Article

Discrete-choice-analysis of consumer preferences for meathybrids - Findings from Germany and Belgium

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Abstract: High levels of meat consumption are increasingly being criticised for ethical, environmental, and social reasons. Plant-based meat substitutes have been identified as healthy sources of protein that, in comparison to meat, offer a number of social, environmental and health benefits and may play a role in reducing meat consumption. However, there has been a lack of research on the role they can play in the policy agenda and how specific meat substitute attributes can influence consumers to replace partially replace meat in their diets.
In this paper, it is focused on consumers' preferences for so-called meathybrid or plant-meat hybrid products. In meathybrids only a fraction of the meat product (e.g. 20% to 50%) is replaced with plant-based proteins. Research demonstrates that in many countries consumers are highly attached to meat and consider it as essential and integral element of their daily diet. For these consumers which are not interested in vegan or vegetarian alternatives as meat substitutes, meathybrids could be a low-threshold option for a more sustainable food consumption behaviour.
In this paper the results of an online survey with 500 German and 501 Belgian consumers are presented. The results show that more than fifty percent of consumers substitute meat at least occasionally. Thus about half of the respondents reveal an eligible consumption behavior in respect to sustainability and healthiness at least sometimes. The applied Discrete-Choice-Experiment demonstrated that the analysed meat products are most preferred by the consumers. Nonetheless, the tested meathybrids variants with different shares of plant-based proteins took the second position followed by the vegetarian base alternative. Therefore, meathybrids could facilitate the diet transition of meat-eaters in direction to a more healthy and sustainable consumption. The analysed consumer segment is more open-minded to the meathybrid concept in comparison to the vegetarian substitutes.

Keywords: meat substitute; meathybrid; consumer preference, plant-based proteins

1. Introduction

There are more than 7.7 billion people on this planet, with forecasts predicting the population to grow to 9.7 billion by 2050 [1]. Securing a sustainable food supply for humankind is therefore becoming a major challenge. Diets with a high share of animal proteins must be adapted in order to ensure that demand is not outstripping production [2,3]. Furthermore, the consumption of meat and meat products in larger portions is associated with higher risks on prevalence of cardiovascular, coronary and cerebrovascular diseases, stroke, diabetes type 2 and colorectal cancer [4].
In addition to these health issues, meat production chains have a considerable impact on the environment through the use of land, application of fertilisers, greenhouse emissions, and water consumption resulting in loss of biodiversity and enhancing climate change [5–8]. Meat and meat

products are also associated with severe animal welfare issues, such as pigtail docking, poultry debeaking, calves separation and the mistreatment in slaughterhouses [9,10].
Integrating new protein sources into the diet means overcoming barriers such as traditional meat consumption across many cultures [11]. A promising strategy is to increase the share of plant proteins in the diet. This could be achieved by using, e.g. textured soy protein, mushroom, wheat gluten, pulses etc. as a complete substitute for animal-protein. Another opportunity is to replace only a fraction of the meat product (e.g. 20% to 50%) with plant-based proteins [12]. Research demonstrates that in many countries consumers are highly attached to meat and consider it as essential and integral element of their daily diet [13]. So-called meathybrids may be an option for the broad consumer segment that is not interested in totally vegan or vegetarian alternatives to meat. In meathybrids only a fraction of the meat product (e.g. 20% to 50%) is replaced by plant-based proteins. Therefore, meathybrids could serve as a low-threshold offer for this group, facilitating the transition in direction to a more healthy and sustainable diet.
As with many novel technologies, consumers' lack of understanding of hybrid meat products may led to scepticism and ultimately to the rejection of these. Through early integration of consumer demand and preferences into the development process, more suitable hybrid products can be designed. Understanding the decision-making process will help to develop tailored communication messages that highlight its benefits as a sustainable and healthy alternative to regular meat products.
The study aims on identifying consumer attitudes and preferences for meat alternatives such as meathybrids. Based on a concise literature overview, a representative online-survey was carried out in Germany and Belgium including a Discrete-Choice-Experiment (DCE) for four product categories (meat balls, chicken nuggets, salami, mortadella).

2. Consumer attitudes and preferences relating to meat and meat alternatives and meathybrid characteristics

The literature analysis focuses on the time period 2010-2020 for presenting the status quo of knowledge about consumer demand for meat and meat alternatives. Elderly articles entered the analysis only if these delivered a fundamental contribution to the research. The research databases and search engines - EBSCO host, Google Scholar, Research Gate and Science Direct were selected for literature research. The following search terms were chosen: meat consumption, food choice motives+meat, food choice & meat, meat alternatives, meat replacer, preferences & meat consumption, attitudes & consumption etc. Furthermore, in the found papers a cross-check was applied in order to identify additional papers.

2.1. Sensory

Concerning meat consumption, there is a consensus that consumer preferences are in particular affected by products' sensory characteristics. An inferior or low sensory quality can constitute a critical barrier for market entry of meat substitutes [14,15]. Therefore, meat substitutes respectively meathybrids must catch up with real meat products concerning sensory characteristics. A study carried out by Topcu *et al.* [16] demonstrated that the sensory quality factors aroma (29.6%) and visible quality (5.3%) explained most of Turkish consumers' preferences for red meat consumption compared to hedonic factors (e.g. product image, nutritional value, cost, meat source, durability, the origin of the meat).
Sensory appeal often is problematic in reducing or changing meat consumption to alternatives like *in vitro* (cultured, lab grown, etc.) meat, eating nose-to-tail (e.g., offal, hooves, eyes etc.) or entomophagy (eating insects) [14]. The replacement of meat by plant proteins without altering sensory characteristics as well as technological properties is a major challenge. Application of plant proteins is limited as their composition and properties highly depend on the isolation method as well as environmental factors. For example, Akwetey *et al.* [17] reported that only 5% of ground beef could be replaced with

whole cow-pea flour in emulsion-type sausages without any negative effects on their sensory and physico-chemical properties. ZAYAS and LIN[18] reported that the addition of 2% preswelled corn germ protein to frankfurters already changes the viscosity of the meat batter. Furthermore, an increase in off-flavour and off-aroma was observed with time in storage. Contrarily, especially high-moisture extrusion technology has advanced the production of vegan meat alternatives with high sensory acceptance in the last decade [19,20]. In this study, there was no sensory tasting, but consumers had to compare meat and meathybrids on their expected taste.

2.2. Environment

Meat production causes more emissions per unit of energy compared with that of plant-based foods because energy is lost at each trophic level. It is the most important source of methane, which has a relatively high global warming potential, but a lower half-life in the environment compared with that of CO_2 [21]. Carbon footprint of plant-based foods on average is twice as low as impact of pork [22], while the impact in some other categories can be more than 60 times lower [23]. Own calculations based on Agri-Footprint database [24] show that the incorporation of plant biomass into pork products in equal proportion can lead to a reduction of their environmental impact.
The majority of Western European consumers are not aware that meat consumption has a large environmental impact [14,25,26]. Contrarily, Apostolidis and McLeay[27] stated that the ecological rationale for switching to meat alternatives is being recognised but cannot overcome sensory shortcomings (see above). Concerning consumer segments, Mullee *et al.*[28] found that vegetarians are more likely to agree that meat production is bad for the environment and unhealthy.
In this study we analyse the impact of a CO_2-label on the choice of meat hybrids.

2.3. Animal Welfare

A study among Belgian consumers explored the relationship between morality and diet choice by investigating how animal and human welfare attitudes can predict a meat eating vs. flexitarian vs. vegetarian diet [29]. Results show that animal health concerns (measured via an animal attitude scale) can predict diet choice. Vegetarians are most concerned, while full-time meat eaters are least concerned. The contrast between flexitarians and vegetarians is greater than the contrast between flexitarians and full-time meat eaters [29]. Due to the lower meat content, it is to expect that consumers consider meathybrids as better for the animal welfare in comparison to a 'pure' meat product.

2.4. Health Consciousness

It is known that frequent consumption of processed meat can increase the risk of cardio vascular diseases as well as all-cause mortality [30,31]. By contrast a higher intake of whole grains, legumes, and nuts is associated with cardiovascular benefits due to the intake of less saturated fatty acids and dietary cholesterol and more soluble fibers and poly unsaturated fatty acids [32,33]. However, plant proteins often have an incomplete amino acid profile because certain essential amino acids are not present in sufficient quantities, e.g. sulfuric amino acids in legumes or lysin in cereals. For this reason they must be mixed with other vegetable proteins or food that contain these amino acids in sufficient concentrations [34].
It is to highlight, that many consumers consider meat products as an important source of nutrients and a traditional component of their diet. It is generally perceived as a healthy food [35]. Concerning gender, in the latter study women tended to be more interested in plant foods (meat is often associated with masculinity). A quarter of the respondents believed that eating vegetarian food frequently is unhealthy. Like in the study of De Backer and Hudders[29] omnivores associated meat with good health and disagreed that meat production is bad for the environment. Perceived healthiness has been a positive predictor of red meat consumption. Furthermore, among omnivores and flexitarians that

represent a potential target group for meathybrids, there are large consumer segments that consider meat substitutes as unhealthy and artificial. Thus in the communication strategy for meat substitutes the mentioned prejudice must be dealt with and re-framed. In this study the health consciousness scale (HS) in the style of Visschers *et al.*[36] was selected for measuring the impact of this psychometric construct on the choice of hybrid products. Furthermore, two health claims and their impact on the choice of meathybrids were analysed.

2.5. Meat Attachment Scale (MEAS)

Recent research put forward the idea that consumers have an affective connection towards meat that may play a role in their willingness to change consumption habits [13]. It is argued that the affection towards meat may represent a continuum in which one end refers to disgust (i.e., negative affect and repulsion, related with moral internalization), while the other shows a pattern of attachment (i.e., high positive affect and dependence towards meat, and feelings of sadness and deprivation when considering abstaining from meat consumption) that may hinder a change in consumption habits [13]. Meat attachment mirrors the main characteristic of the general concept of attachment, which is the presence of a positive bond and desire to maintain closeness to the object of attachment.
In this study 15 out of the 16 items of the Meat Attachment Questionnaire of Graça *et al.*[13] were selected for measuring the impact of this psychometric construct on the choice of hybrids.

2.6. Food Neophobia Scale (NPS)

Food neophobia refers to reluctance to eat unfamiliar foods [37]. It has been the subject of a plethora of studies across many countries, and it affects the quality as well variety of foods in the diet [38–42]. The knowledge about population segments that have greater or lesser neophobia, allows to identify early adopters of innovative products [43].
According to Tucker[15] more elderly consumers more likely hold negative views towards in vitro meat. They saw in vitro not as real meat, not as something natural, and hence unhealthy. It is to hypothesise, that this finding could hold for meathybrids that are partly highly processed as well. According to Apostolidis and McLeay[27] low levels of acceptance for meat substitutes have been associated with high levels of the construct food neophobia.
In this study the food neophobia scale (NPS) of Pliner and Hobden[37] was selected for measuring the impact of this psychometric construct on the choice of meathybrids.

2.7. Product familiarity

According to Hoek *et al.*[44] the unfamiliarity with meat substitutes is a key barrier for non-users and light/medium-users. Similarly, Schösler *et al.*[45] found that lack of familiarity hampers a change to real vegetarian meals.
In this study consumers are asked for their previous consumption of meat substitutes and the impact of product familiarity on the choice of hybrids is analysed.

3. Data collection and methods of data analsyis

Consumer data was collected using a quantitative online survey approach. The respondents were panelists and have been been recruited by the market research company Savanta (London, UK). The questionnaire comprised questions to the general meat consumption on the one hand and specific question concerning preferences for meat substitutes on the other hand.

So-called choice experiments were integrated in the survey for measuring the importance and preference of different levels of plant-based protein shares in mortadella, salami, chicken nuggets and meat balls. Choice experiments have been shown to reduce social desirability bias [46], as individuals

often display socially desirable preferences in surveys [47].
The online survey was carried out in Germany with 500 and in Belgium with 501 respondents. Participants had to be meat eaters and thus vegetarians and vegans have been sorted out a priori. Furthermore, the participants had to be mainly, respectively to 50% responsible for food shopping in the household.
The study design and the practicability of the experiment were tested in a pretest with 20 participants. The pretest results led to slight changes in the questionnaire design. Data collection took place in the time period from 8th November until 19th November 2019 (see Table 3).
In the result section we report descriptive results. For scale development (NPS, MEAS, HS) Cronbach's alpa was applied [48]. Furthermore, confirmatory factor analyses were run to confirm the validity of the scales by using the R-package psych [49]. For measuring NPS the list of Pliner and Hobden[37] was selected. The wording of the German version has been chosen from a study by [50]. Participants answered on a five-point response scale that verbally and numerically anchored (1=totally disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=totally agree). The five-point scale was used instead of the originally used seven-point scale for a better display of the questionnaire on tablet and smartphones. The items indicated with (r) in Table 6 were inversely re-coded. Considering that the inclusion of invalid items creates the risk of invalid conclusion [51], a principal components analysis (Varimax rotation, eigenvalues greater than one) was carried out to explain the variability of the NPS followed by a confirmatory factor analysis.
For MEAS participants answered on a five-point response scale that was verbally and numerically anchored (1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree). The items indicated with (r) in Table 6 were inversely re-coded. Likewise, for the HS a principal component analysis was carried out followed by a confirmatory factor analysis [48].
Furthermore, a multinomial logistic regression model was applied for measuring the impact of several parameters on the the choice of meat and meathybrid products. Data was collected via a Discrete-Choice-Experiment (DCE).

3.1. Discrete-Choice-Experiment (DCE) and Experimental Design

DCE method is based on micro-economic theory according to which consumers always try to maximize their benefit [52]. In DCEs, consumers must choose from a set of different products offered at determined prices. The products differ regarding the tested product attributes (e.g. share of local feed, price, etc.). According to micro-economic theory, participants will choose the product with the highest benefit. By means of DCEs, consumers' benefit for each tested product attribute can thus be revealed, as well as the influence of each product attribute on the probability of purchasing/choosing the product.
In the DCE of this study the products varied by six attributes: plant-based protein share, EU-organic-label, origin label for the protein source, environmental claim, nutritional label, and price (see Table 1). The EU-organic-label was included since previous studies had shown the importance of this aspect to consumers. The five price levels used in the choice experiment were within the price range that encompassed observed market prices at food retailers in Germany during the winter of 2018/19. The reported attributes and attribute levels were used for generating the experimental design of the choice experiment. The DCE was carried out for four product categories (meatballs, mortadella, salami, chicken nuggets) on the basis of the same underling experimental design structure.

In each choice set, consumers had the choice between four product alternatives and a no-choice option. The no-choice option was included to get a more realistic purchase situation and thus raise the validity of the data [53]. Furthermore, there was always one 100% meat option and one vegetarian option in the sets whereas for two options the plant-based protein share varied between 50% and 20%.

A D-efficient unlabelled design (.949) was generated using the software Ngene [54] and for each product category eight choice sets were generated. Thus in total there were 32 choice-sets. The priors used were based on on expert judgement and literature.

attributes	levels
plant-based protein share	100% (vegetarian), 50%, 35%, 20%, 20, 0% (meat)
EU organic label	yes, no
origin label prot. source	locally produced produced in Ger/Belg no indicated origin
environmental claim	20% reduced carbon foot print no indicated claim
nutritional label	high content of non-saturated fatty acids high in fibre no indicated label
price	high, middle, low

Table 1. Attributes and attribute levels used in the DCE Attribute

Each participant received two choice-sets from each product category and thus had to answer in total eight choice sets. The survey order of the choice sets of the alternatives was randomised to prevent ordering effects [55]. The products respectively the characteristics were depicted in photographs (see Table 2).

	Meat ball 1	Meat ball 2	Meat ball 3	Meat ball 4
				
	300g	300g	300g	300g
Ingredients (plant-based protein share)	100% pork	50% pork + 50% plant-based protein seed	65% pork + 35% plant-based protein seed	100% vegetarian
Organic label				
Price	3.29	2.29	2.29	2.29
Origin of meat resp. plant-based protein source	Locally produced			Produced in Germany
Environmental Claim		20% reduced carbon foot print		
Nutrional Label		high content of non-saturated fatty acids		

Table 2. Choice-set example - meat balls

3.2. Theoretical Background

3.3. Multinomial logistic regression

Multinomial logistic Regression is the regression analysis to conduct when the dependent variable is nominal with more than two levels. It is used to model nominal outcome variables, in which the log

odds of the outcomes are modeled as a linear combination of the predictor variables. The multinomial logistic model belongs to the family of generalized linear models and as mentioned is used when the response variable is a categorical variable.
Suppose that variable Y_i represents the offered alternatives in a choice experiment (e.g. choice between meat and meathybrid), with i= 1,..., n and n is the number of possible product alternatives. In case n equals 2 and Y has outcomes Y_1 and Y_2. Both the counts of Y_1 and Y_2 follow a binomial distribution. The probability of occurrence of Y_1 is π_1 and that of Y_2 is π_2. Logistic regression relates probability π_1 to a set of predictors using the logit link function:

$$logit(\pi_1) = ln(\frac{\pi_1}{\pi_2}) = ln(\frac{\pi_1}{1-\pi_1}) = \mathbf{x}'\beta \tag{1}$$

where $\mathbf{x}$ is a vector of predictors (e.g. NPS, MEAS or buying frequency of organic meat), and β is a vector of model coefficients that are typically estimated by maximum likelihood. Equation 1 can be rewritten as:

$$(\frac{\pi_1}{1-\pi_1}) = exp(\mathbf{x}'\beta) = exp(\eta) \tag{2}$$

The quotient in Equation 2 is referred to as the odds. From Equation 2 follows that:

$$\pi_1 = \frac{exp(\eta)}{1+exp(\eta)} \tag{3}$$

The binomial logistic regression model is easily generalized to the multinomial case. If there are n product alternatives there are also n variables Y_1,..., Y_n with corresponding probabilities of occurrence π_1,..., π_n. Analogous to binomial logistic regression the odds π_1/π_n,..., $\pi_n - 1/\pi_n$ are modelled by means of $exp(\eta_1)$,..., $exp(\eta_{n-1})$. From $\sum_{i=1}^{n} \pi_i = 1$ it follows that:

$$\pi_1 = \frac{exp(\eta_i)}{exp(\eta_1) + exp(\eta_2) + ... + exp(\eta_n)} \tag{4}$$

where $exp(\eta_n)$= 0. This model ensures that all probabilities are in the interval [0,1] and that the probabilities sum to 1.
In this paper the dependent variable is taken from the DCE where respondents had to indicate if they would buy/choose one out of the four offered options or none of these options. The NPS, HS and MEAS as well as other parameters entered the regression analysis as independent variables. In addition, all three scales were interacted with the different levels of the attribute 'plant-based protein share' for analysing their effect on meat, hybrids and the vegetarian alternative.
Given the theoretical background, an model was built according to the following expression:

$$\begin{aligned}
\mathbf{x}'\beta = &\text{meat} * \beta_1 + \text{meat+50plant} * \beta_2 + \text{meat+35plant} * \beta_3 + \text{meat+20plant} * \beta_4 \\
&+ \text{reduced CO2} * \beta_5 + \text{organic} * \beta_6 + \text{Ger/Bel origin} * \beta_7 + \text{local origin} * \beta_8 \\
&+ \text{high in fibre} * \beta_5 + \text{high of nsf. acids} * \beta_6 + \text{price} * \beta_7 \\
&+ \text{HS x meat} * \beta_8 + \text{HS x meat+50plant} * \beta_9 + \text{HS x meat+35plant} * \beta_{10} \\
&+ \text{HS x meat+20plant} * \beta_{11} + \text{NPS x meat} * \beta_{12} + \text{NPS x meat+50plant} * \beta_{13} \\
&+ \text{NPS x meat+35plant} * \beta_{14} + \text{NPS x meat+20plant} * \beta_{15} + \text{MEAS x meat} * \beta_{16} \\
&+ \text{MEAS x meat+50plant} * \beta_{17} + \text{MEAS x meat+35plant} * \beta_{18} + \text{MEAS x meat+20plant} * \beta_{19} \\
&+ \text{FAMILIARITY x meat} * \beta_{20} + \text{FAMILIARITY x meat+50plant} * \beta_{21} \\
&+ \text{FAMILIARITY x meat+35plant} * \beta_{22} + \text{FAMILIARITY x meat20plant} * \beta_{23} + \text{no-option}
\end{aligned} \tag{5}$$

From the estimation results odds ratios are calculated. Odds ratios in logistic regression can be interpreted as the effect of a one unit of change in X in the predicted odds ratio with the other variables in the model held constant.
In this study for estimating the specified model the software R [56] and the package mlogit [57] were used. For visualisation of odds ratios from the estimated model the package sjplot [58] was applied.

		Germany		Belgium	
attribute	characteristics	n	%	n	%
gender	male	245	49.0	245	48.9
	female	255	51.0	256	51.1
federal state	Baden-Württemberg | Bruxelles	66	13.2	62	12.4
	Bayern | Brabant wallon	75	15.0	27	5.4
	Berlin | Hainaut	22	4.4	68	13.6
	Brandenburg | Liège	15	3.0	44	8.8
	Bremen | Luxembourg	5	1.0	13	2.6
	Hamburg | Namur	10	2.0	27	5.4
	Hessen | Antwerpen	37	7.4	88	17.6
	Mecklenburg-Vorp. | Provincie Limb.	10	2.0	20	4.0
	Niedersachsen | Oost-Vlaand.	50	10.0	58	11.6
	Nordrhein-Westfalen | Vlaams-Brab.	114	22.8	60	11.9
	Rheinland-Pfalz | West-Vlaand.	20	4.0	34	6.8
	Saarland	5	1.0		
	Sachsen	26	5.2		
	Sachsen-Anhalt	15	3.0		
	Schleswig-Holstein	15	3.0		
	Thüringen	15	3.0		
age	$<$ 25 years	65	13.0	59	11.8
	25-34 years	66	13.2	94	18.8
	35-44 years	99	19.8	100	20.0
	45-54 years	84	16.8	99	19.8
	55-64 years	73	14.6	71	14.2
	$>$ 64 years	113	22.6	78	15.6
education	no school qualifications	2	0.4	22	4.4
	still in school	4	0.8	18	3.6
	junior high diploma	88	17.6	20	4.0
	high school diploma	193	38.6	229	45.7
	university-entrance diploma	105	21.0	78	15.6
	bachelor or master degree	89	17.8	122	24.4
	other degree	19	3.8	12	2.4
net income	no income	26	5.2	39	7.8
	less than 500	30	6.0	19	3.8
	500 up to 1.000	46	9.2	36	7.2
	1.000 up to 1.500	95	19.0	98	19.6
	1.500 up to 2.000	92	18.4	115	23.0
	2.000 up to 2.500	69	13.8	89	17.8
	2.500 up to 3.000	57	11.4	38	7.6
	3.000 up to 3.500	27	5.4	27	5.4
	3.500 up to 4.000	25	5.0	23	4.6
	4.000 or more	33	6.6	17	3.4
household size	1	121	24.2	112	22.4
	2	207	41.4	164	32.7
	3	92	18.4	96	19.2
	4	55	11.0	82	16.4
	5	20	4.0	33	6.6
	6	4	0.8	9	1.8
	$>$6	1	0.2	5	1.0

Table 3. Sample

4. Results

4.1. General buying behaviour

At the beginning of the questionnaire the participants had to indicate where they buy most of their meat products. The classical retailer took the first position (48.6%) followed by discount shops (38.6%). Butcheries were on third position (10.2%). All other options were only of minor importance (see Figure 1).

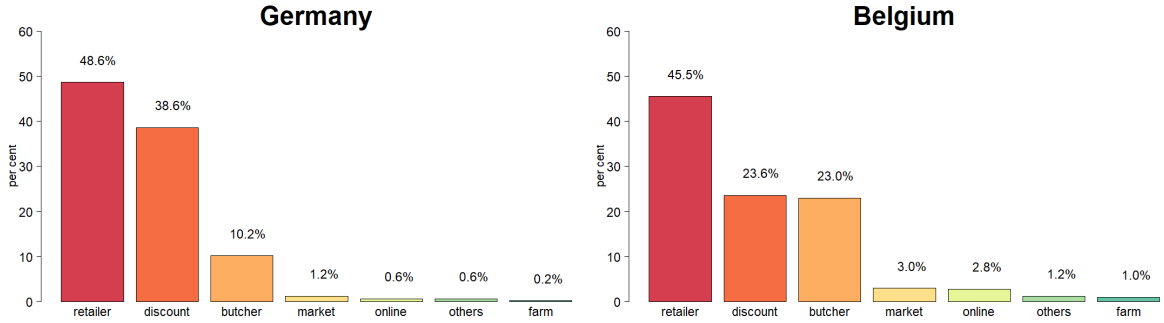

Figure 1. Preferred buying location of meat/meat products

Furthermore, respondents were asked for their buying frequency of organic respectively free-range meat. About 22% of the participants indicated to buy such products often (18.2%) or always (4.2%)(see Table 4). In 2019 a survey was conducted by Kitchen Stories investigating the purchasing behavior towards organic food in Germany. In the mentioned study, somewhat higher values were found with 13.2% bought mostly organic products, while for 18.6% of the respondents organic food made up more than half of the shopping cart.

	Germany	Belgium
never	24.4%	15.4%
sometimes	57.7%	62.2%
often	15.2%	18.2%
always	3.0%	4.2%

Table 4. Buying frequency organic/free-range meat

4.2. Scales: Meat Attachement Scale (MEAS),Neophobia Food Scale(FNS) and Health Scale(HS)

4.2.1. Meat Attachement Scale (MEAS)

In Germany, due to the confirmatory factor analysis the item "I would feel fine with a meatless diet" was deleted from the scale because in the four-factor solution this item has a similar loading on different factors and its deletion increased the calculated indices. The reliability analysis for the global MEAS showed in Germany a high internal consistency with a standardized Cronbach α of .86. The Comparative Fit Index (CFI=.962), the Tucker-Lewis Index (TLI=.952) and the Root Mean Square Error of Approximation (RMSEA= .060) showed acceptable values.
In Belgium, likewise due to the confirmatory factor analysis the item "I would feel fine with a meatless diet" was deleted from the scale because in the four-factor solution this item has a similar loading on different factors. The reliability analysis for the global MEAS showed a high internal consistency with a standardized Cronbach α of .86. The Comparative Fit Index (CFI=.959), the Tucker-Lewis Index (TLI=.947) and the Root Mean Square Error of Approximation (RMSEA= .067) showed acceptable values.
In comparison to Graça *et al.* [13] in both countries we received higher values for the non-reversed

items and lower values for the reversed item what is due to the fact that vegans and vegetarians were not part of this study (see Table 5). On average respondents agree to all of the statements. The highest means received the statements "I love meals with meat" (3.94) and the reverse-coded item "Meat reminds me of diseases". The MEAS findings demonstrates that on average German and Belgium respondents consider meat not as an unhealthy product but as an essential part of their diet.

4.2.2. Food Neophobia Scale (NPS)

For Germany, after deleting two items from the original NPS-list due to low item-correlations in the reliability analysis and one item due to the confirmatory factor analysis, NPS showed an acceptable internal consistency with a standardized Cronbach α of .76 (see Table 6). The confirmatory factor analysis (two-factor-solution) produced acceptable values for the three considered indices (CFI=.961 TLI=.937 and RMSEA=.074). The deleted items were: "I do not trust new (different or innovative) food", "If I don't know what a food is, I won't try it", "I am very particular about the food I eat". For use in the regression analysis the individual scores, that is the z-standardised mean value across the seven items were calculated. The higher the NPS-score is, the higher is indiviudals' food neophobia. For Belgium, item no. 9 had to be deleted due to the findings of the confirmatory factor analysis and the NPS showed an acceptable internal consistency with a standardized Cronbach α of .75. The comparative fit index (CFI=.949) and the Tucker-Lewis Index (TLI) (.929) as well as the Root Mean Square Error of Approximation (RMSEA) .073 showed acceptable values for the two-factor solution.

4.2.3. Health Scale (HS)

For the applied HS in Germany (α=.81) and Belgium (α=.88) acceptable internal consistencies could be measured (see Table 7).

	Germany			Belgium		
statement	std. α	$\overline{x}$	σ	std. α	$\overline{x}$	σ
I love meals with meat.	0.84	3.94	1.00	0.84	3.69	1.03
To eat meat is one of the good pleasures in life.	0.85	3.38	1.08	0.84	3.36	1.10
I'm a big fan of meat.	0.84	3.58	1.07	0.84	3.58	1.07
A good steak is without comparison.	0.84	3.76	1.12	0.85	3.43	1.13
By eating meat I'm reminded of the death and suffering of animals.(r)	0.86	3.50	1.19	0.87	3.42	1.25
To eat meat is disrespectful towards life and the environment.(r)	0.86	3.30	1.19	0.87	3.23	1.12
Meat reminds me of diseases.(r)	0.86	3.86	1.18	0.87	3.70	1.15
To eat meat is an unquestionable right of every person.	0.86	3.57	1.12	0.86	3.60	1.05
According to our position in the food chain, we have the right to eat meat.	0.86	3.68	1.13	0.87	3.70	1.15
Eating meat is a natural and indisputable practice.	0.85	3.75	0.98	0.85	3.58	1.00
I don't picture myself without eating meat regularly.	0.85	3.56	1.14	0.85	3.44	1.10
If I couldn't eat meat I would feel weak.	0.85	3.12	1.19	0.85	3.07	1.07
I would feel fine with a meatless diet.		3.32	1.14		3.11	1.11
If I was forced to stop eating meat I would feel sad.	0.85	3.38	1.15	0.85	3.35	1.14
Meat is irreplaceable in my diet.	0.84	3.43	1.11	0.85	3.29	1.02

Note: 5-point Likert scale: 1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree)

Table 5. Meat attachement questionnaire scale (MEAS)

	Germany			Belgium		
statement	std. α	$\bar{x}$	σ	std. α	$\bar{x}$	σ
I am constantly sampling new and different food. (r)	0.74	2.75	1.17	0.74	2.79	1.14
I do not trust new (different or innovative) food.		2.93	1.11	0.73	2.81	1.05
If I don't know what a food is, I won't try it.		3.85	1.00	0.74	3.16	1.08
I prefer food from different cultures. (r)	0.72	2.59	1.07	0.75	2.92	1.03
I am reluctant to eat foreign food that I see for the first time.	0.75	2.96	1.21	0.71	2.86	1.17
If I go to a buffet, meetings or parties, I'll eat new food. (r)	0.73	2.32	1.09	0.73	2.45	0.99
I'm afraid to eat food that I did not eat before.	0.74	2.49	1.23	0.71	2.66	1.18
I am very particular about the food I eat.		2.94	1.13	0.74	3.00	1.26
I will eat almost anything. (r)	0.76	2.32	1.13		2.65	1.20
I like to try new ethnic restaurants. (r)	0.70	2.36	1.10	0.73	2.61	1.07

Note: 5-point Likert scale: 1=totally disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=totally agree)

Table 6. Food neophobia scale (NPS)

	Germany			Belgium		
statement	std. α	$\bar{x}$	σ	std. α	$\bar{x}$	σ
I think it is important to eat healthily	0.74	5.78	1.30	0.83	5.52	1.43
My health is dependent on how and what I eat	0.67	5.38	1.40	0.80	5.29	1.49
If one eats healthily, one gets ill less frequently	0.82	5.33	1.37	0.88	5.14	1.53

Note: 5-point Likert scale: 1=totally disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=totally agree)

Table 7. Health scale (HS)

4.3. Consumption and perception of substitutes

The survey questionnaire comprehended several direct questions about the consumption of meat substitutes. In this context respondents were asked if they deliberately substitute meat on the days they do not eat meat. In this context a high proportion of 54.2% of the respondents stated to choose consciously meatless alternatives (see Table 8).

	Germany	Belgium
	%	%
yes	54.2	58.7
no	45.8	41.3

Table 8. Deliberate substitution of meat on the days respondents do not eat meat

Subsequently, this group had to indicate with which products they concretely substitute meat. For this purpose they received a list of twelve products from that up to three products could be chosen. The option fish was selected by 48.3% of this segment in Germany and 66.7% in Belgium, followed by cheese (G:47.6%, B:29.6%), eggs (G:41.7%, B:58.8%), pasta (G:39.5%, B:36.7%) and salad (G:35.4%, B:16.7%) as most preferred substitutes (see Table 9). It is to highlight that the top three on the list are non-vegan alternatives whereas vegan alternatives like protein-rich lentils, tofu, or seitan were only of minor importance.

Additionally, all respondents were asked how often they buy plant-based meat substitutes, such as veggie burgers. Interestingly, only 4.0% indicated to consume such products frequently whereas 14.4% stated to do so at least sometimes (see Table 10).

In the study, respondents had to indicate if they consider either meathybrids or meat as tastier. Furthermore, they had to decide which of the alternatives is better for the environment, better for animal welfare and healthier.

	Germany		Belgium	
nr	product	%	product	%
1	Fish	48.3	Fish	66.7
2	Cheese	47.6	Egg(s)	58.8
3	Egg(s)	41.7	Pasta	36.7
4	Pasta	39.5	Cheese	29.6
5	Salad	35.4	Salad	16.7
6	Other legumes	15.1	Lentils	10.9
7	Lentils	9.6	Nuts	6.5
8	Nuts	8.9	Other legumes	5.4
9	Tofu	6.3	Tofu	5.1
10	Seitan	1.8	Other	2.3
11	Other	1.1	Tempeh	1.0
12	Tempeh	0.4	Seitan	0.7

Table 9. Ranking list consumed meat alternatives

	Germany	Belgium
	%	%
never	45.6	41.3
tried it once	16.0	14.6
rarely	20.0	23.2
sometimes	14.4	16.6
frequently	4.0	4.4

Table 10. Frequency of consumption of meat alternatives such as veggie burgers

Concerning the parameters environment and animal welfare the meathybrid was evaluated much better then the meat option (see Table 11). Contrarily, meat was perceived as tastier in comparison to the meathybrid by 62.4% of the respondents in Germany and 62.7% in Belgium.
Concerning the perceived healthiness the findings differ between the countries. Whereas in Germany the hybrid is perceived as healthier, the opposite holds for Belgium.

	Germany			Belgium		
	meat	neither/nor	hybrid	meat	neither/nor	hybrid
tastier	**62.4%**	20.8%	16.8%	**62.7%**	14.0%	23.4%
healthier	31.0%	27.2%	**41.8%**	**45.3%**	14.4%	40.3%
better for environment	15.8%	31.0%	**53.2%**	22.6%	24.2%	**53.3%**
better for animal welfare	15.6%	26.8%	**57.6%**	20.2%	28.9%	**50.9%**

Table 11. Perception meat vs. hybrid

4.4. Multinomial logit regression analysis

In the multinomial regression analysis, it was explored whether the MEAS, the NPS, the HS and all other analysed parameters had an impact on the decision in the DCE (see section 3.3 for the applied model). In the DCE the respondents were directly asked if they would choose one out of the four offered product alternatives or none of these products.
On the basis of the carried out choice experiments four logistic regression models for the product categories mortadella, chicken nuggets, salami and meat balls were calculated for Germany and four models for Belgium (see Table 12). In the estimation models, the vegetarian option was set as reference category for the estimation against the alternatives meat, meat+50%-plant-based protein seed, meat+35% plant-based protein seed and meat+20%-plant-based protein seed.

As expected the price parameter is negative and significant in all models and with one exemption whereas the organic label predominantly exerts an positive effect on product choice.
The coefficients for the meat options were all significant and revealed the highest positive values in comparison to all other parameters. Thus, the fact that the product is a pure meat product has the highest relevance in the analysed sample of meat eaters. Nonetheless, it is to highlight that all coefficients for the meathybrids were positive too and out of the 24 coefficients for hybrids 15 have been significant. That is, the vegetarian product was the least preferred in the experiment whereas the pure meat products had the highest consumer preference followed by the hybrids. For the plant-based shares of 50%, 35% and 20% in the meathybrids no real preference order can be stated. In dependence of the country and the product category sometimes the plant-based share of 50% is the most preferred option (e.g. nuggets in Germany=.930***) and sometimes the lowest share (e.g. meat balls in Belgium=.837*). Nonetheless, it can be generalised that the hybrids perfom better in the DCE compared to the vegetarian alternative. Furthermore, a previous use of meat substitutes has a positive impact on the choice of hybrids in particular for a 50% plant-based protein share (7 out of 8 cases). Contrarily, this parameter has a negative impact on the choice of the meat alternatives in the product categories mortadella, salami and meat balls.
Concerning the environmental label 'reduced CO_2' six out of the eight coefficients are positive and significant. Thus, the use of such a label on the product packaging for hybrids can be recommended. For the applied health labels this holds only for the product category chicken nuggets and the claim "high of non-saturated acids" whereas for the other products no such effect could be measured. Across all products and countries the local origin has a positive effect on product choice (6 out of 8 parameters are significant) whereas these holds for the national labels only for Germany.
As expected, the MEAS exerts in both countries a positive impact on the preference of the meat alternatives in all product categories whereas for the hybrids there are only few significant parameters (3 out of 24). Therefore, this psychological construct represents a barrier for the consumption of hybrids or vegetarian alternatives because it directly increases the preference for the default option "pure" meat.
Concerning the HS, it can be stated that the lower the health consciousness is, the lower is the preference for meat. Interestingly, for most of the hybrid variants across product categories and countries (19 out of 24 parameters) there are no significant differences between the hybrid variants and the vegetarian alternatives. Thus, it can be concluded that on average the health conscious segment sees no serious differences in the health characteristics of these options. That is, the vegetarian and hybrids alternatives are seen both as healthier compared to the meat alternative from this segment.
For the impact of NPS on the preference of hybrids the results are quite mixed. Only nine out of 24 parameters are significant and no real order or systemic behaviour can be identified. Therefore, the hypothesis, that food neophobia is a barrier for the choice of hybrids can not be affirmed. In this context, it is to point out that in Belgium the NPS even reduces the choice probability of the pure meat alternatives (3 out 4 cases significant) whereas no such effect can be found in Germany.
In the Figures 2 and 3 the odds ratios of the estimations are graphically displayed. The figures clearly show that the sample has with far distance the highest preference for the pure meat alternatives.

	Mortadella		Salami		Nuggets		Meat balls	
	GER	BEL	GER	BEL	GER	BEL	GER	BEL
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
meat	1.596***	1.713***	1.869***	2.001***	2.508***	2.322***	1.614***	1.828***
	(0.143)	(0.154)	(0.126)	(0.134)	(0.158)	(0.152)	(0.152)	(0.158)
meat+50plant	0.372**	0.486***	0.137	0.549***	0.930***	0.601***	0.138	0.770***
	(0.167)	(0.170)	(0.178)	(0.171)	(0.208)	(0.210)	(0.187)	(0.178)
meat+35plant	0.202	0.100	0.473*	0.598**	0.107	1.222***	0.187	0.203
	(0.244)	(0.274)	(0.260)	(0.241)	(0.366)	(0.250)	(0.265)	(0.314)
meat+20plant	0.205	0.482**	0.473**	0.643***	0.925***	0.662***	0.366	0.837***
	(0.269)	(0.236)	(0.208)	(0.227)	(0.241)	(0.233)	(0.236)	(0.222)
reduced CO2	0.557***	0.355**	0.426**	−0.014	0.120	0.361**	0.311*	−0.113
	(0.150)	(0.159)	(0.181)	(0.185)	(0.175)	(0.171)	(0.176)	(0.168)
organic	0.221**	0.186*	0.348***	0.175*	0.289***	0.234**	0.171	0.151
	(0.099)	(0.102)	(0.104)	(0.106)	(0.111)	(0.109)	(0.107)	(0.105)
Ger/Bel origin	0.756***	−0.119	0.344*	−0.019	0.102	0.205	0.644***	0.132
	(0.186)	(0.187)	(0.178)	(0.175)	(0.183)	(0.180)	(0.210)	(0.207)
local origin	0.563***	0.190	0.502***	0.094	0.457***	0.685***	0.758***	0.678***
	(0.150)	(0.150)	(0.154)	(0.153)	(0.160)	(0.156)	(0.158)	(0.155)
High in fibre	−0.170	−0.231	−0.483	0.490	−0.371	0.256	−0.069	0.099
	(0.211)	(0.220)	(0.378)	(0.326)	(0.252)	(0.222)	(0.208)	(0.182)
High of nsf. acids	−0.265	−0.136	0.167	0.073	0.347*	0.590***	−0.257	−0.633***
	(0.188)	(0.193)	(0.185)	(0.186)	(0.199)	(0.207)	(0.212)	(0.216)
price	−1.293***	−0.484**	−0.544***	−0.308	−0.672**	−0.786***	−0.576***	−0.358***
	(0.205)	(0.190)	(0.197)	(0.194)	(0.265)	(0.256)	(0.100)	(0.093)
HS x meat	−0.362***	−0.227***	−0.281***	−0.273***	−0.181*	−0.178**	−0.351***	−0.132
	(0.099)	(0.082)	(0.100)	(0.093)	(0.098)	(0.089)	(0.098)	(0.089)
HS x meat+50	−0.089	−0.175*	−0.343***	0.022	−0.045	−0.060	−0.345***	−0.039
	(0.113)	(0.099)	(0.121)	(0.117)	(0.121)	(0.117)	(0.114)	(0.104)
HS x meat+35	−0.211	−0.149	−0.266	−0.287	−0.163	−0.336	−0.404*	−0.701***
	(0.215)	(0.253)	(0.215)	(0.200)	(0.247)	(0.209)	(0.207)	(0.223)
HS x meat+20	−0.011	−0.038	−0.266	−0.144	−0.056	−0.167	−0.214	0.040
	(0.224)	(0.212)	(0.173)	(0.192)	(0.168)	(0.161)	(0.183)	(0.187)
NPS x meat	0.137	−0.243***	0.233**	−0.164*	0.126	−0.301***	0.241**	−0.245***
	(0.099)	(0.080)	(0.101)	(0.093)	(0.101)	(0.092)	(0.095)	(0.089)
NPS x meat+50	0.175	−0.126	0.091	−0.204*	0.221*	−0.201*	0.173	−0.188*
	(0.114)	(0.099)	(0.130)	(0.112)	(0.128)	(0.118)	(0.118)	(0.102)
NPS x meat+35	0.051	−0.141	0.450**	−0.222	0.433	−0.423*	0.531**	−0.104
	(0.232)	(0.257)	(0.227)	(0.197)	(0.293)	(0.223)	(0.233)	(0.232)
NPS x meat+20	0.504**	−0.128	0.159	0.170	0.085	−0.486***	0.375*	−0.140
	(0.236)	(0.193)	(0.182)	(0.193)	(0.172)	(0.163)	(0.205)	(0.192)
MEAS x meat	0.580***	0.307***	0.554***	0.544***	0.535***	0.560***	0.658***	0.359***
	(0.103)	(0.081)	(0.102)	(0.094)	(0.103)	(0.091)	(0.101)	(0.089)
MEAS x meat+50	0.151	−0.097	0.156	0.144	0.303**	0.200*	−0.013	0.083
	(0.115)	(0.098)	(0.126)	(0.113)	(0.126)	(0.117)	(0.118)	(0.101)
MEAS x meat+35	0.142	−0.068	0.523**	0.543***	0.560**	0.190	0.132	0.023
	(0.224)	(0.259)	(0.245)	(0.203)	(0.274)	(0.225)	(0.242)	(0.226)
MEAS x meat+20	−0.032	0.170	0.067	0.114	0.139	0.439***	−0.087	−0.163
	(0.251)	(0.196)	(0.178)	(0.192)	(0.181)	(0.162)	(0.195)	(0.192)
FAMILIARITY x meat	−0.188**	−0.125	−0.290***	−0.256***	0.016	0.135	−0.135	−0.157*
	(0.096)	(0.082)	(0.094)	(0.091)	(0.100)	(0.093)	(0.092)	(0.092)
FAMILIARITY x meat+50	0.321***	0.173*	0.195*	0.124	0.442***	0.529***	0.316***	0.233**

Table 12 – continued from previous page

	Mortadella		Salami		Nuggets		Meat balls	
	GER	BEL	GER	BEL	GER	BEL	GER	BEL
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.106)	(0.096)	(0.116)	(0.108)	(0.120)	(0.116)	(0.108)	(0.102)
FAMILIARITY x meat+35	0.299	0.369	0.160	−0.086	1.181***	0.371*	0.601***	0.931***
	(0.204)	(0.231)	(0.216)	(0.209)	(0.272)	(0.205)	(0.215)	(0.254)
FAMILIARITY x meat+20	0.242	0.343*	0.185	0.201	0.019	0.267	0.429**	0.128
	(0.224)	(0.199)	(0.165)	(0.174)	(0.173)	(0.167)	(0.180)	(0.175)
no option	−0.826***	0.692***	−0.113	0.290	−0.292	−0.243	−0.330	0.285
	(0.281)	(0.265)	(0.257)	(0.248)	(0.563)	(0.535)	(0.277)	(0.277)
Observations	1,000	1,002	1,000	1,002	1,000	1,002	1,000	1,002
Log Likelihood	−1,220.917	−1,366.974	−1,201.299	−1,272.771	−1,177.140	−1,261.003	−1,227.343	−1,310.656
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 12. Estimation results

5. Discussion

The descriptive results show that more than fifty percent of consumers substitute meat at least occasionally. Thus about half of the respondents reveal an eligible consumption behavior in respect to sustainability and healthiness at least sometimes. Furthermore, about a fifth indicated to consume sometimes respectively frequently meat alternatives such as veggie burgers.

The DCEs revealed that the considered meat products are most preferred by the consumers. Nonetheless, the tested meathybrids variants with different shares of plant-based proteins took the second position followed by the vegetarian base alternative. Therefore, meathybrids could facilitate the diet transition of meat-eaters in direction to a more healthy and sustainable consumption. The analysed consumer segment is more open-minded to the meathybrid concept in comparison to the vegetarian substitutes.

Concerning the impact factors on choosing either meatbrids or meat it becomes obvious that familiarity with meat substitutes respectively their former use play a great role in preference formation. Therefore, it can be recommended to increase the share of meat substitutes/meat hybrids in school/public canteens and to financially support other canteens which replace meat by plant substitutes or hybrids. Herewith, consumers are confronted more often with meat alternatives and familiarity with such products can be increased.

The findings for the MEAS show that the more consumers are attached to meat the lower is the choice probability for meathybrids. Thus, for the segment of highly meat attached consumers the latter alternative is no option. Meat attachment as a psychological construct represents a barrier for diet change and transition. Future research should address this topic, and analyse how to overcome this attitude.

In general, the scepticism of consumers of mixing meat and plant protein has been greatly reduced in recent years. The analysed hybrids performed better then the vegetarian base alternative in the DCEs. It appears, as if the feeling that the food industry is just willing to increase their turnover by using cheap plant protein in the meat formulation has disappeared. It is to highlight that meathybrids are even perceived not as unhealthier in comparison to meat. Consumers are nowadays accustomed to found e.g. peas no longer in their original form in foods but also as protein powder. Therefore, the development of hybrid products, which could serve the consumer with the best of both animal and plant source will enable all different kinds of consumer groups. This will support all the industrial fields named to get valorisation of high-quality new hybrid products.

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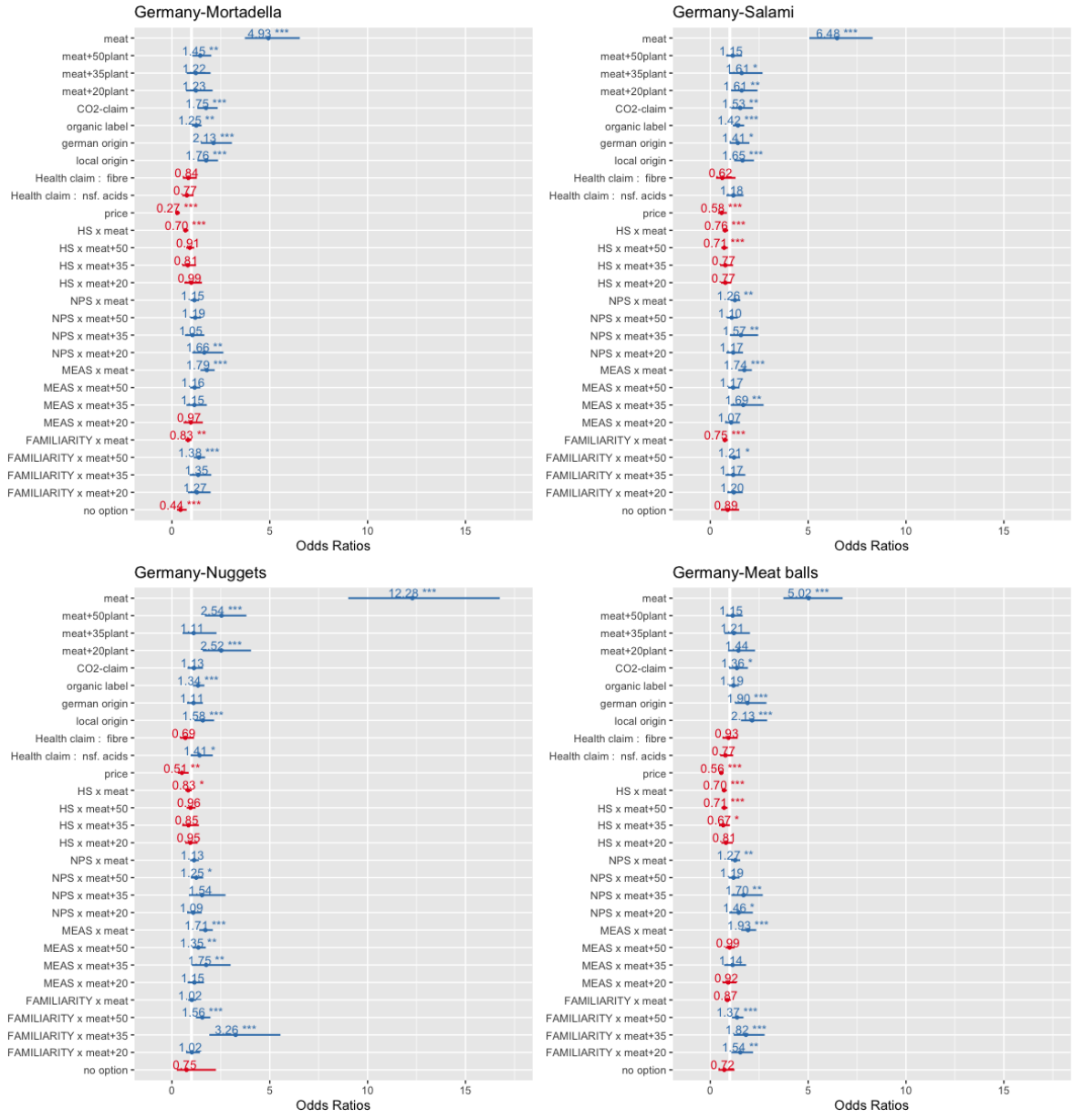

Figure 2. Odds ratios - estimations Germany

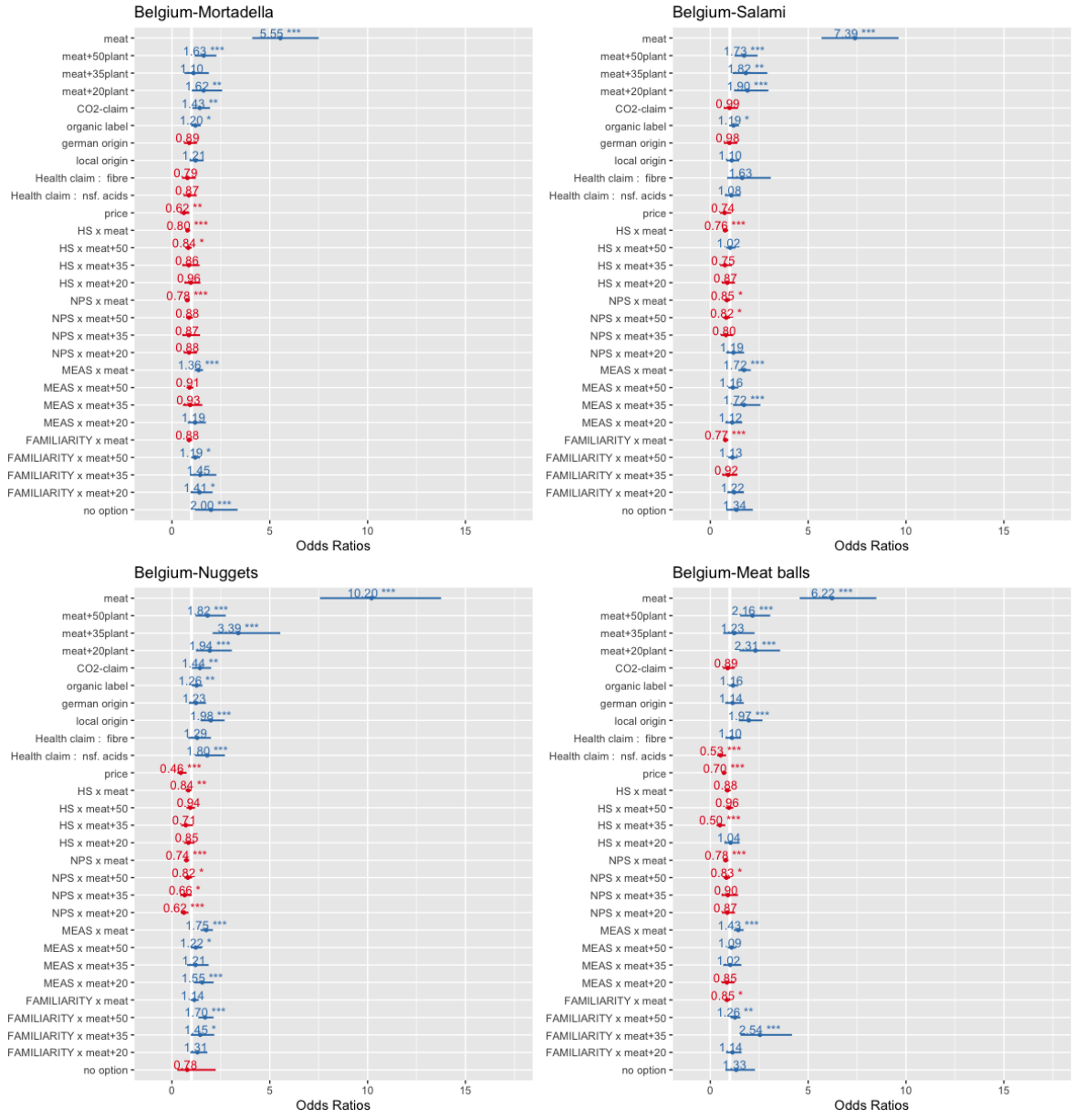

Figure 3. Odds ratios - estimations Belgium

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