Article

Consumer preferences for meat products blended with plant-based proteins in Germany

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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 in comparison to meat. This alternative offers several social, environmental and health benefits and may play a role in reducing meat consumption. However, there has been a lack of research on how specific meat substitute attributes can influence consumers to replace or partially replace meat in their diets. Research demonstrates that in many countries consumers are highly attached to meat. They consider it as an essential and integral element of their daily diet. For these consumers which are not interested in vegan or vegetarian alternatives to meat, so-called meathybrids could be a low-threshold option for a more sustainable food consumption behaviour. In meathybrids only a fraction of the meat product (e.g. 20% to 50%) is replaced with plant-based proteins. In this paper, the results of an online survey with 500 German consumers are presented with focus on preferences and attitudes relating to meathyrids. 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 behaviour in respect to sustainability and healthiness to a certain degree. Concerning the determinants of choosing either meathybrid or meat it becomes evident that the highest effect is exerted by the health perception. The healthier meathybrids are perceived, the higher is the choice probability. Thus, this egoistic motive seems to outperform altruistic motives like animal welfare or environmental concerns when it comes to choice for this new product category.

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

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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].

Diversity in eating habits is getting lost because developing countries adopt a more animal-rich, western style diet. In this context [11] stated that humankind is heading for a generalization of its diet through animal proteins.

These facts underline the importance of integrating new protein sources into the diet. However, this means overcoming barriers such as traditional meat consumption across many cultures [12]. To this effect, a promising alternative pathway is to increase the share of plant proteins in the diet. This could be done 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 [13]. Research demonstrates that in many countries consumers are highly attached to meat and consider it as essential and integral element of their daily diet [14]. So-called meathybrids may be an option for the broad consumer segment that is not interested in vegan or vegetarian alternatives to meat. In meathybrids only a fraction of the meat product (e.g. 20% to 50%) is replaced with 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 literature overview, a representative online-survey was carried out in Germany.

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 [15,16]. Therefore, meat substitutes respectively meathybrids must catch up with real meat products concerning sensory characteristics. A study carried out by [17] 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 and 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) [15]. 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, [18] reported that only 5% of ground beef could be replaced with whole cowpea flour in emulsion-type sausages without any negative effects on their sensory and physico-chemical properties.

[19] 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

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 [20]. Carbon footprint of plant-based foods on average is twice as low as impact of pork [21], while the impact in some other categories can be more than 60 times lower [22]. Incorporation of plant biomass into pork products in equal proportion lead to the reduction of their environmental impact.

The majority of Western European consumers are not aware that meat consumption has a large environmental impact [15,23,24]. Contrarily, [25] stated that the ecological rationale for switching to meat alternatives is being recognised but cannot overcome sensory shortcomings (see above). Concerning consumer segments, [26] found that vegetarians are more likely than semi-vegetarians to agree that meat production is bad for the environment and unhealthy.

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 [27]. 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 [27].

2.4. Health

It is known that frequent consumption of processed meat can increase the risk of cario vascular disease as well as all-cause mortality [28,29]. 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 [30,31]. 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 [32].

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 [33]. 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. More than half of semi-vegetarians did not agree that meat consumption is per se unhealthy. Like in the study of [27] 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.

2.5. Meat attachment

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 [14]. 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 [14]. 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 [14] were selected for measuring the psychometric construct.

2.6. Food Neophobia (FNS)

Food neophobia refers to reluctance to eat unfamiliar foods [34]. 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 [35–39]. The knowledge about population segments that have greater or lesser neophobia, allows to identify early adopters of innovative products [40].

According to [16] 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 possibly this finding could hold for meathybrids that are partly highly processed as well. According to [25] 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 (FNS) of [34] was selected for measuring the psychometric construct.

3. Data collection and methods of data analysis

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

The online survey was carried out in Germany with 500 respondents. Participants had to be meat eaters and thus vegetarians and vegans were sorted out. 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 questionnaire 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 1).

In the result section, we report descriptive results. For scale development (FNS, MAQ) Cronbach's alpha is calculated and reported. For measuring FNS, the list of [34] was selected. The wording of the German version has been chosen from a study by [41]. 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 tablets and smartphones. The items indicated with (r) in Table 4 were inversely re-coded. Considering that the inclusion of invalid items creates the risk of invalid conclusions [42], a principal components analysis (Varimax rotation, eigenvalues greater than one) and a confirmatory factor analysis were carried out to explain the variability of the FNS.

For MAQ, 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 4 were inversely re-coded. Like for the FNS, a principal component analysis and a confirmatory factor analysis were carried out.

Furthermore, a multinomial logistic regression model is applied for measuring the impact of several parameters on the the choice of either a hybrid or a meat product.

3.1. Logistic regression analysis

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 [43].

Suppose that variable Y_i represents the offered alternatives in a choice experiment (e.g. choice between meat and meathybrid), with $i = 1, \ldots, n$ 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:

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

where $\mathbf{x}$ is a vector of predictors (e.g. FNS, MAQ 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:

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

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

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

The binomial logistic regression model is easily generalized to the multinomial case. If there are n product alternatives there are also n variables $Y_1, \ldots, Y_n$ with corresponding probabilities of occurrence $\pi_1, \ldots, \pi_n$. Analogous to binomial logistic regression the odds $\pi_1/\pi_n, \ldots, \pi_n - 1/\pi_n$ are modelled by means of $exp(\eta_1), \ldots, exp(\eta_{n-1})$. From $\sum_{i=1}^{n} \pi_i = 1$ it follows that:

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

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 a comparison task where respondents had to indicate if they would either choose meat, the meathybrid alternative or none of these options. The FNS and MAQ-scale as well as other parameters entered the regression analysis as independent variables. These independent variables are the buying frequency of organic/free range meat, the buying frequency of plant-based alternatives and the evaluation if either meathybrid or meat is perceived as healthier, better for the environment, more tasty or better for the environment.

Given the theoretical background, data was modelled according to the following expression:

$$
\begin{aligned}
\mathbf{x}'\beta = & \text{buy.freq. organic/free range} * \beta_1 \\
& + \text{healthier} * \beta_2 \\
& + \text{more tasty} * \beta_3 \\
& + \text{better for the environment} * \beta_4 \\
& + \text{better for animal welfare} * \beta_5 \\
& + \text{FNS} * \beta_6 \\
& + \text{MAQ} * \beta_7 \\
& + \text{buy.freq. plant-based alternatives} * \beta_8 \\
& + constant
\end{aligned}
\tag{5}
$$

The above mentioned parameters are estimated for meathybrid (Y_1) and the "none"-option (Y_2) whereas meat (Y_3) was set as reference category in the estimation. 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 [44] and the package mlogit [45] were used. For visualisation of odds ratios from the estimated model the package sjplot [46] was applied.

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)

Furthermore, respondents were asked for their buying frequency of organic respectively meat from free-range production. About 22% of the participants indicated to buy such products often (18.2%) or always (4.2%)(see Table 2). In 2019 a survey was conducted by Kitchen Stories [47] 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.

4.2. Meat Attachement Questionnaire (MAQ) and Food Neophobia Scale(FNS)

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 MAQ showed in Germany a high internal consistency with a standardized Cronbach α of 0.86. The Comparative Fit Index (CFI=0.962), the Tucker-Lewis Index (TLI=0.952) and the Root Mean Square Error of Approximation (RMSEA= 0.060) showed acceptable values. In comparison to [14] we received higher values for the non-reversed items and lower values for the reversed item what might be due to the fact that vegans and vegetarians were not part of this study (see Table 3). 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". This evaluation demonstrates that most of the respondents consider meat not as an unhealthy product but as an essential part of their diet. For use in the regression analysis the individual scores, that is the z-standardised mean value across the 14 items were calculated. The higher the MAQ-score is, the higher is indiviudals' attachement to meat. After deleting two items from the original FNS-list due to low item-correlations in the reliability analysis and one item due to the confirmatory factor analysis, FNS showed an acceptable internal consistency

attribute	characteristics	n	%
gender	male	245	49.0
	female	255	51.0
federal state	Baden-Württemberg	66	13.2
	Bavaria	75	15.0
	Berlin	22	4.4
	Brandenburg	15	3.0
	Bremen	5	1.0
	Hamburg	10	2.0
	Hesse	37	7.4
	Mecklenburg-Vorpommern	10	2.0
	Lower Saxony	50	10.0
	North Rhine-Westphalia	114	22.8
	Rhineland-Palatinate	20	4.0
	Saarland	5	1.0
	Saxony	26	5.2
	Saxony-Anhalt	15	3.0
	Schleswig-Holstein	15	3.0
	Thuringia	15	3.0
age	< 25 years	65	13.0
	25-34 years	66	13.2
	35-44 years	99	19.8
	45-54 years	84	16.8
	55-64 years	73	14.6
	> 64 years	113	22.6
education	no school qualifications	2	0.4
	still in school	4	0.8
	junior high diploma	88	17.6
	high school diploma	193	38.6
	university-entrance diploma	105	21.0
	bachelor or master degree	89	17.8
	other degree	19	3.8
net income	no income	26	5.2
	less than 500	30	6.0
	500 up to 1.000	46	9.2
	1.000 up to 1.500	95	19.0
	1.500 up to 2.000	92	18.4
	2.000 up to 2.500	69	13.8
	2.500 up to 3.000	57	11.4
	3.000 up to 3.500	27	5.4
	3.500 up to 4.000	25	5.0
	4.000 or more	33	6.6
household size	1	121	24.2
	2	207	41.4
	3	92	18.4
	4	55	11.0
	5	20	4.0
	6	4	0.8
	>6	1	0.2

Table 1. Sample

	%
never	15.4
sometimes	62.2
often	18.2
always	4.2

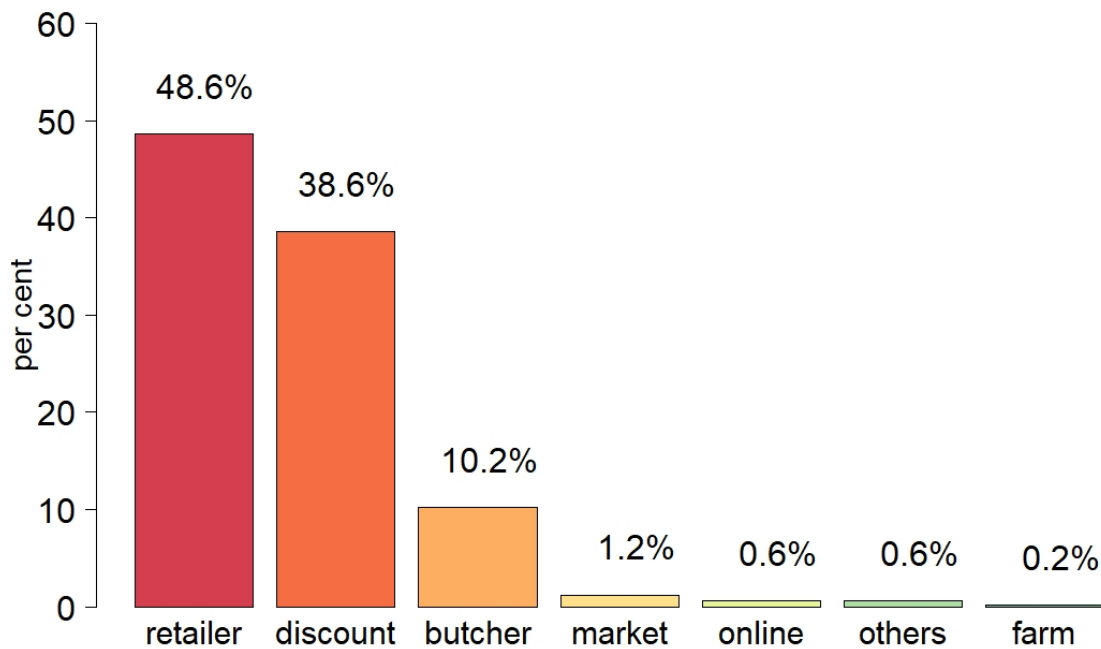**Table 2.** Buying frequency organic/free-range meat

Figure 1. Preferred buying location of meat/meat products

with a standardized Cronbach α of 0.76. The confirmatory factor analysis (two-factor-solution) produced acceptable values for the three considered indices (CFI=0.961 TLI=0.937 and RMSEA=0.074). 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 FNS-score is, the higher is indiviudals' food neophobia.

4.3. Consumption 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 5).

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, followed by cheese (47.6%), eggs (41.7%), pasta (39.5%) and salad (35.4%) as most preferred substitutes (see Table 6). 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 7).

4.4. Comparison meat vs. meathybrid

In order to analyse the preference for meathybrids in more detail respondents received a comparison task. The question for this task was: "Consider a food product made of 100% meat

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

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

Table 3. Meat attachment questionnaire scale (MAQ)

statement	std. α	$\bar{x}$	σ
I am constantly sampling new and different food. (r)	0.74	2.75	1.17
I do not trust new (different or innovative) food.		2.93	1.11
If I don't know what a food is, I won't try it.		3.85	1.00
I prefer food from different cultures. (r)	0.72	2.59	1.07
I am reluctant to eat foreign food that I see for the first time.	0.74	2.96	1.21
If I go to a buffet, meetings or parties, I'll eat new food. (r)	0.73	2.32	1.09
I'm afraid to eat food that I did not eat before.	0.73	2.49	1.23
I am very particular about the food I eat.		3.06	1.13
I will eat almost anything. (r)	0.76	2.32	1.10
I like to try new ethnic restaurants. (r)	0.70	2.36	1.10

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

Table 4. Food neophobia scale (FNS)

and a comparable food product made of 60% meat and 40% plant-based proteins. Which product do you think is ...

- healthier?
- tastier?
- more expensive ?
- better for the environment?
- better for animal welfare?

Subsequently, respondents had to indicate if they would <u>pay more</u> either for a meathybrid or meat respectively if they would <u>choose</u> either a meathybrid or a meat product. Concerning the parameters health, environment and animal welfare the meathybrid was evaluated much better then the meat option (see Table 8). Contrarily, meat was perceived as tastier in comparison to the meathybrid by 62.4% of the respondents. Concerning the willingness-to-pay more for a product only 20.4% of the interviewees named the meathybrid option and likewise only 27.4% indicated to choose the meathybrid in the direct comparison.

4.5. Multinomial logit regression analysis

In the multinomial regression analysis, it was explored whether the MAQ and the FNS have an impact on the choice decision in the questionnaire. In the mentioned choice task the respondents were

yes	no
54.2%	45.8%

Table 5. deliberately substitute meat on the days they do not eat meat

nr product	%
1 Fish	48.3
2 Cheese	47.6
3 Egg(s)	41.7
4 Pasta	39.5
5 Salad	35.4
6 Other legumes	15.1
7 Lentils	9.6
8 Nuts	8.9
9 Tofu	6.3
10 Seitan	1.8
11 Other	1.1
12 Tempeh	0.4

Table 6. Ranking list consumed meat alternatives

directly asked if they would either choose the meat or the hybrid product or none of these products (see section before). Furthermore, the results respectively parameters from the direct comparison (health, taste, environment, animal welfare) between meat and hybrid entered the regression as independent variables as well as the buying frequency of organic/free range meat and the buying frequency of plant-based alternatives (like veggie burger).

The parameters from the direct comparison were re-coded so that +1 reflects the choice of the hybrid (e.g. as more healthy, better for the environment, ...), -1 the choice of meat and zero the choice of the option "neither/nor" (see section before). As reference category for the multinomial logit model the meat option was chosen.

The regression model was checked for indications of multicollinearity by examining the condition index. Values greater than 30 are typically considered as problematic [48]. No violations of limits were found.

It is to highlight that the constant for the meatyhbrid revealed a negative and significant value (-1.470***). This is, the analysed sample has a much higher preference for the reference category meat in comparison to the meathybrid alternative. The MAQ-results demonstrate that the more meat attached the interviewees are, the higher is the probability not to choose the hybrid option (-0.837***)(see Table 9). Furthermore, the extent of food neophobia (-0.254*) exerted an significant negative effect on this alternative whereas for the buying frequency of organic respectively meat from free range production no significant effect can be measured (0.038).

If respondents evaluated the hybrid as healthier, better for the environment or better for animal welfare in the comparison task the choice probability for this option increased significantly. In this context it is to highlight that the health perception had by far the strongest impact (1.386***) whereas the effect for the environmental and animal welfare perceptions were roughly only half of this size. With increasing buying frequency of plant-based meat alternatives like e.g. veggie burgers likewise the choice probability of the hybrid option increased (0.292**).

Interestingly, the taste evaluation in the comparison task had across all independent variables a relatively strong effect on the choice of the hybrid option. That is, if the respondents perceived the taste of the meathybrid as better the choice probability increases substantially.

In Figure 2 the odds ratios for the meathybrid coefficients from the multinomial logit regression are displayed. The fact that the alternative was a hybrid reduces the choice probability by 77% (odds ratio=0.23). Similarly holds for the situation where the MAQ increases. Due to the fact that the MAQ is

	%
never	45.6
tried it once	16.0
rarely	20.0
sometimes	14.4
frequently	4.0

Table 7. Frequency of consumption of meat alternatives such as veggie burgers

	meat	neither/nor	hybrid
healthier	31.0%	27.2%	**41.8%**
tastier	**62.4%**	20.8%	16.8%
more expensive	26.6%	25.8%	**47.6%**
better for environment	15.8%	31.0%	**53.2%**
better for animal welfare	15.6%	26.8%	**57.6%**
I would pay more for ...	33.0%	**46.6%**	20.4%
I would choose ...	**59.4%**	13.2%	**27.4%**

Table 8. Comparison meat vs. hybrid

z-transformed an increase about one standard deviation leads to a reduction in the choice probability of 57%.

On the other hand the choice probability increases by the factor 4 (odds ratio=4.00) if the consumer perceives the meathybrid as healthier. Therefore, the health perception nearly compensates the existing difference in preference of the alternatives. Likewise, a better assumed/expected taste of the meathybrid substantially increases the preference for this alternative by the factor 3.62. In the situation the hybrid is perceived as better for the environment the choice probability doubles.

Table 9. Multinomial logit regression - results

	Dependent variable:	
	hybrid	neiter/nor
	(1)	(2)
buy. freq. organic/free range	−0.038	−0.328**
	(0.141)	(0.166)
healthier	1.386***	0.533**
	(0.213)	(0.210)
more tasty	1.289***	1.211***
	(0.205)	(0.201)
better for environment	0.700***	0.102
	(0.223)	(0.225)
better for animal welfare	0.498**	−0.430*
	(0.250)	(0.224)
Food Neophobia Scale (FNS)	-0.254*	-0.169
	(0.149)	(0.169)
Meat Attachement (MAQ)	−0.837***	−0.241
	(0.168)	(0.171)
buy. freq. plant-based alt.	0.292**	−0.062
	(0.142)	(0.170)
Constant	−1.470***	−0.950***
	(0.234)	(0.171)
Akaike Inf. Crit.	710.008	710.008
Note:	*$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$*	

5. Discussion

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. Furthermore, about 18% indicated to consume sometimes respectively frequently meat alternatives such as veggie burgers. In the carried out direct comparison between meat and meathybrids about 27% of the respondents choose the latter alternative. These findings demonstrate that a substantial amount of consumers is open-minded to the "meathybrid" concept. Even a higher share believes that this alternative is healthier, better for the environment and animal welfare in comparison to meat whereas it is perceived as more expensive at the same time. Concerning the impact factors on choosing either a meathybrid or meat it becomes obvious that the perception of meathybrids as more environment-friendly as well as a more animal-welfare-friendly products positively influence the choice decision. Nonetheless, the by far highest effect is exerted by the health perception. The healthier meathybrids are perceived the higher is the choice probability. Thus this egoistic motive seems to outperform altruistic motives when it comes to choice. In this line, it is to recommend to lay an emphasis on healthy characteristics of meathybrids in product marketing for
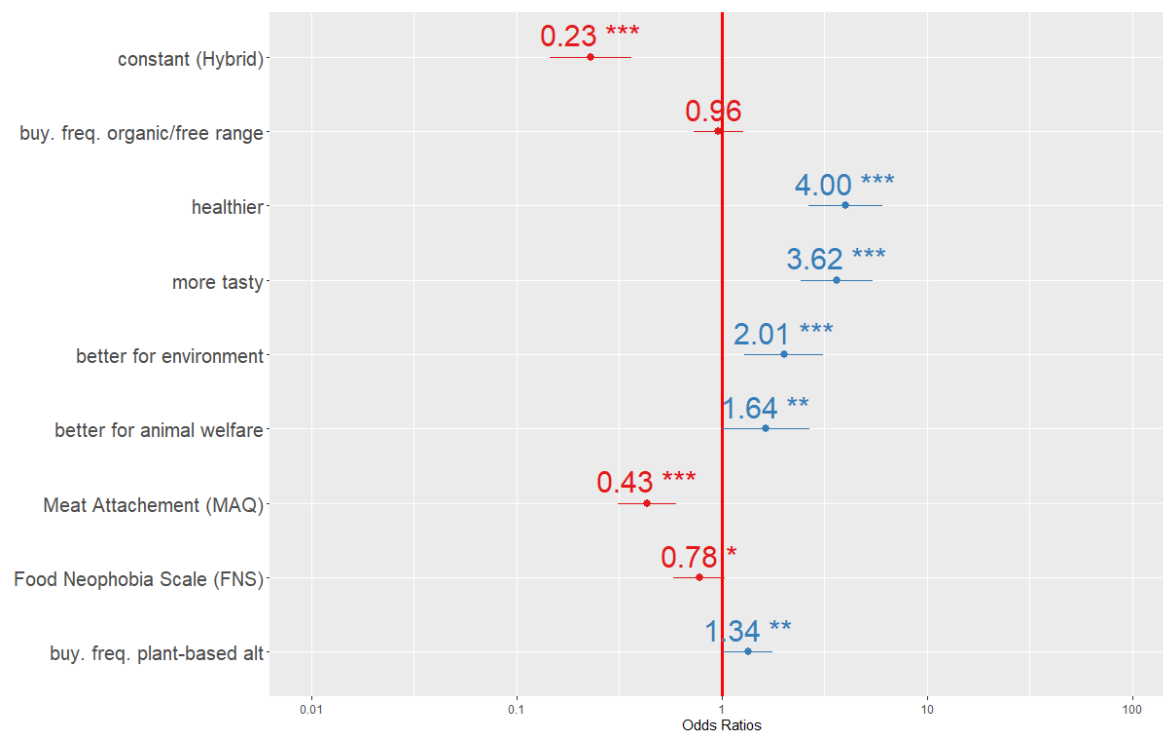
Figure 2. Odds ratios - estimation results meathybrid

a successful market entry. These can be used as unique selling proposition (USP) against competitors. With regard to consumer segments, it can be stated that there is no advantage in focusing on organic buyers as a target group. Across all respondents the parameter buying frequency of organic or meat from free range production had no impact on the choice of a meathybrid product.

Concerning the analysed scales, it can be stated that there is a problem with food neophobia when it comes to meathybrids. The individual degree of food neophobia exerts a negative effect on the choice of this product category. Thus, it can be hypothesized that meathybrids are perceived to a certain degree as 'exotic', 'neo' or 'artificial' as for example burgers based on insects or cultured meat where FNS is likewise a big barrier.

The findings for the MAQ-scale show that the more consumers are attached to meat the lower is the choice probability for choosing meathybrids. Thus for the segment of highly meat attached consumer this alternative is no option.

Nonetheless, the scepticism of consumers of mixing meat and plant protein has been greatly reduced in recent years. The feeling that the food industry is just willing to increase their turnover by using cheap plant protein in the meat formulation has obviously disappeared. It is to highlight that meathybrids are even perceived as healthier in comparison to meat.

Thus, 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.

Especially high-moisture extrusion technology has advanced the production of vegen meat alternatives with high sensory acceptance in the last decade [49,50].

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References

1. Max Roser, H.R.; Ortiz-Ospina, E. World Population Growth. *Our World in Data* **2013**.
2. De Boer, J.; Schösler, H.; Aiking, H. "Meatless days" or "less but better"? Exploring strategies to adapt Western meat consumption to health and sustainability challenges. *Appetite* **2014**, *76*, 120–128. doi:10.1016/j.appet.2014.02.002.
3. Hallström, E.; Röös, E.; Börjesson, P. Sustainable meat consumption: A quantitative analysis of nutritional intake, greenhouse gas emissions and land use from a Swedish perspective. *Food Policy* **2014**, *47*, 81–90. doi:10.1016/j.foodpol.2014.04.002.
4. Richi, E.B.; Baumer, B.; Conrad, B.; Darioli, R.; Schmid, A.; Keller, U. Health risks associated with meat consumption: A review of epidemiological studies, 2015. doi:10.1024/0300-9831/a000224.
5. Kroeze, C.; Bouwman, L. The role of nitrogen in climate change, 2011. doi:10.1016/j.cosust.2011.08.015.
6. De Vries, W.; Kros, J.; Reinds, G.J.; Butterbach-Bahl, K. Quantifying impacts of nitrogen use in European agriculture on global warming potential, 2011. doi:10.1016/j.cosust.2011.08.009.
7. Erisman, J.W.; Galloway, J.; Seitzinger, S.; Bleeker, A.; Butterbach-Bahl, K. Reactive nitrogen in the environment and its effect on climate change, 2011. doi:10.1016/j.cosust.2011.08.012.
8. Profeta, A.; Hamm, U. Do consumers care about local feedstuffs in local food? Results from a German consumer study. *NJAS - Wageningen Journal of Life Sciences* **2019**, *88*, 21–30. doi:10.1016/j.njas.2018.12.003.
9. Grandin, T. Welfare Problems in Cattle, Pigs, and Sheep that Persist Even Though Scientific Research Clearly Shows How to Prevent Them. *Animals* **2018**, *8*, 124. doi:10.3390/ani8070124.
10. Dawkins, M. *Animal Suffering*, 1 ed.; Springer Netherlands, 1980; p. 150. doi:10.1007/978-94-009-5905-7.
11. Sans, P.; Combris, P. World meat consumption patterns: An overview of the last fifty years (1961-2011). *Meat Science* **2015**, *109*, 106–111. doi:10.1016/j.meatsci.2015.05.012.
12. Stoll-Kleemann, S.; Schmidt, U.J. Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. *Regional Environmental Change* **2017**, *17*, 1261–1277. doi:10.1007/s10113-016-1057-5.
13. Neville, M.; Tarrega, A.; Hewson, L.; Foster, T. Consumer-orientated development of hybrid beef burger and sausage analogues. *Food Science and Nutrition* **2017**, *5*, 852–864. doi:10.1002/fsn3.466.
14. Graça, J.; Calheiros, M.M.; Oliveira, A. Attached to meat? (Un)Willingness and intentions to adopt a more plant-based diet. *Appetite* **2015**, *95*, 113–125. doi:10.1016/J.APPET.2015.06.024.
15. Hartmann, C.; Siegrist, M. Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science and Technology* **2017**, *61*, 11–25. doi:10.1016/j.tifs.2016.12.006.
16. Tucker, C.A. The significance of sensory appeal for reduced meat consumption. *Appetite* **2014**, *81*, 168–179. doi:10.1016/j.appet.2014.06.022.
17. Topcu, Y.; Uzundumlu, A.S.; Baran, D. How sensory and hedonic quality attributes affect fresh red meat consumption decision of Turkish consumers? *Italian Journal of Food Science* **2015**, *27*, 53–62. doi:10.14674/1120-1770/ijfs.v185.
18. Akwetey, W.Y.; Ellis, W.O.; Oduro, I.N. Using whole cowpea flour (WCPF) in frankfurter-type sausages. *J Anim Prod Adv* **2012**, *2*, 450–455.
19. ZAYAS, J.; LIN, C. Effect of the Pretreatment of Corn Germ Protein on the Quality Characteristics of Frankfurters. *Journal of Food Science* **1989**, *54*, 1452–1456. doi:10.1111/j.1365-2621.1989.tb05133.x.
20. Godfray, H.C.J.; Aveyard, P.; Garnett, T.; Hall, J.W.; Key, T.J.; Lorimer, J.; Pierrehumbert, R.T.; Scarborough, P.; Springmann, M.; Jebb, S.A. Meat consumption, health, and the environment. *Science (New York, N.Y.)* **2018**, *361*. doi:10.1126/science.aam5324.
21. McAuliffe, G. A thematic review of life cycle assessment (LCA) applied to pig production. *Environmental Impact Assessment Review* **2015**, *56*, 12–22.

22. Zhu, X.; van Ierland, E.C. Protein Chains and Environmental Pressures: A Comparison of Pork and Novel Protein Foods. *Environmental Sciences* **2004**, *1*, 254–276. doi:10.1080/15693430412331291652.

23. Profeta, A. The Impact of Health Claims in Different Product Categories. *Journal of International Food and Agribusiness Marketing* **2019**. doi:10.1080/08974438.2019.1599753.

24. Macdiarmid, J.I.; Douglas, F.; Campbell, J. Eating like there's no tomorrow: Public awareness of the environmental impact of food and reluctance to eat less meat as part of a sustainable diet. *Appetite* **2016**, *96*, 487–493. doi:10.1016/j.appet.2015.10.011.

25. Apostolidis, C.; McLeay, F. Should we stop meating like this? Reducing meat consumption through substitution. *Food Policy* **2016**, *65*, 74–89. doi:10.1016/j.foodpol.2016.11.002.

26. Mullee, A.; Vermeire, L.; Vanaelst, B.; Mullie, P.; Deriemaeker, P.; Leenaert, T.; De Henauw, S.; Dunne, A.; Gunter, M.J.; Clarys, P.; Huybrechts, I. Vegetarianism and meat consumption: A comparison of attitudes and beliefs between vegetarian, semi-vegetarian, and omnivorous subjects in Belgium. *Appetite* **2017**, *114*, 299–305. doi:10.1016/j.appet.2017.03.052.

27. De Backer, C.J.; Hudders, L. Meat morals: Relationship between meat consumption consumer attitudes towards human and animal welfare and moral behavior. *Meat Science* **2015**, *99*, 68–74. doi:10.1016/j.meatsci.2014.08.011.

28. Bernstein, A.M.; Sun, Q.; Hu, F.B.; Stampfer, M.J.; Manson, J.E.; Willett, W.C. Major dietary protein sources and risk of coronary heart disease in women. *Circulation* **2010**, *122*, 876–883. doi:10.1161/CIRCULATIONAHA.109.915165.

29. Sinha, R.; Cross, A.J.; Graubard, B.I.; Leitzmann, M.F.; Schatzkin, A. Meat intake and mortality: A prospective study of over half a million people. *Archives of Internal Medicine* **2009**, *169*, 562–571. doi:10.1001/archinternmed.2009.6.

30. Hu, F.B. Plant-based foods and prevention of cardiovascular disease: An overview. American Journal of Clinical Nutrition. American Society for Nutrition, 2003, Vol. 78. doi:10.1093/ajcn/78.3.544s.

31. Chalvon-Demersay, T.; Azzout-Marniche, D.; Arfsten, J.; Egli, L.; Gaudichon, C.; Karagounis, L.G.; Tomé, D. A systematic review of the effects of plant compared with animal protein sources on features of metabolic syndrome1-3. *Journal of Nutrition* **2017**, *147*, 281–292. doi:10.3945/jn.116.239574.

32. Young, V.R.; Pellett, P.L. Plant proteins in relation to human protein and amino acid nutrition. American Journal of Clinical Nutrition. American Society for Nutrition, 1994, Vol. 59. doi:10.1093/ajcn/59.5.1203S.

33. Verbeke, W. Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. *Food Quality and Preference* **2015**, *39*, 147–155. doi:10.1016/J.FOODQUAL.2014.07.008.

34. Pliner, P.; Hobden, K. Development of a scale to measure the trait of food neophobia in humans. *Appetite* **1992**, *19*, 105–120. doi:10.1016/0195-6663(92)90014-W.

35. Capiola, A.; Raudenbush, B. The Effects of Food Neophobia and Food Neophilia on Diet and Metabolic Processing. *Food and Nutrition Sciences* **2012**, *03*, 1397–1403. doi:10.4236/fns.2012.310183.

36. Damsbo-Svendsen, M.; Frøst, M.B.; Olsen, A. A review of instruments developed to measure food neophobia. *Appetite* **2017**, *113*, 358–367. doi:10.1016/j.appet.2017.02.032.

37. Falciglia, G.A.; Couch, S.C.; Gribble, L.S.; Pabst, S.M.; Frank, R. Food neophobia in childhood affects dietary variety. *Journal of the American Dietetic Association* **2000**, *100*. doi:10.1016/S0002-8223(00)00412-0.

38. Henriques, A.S.; King, S.C.; Meiselman, H.L. Consumer segmentation based on food neophobia and its application to product development. *Food Quality and Preference* **2009**, *20*, 83–91. doi:10.1016/j.foodqual.2008.01.003.

39. Knaapila, A.; Tuorila, H.; Silventoinen, K.; Keskitalo, K.; Kallela, M.; Wessman, M.; Peltonen, L.; Cherkas, L.F.; Spector, T.D.; Perola, M. Food neophobia shows heritable variation in humans. *Physiology and Behavior* **2007**, *91*, 573–578. doi:10.1016/j.physbeh.2007.03.019.

40. Vidigal, M.C.; Minim, V.P.; Simiqueli, A.A.; Souza, P.H.; Balbino, D.F.; Minim, L.A. Food technology neophobia and consumer attitudes toward foods produced by new and conventional technologies: A case study in Brazil. *LWT - Food Science and Technology* **2015**, *60*, 832–840. doi:10.1016/j.lwt.2014.10.058.

41. Siegrist, M.; Hartmann, C. Impact of sustainability perception on consumption of organic meat and meat substitutes. *Appetite* **2019**, *132*, 196–202. doi:10.1016/j.appet.2018.09.016.

42. Hartmann, C.; Shi, J.; Giusto, A.; Siegrist, M. The psychology of eating insects: A cross-cultural comparison between Germany and China. *Food Quality and Preference* **2015**, *44*, 148–156. doi:10.1016/j.foodqual.2015.04.013.

43. Long, J.S.; Freese, J. Regression models for categorical dependent variables using Stata, 2nd Edition. *undefined* **2001**.

44. R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2020.

45. Croissant, Y. *mlogit: Multinomial Logit Models*, 2020.

46. Lüdecke, D. *sjPlot: Data Visualization for Statistics in Social Science*, 2020.

47. Statista. Germany: organic food purchase 2019, 2019.

48. Cohen. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*; Routledge, 2013. doi:10.4324/9780203774441.

49. Asgar, M.A.; Fazilah, A.; Huda, N.; Bhat, R.; Karim, A.A. Nonmeat protein alternatives as meat extenders and meat analogs. *Comprehensive Reviews in Food Science and Food Safety* **2010**, *9*, 513–529. doi:10.1111/j.1541-4337.2010.00124.x.

50. Osen, R.; Toelstede, S.; Wild, F.; Eisner, P.; Schweiggert-Weisz, U. High moisture extrusion cooking of pea protein isolates: Raw material characteristics, extruder responses, and texture properties. *Journal of Food Engineering* **2014**, *127*, 67–74. doi:10.1016/j.jfoodeng.2013.11.023.

Sample Availability: Samples of the compounds ...... are available from the authors.