2)		tvalue (p)	tvalue (p)
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)

5. Discussion

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

5.1. Possible horsemeat market increase

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

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

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

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

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

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

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

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

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

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

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

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

6. Conclusion

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

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