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Adaption of the meat attachment scale (MEAS) to Germany: interplay with food neophobia, preference for organic foods, social trust and trust in food technology innovations

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Abstract

Meat-based diets are still the norm, and vegans and vegetarians represent only a small minority of the population. A transition, respectively, behavioural change towards a diet with less meat can only occur by adopting a positive attitude towards dietary changes based on reasons and motivations. The main aim of this study is to apply the meat attachment scale (MEAS) in Germany in order to analyse if this construct is a barrier towards a diet with less meat in this country. For this purpose, the impact of meat attachment on the trust in different protein alternatives (plant-based, insects, cultured meat) and related food processing technologies is analysed. The findings reveal that a high level of meat attachment goes along with lower trust in plant-based proteins. Similar holds for cultured meat and insect proteins. Thus it appears that, at least for the moment, cultured meat or proteins from insects are not a logical substitute for the heavily meat attached consumer. Furthermore, in the analysis, we considered if meat attachment as measured by the MEAS is correlated with other scales/preferences such as food neophobia, social trust, and attitude towards respective preference for organic products. Literature shows that all mentioned constructs impact the acceptance, preference or trust in more sustainable food product innovation, respectively, more sustainable food processing techniques. The outcome of the correlation analysis demonstrated that in particular food neophobia and meat attachment are not correlated with each other. That is, the MEAS represents a predictor for trust in food (processing) technologies as e.g. plant-based proteins or cultured meat that is independent of the neophobia construct.

Keywords: Meat attachment, Food neophobia, Consumer preference, Reference for organic foods

Introduction

High consumption of meat, low regard for meat substitutes, and a lack of willingness to adopt a more plant-based diet are still the dominant cultural pattern in most western societies (Latvala et al. 2012; Boer et al. 2014; Profeta et al. 2021; Enneking et al. 2007). Meat-based diets are still the norm and vegans and vegetarians represent only a small

minority of the population. As consumers' concerns about meat production systems are rising, they feel conflicted about consuming meat and thus look for more sustainable alternatives (Aiking et al. 2006; Kumar et al. 2016; Hwang et al. 2020; Profeta and Balling 2007). Nonetheless, many consumers like to enjoy meals with meat and want to stick to it but in parallel do not want their consumption to be associated with negative concerns pertaining to meat production (Schröder and McEachern 2004; Hoek et al. 2011; Circus and Robison 2019; Profeta et al. 2011). Such conflicting emotions lead to the so-called meat paradox (Buttlar and Walther 2018). This is defined as disconnection between not wanting animals to suffer, yet killing them for food (Dowsett et al. 2018).

Securing a sustainable food supply for humankind is 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 (Boer et al. 2014; Hallström et al. 2014, 2015). Furthermore, the consumption of meat and meat products in larger portions is associated with a higher risk of cardiovascular, coronary and cerebrovascular diseases, stroke, diabetes type 2 and colorectal cancer (Richi et al. 2015). Therefore, there is need a for a behavioural change viz. reduced meat consumption.

Over the recent past, meat substitutes (in particular, plant-based meat, cultured meat and edible insects) have gained increasing popularity as an innovative way to circumvent some of the negative impacts induced by conventional meat production and consumption patterns (Post 2012; Hocquette 2016; Kumar et al. 2016; Bryant et al. 2019; Hwang et al. 2020), while also providing alternative sources to meet protein demand (Alexander et al. 2017; Schouteten et al. 2016). However, its rapid growth is still countered by low consumer acceptance (Hoek et al. 2011; Michel et al. 2021; Jahn et al. 2021).

A transition, respectively, behavioural change towards a diet with less meat can only occur with adopting a positive attitude towards dietary changes based on reasons and motivations as outlined by Ogden et al. (2007). According to Fiddes (2004) the issue is not why we eat meat at all, but rather why we do so consistently and in such quantities, and often with such ceremony and strong emotional responses. Likewise, Graça et al. (2015) demonstrated that consumers have an affective connection towards meat that plays a role in their willingness to change consumption habits. They developed the so-called meat attachment scale (MEAS) and found that this scale is a separate, self-standing and relevant psychological construct with respect to meat consumption and substitution. According to their research, it provided explanatory power above and beyond that of the theory of planned behaviour components alone and represents a useful tool to understand further meat consumption and potential motivations for reduction (Graça et al. 2015).

Graça et al. (2015) argue that the affection towards meat may represent a continuum, in which one end refers to disgust (i.e. negative affect and repulsion, related to 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. 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. The MEAS consists of the following four dimensions: (1) hedonism (i.e. higher scores referring to meat represented as a source of pleasure), (2)

affinity (i.e. higher scores indicative of affinity towards meat consumption), (3) entitlement (i.e. higher scores referring to feelings of entitlement towards meat consumption) and (4) dependence (i.e. higher scores indicating feelings of dependence on meat consumption).

In this study, as a first step, we aim to apply the MEAS in Germany and compare the results with studies carried out in other countries. In this context, it is checked if the same underlying factors found by Graça et al. (2015) can be reproduced for Germany. Furthermore, we consider if meat attachment as measured by the MEAS is correlated with other scales/preferences such as food neophobia, social trust, and attitude towards respective preference for organic products. Literature shows that all mentioned constructs impact the acceptance, preference or trust in more sustainable food product innovation, respectively, more sustainable food processing techniques (Dolgopolova et al. 2015; Macready et al. 2020; Simões-Wüst et al. 2017). Therefore, it is interesting to consider if these constructs are related.

In the final part of the analysis, we consider the impact of all analysed scales on consumers' trust in different food technology innovations, e.g. foods made of plant-based proteins, cultured meat or products based on insect proteins. Furthermore, the impact on additional food processing technologies, e.g. high pressure, and Crispr-CAS, is analysed.

Over the recent past, meat substitutes (in particular, plant-based meat, cultured meat and edible insects) have gained increasing popularity as an innovative way to circumvent some of the negative impacts induced by conventional meat production and consumption patterns (Post 2012; Hocquette 2016; Kumar et al. 2016; Bryant et al. 2019; Hwang et al. 2020), while also providing alternative sources to meet protein demand (Alexander et al. 2017; Schouteten et al. 2016). However, its rapid growth is still countered by low consumer acceptance (Hoek et al. 2011; Michel et al. 2021; Jahn et al. 2021).

Besides consumers' trust evaluation of certain protein/meat alternatives, we were interested in consumers' trust in the selected food processing technologies Cripsr-CAS, pulsed electric fields (PEF), ohmic heating and high pressure as well. All these technologies are heavily used in the fields of alternative proteins. Gene-editing technology can facilitate the development of cultured meat production (Park and Park 2023) whereas ohmic heating is an emerging technology for the improvement of the techno-functional properties of legume-based raw materials (e.g. bean flour) (Varghese et al. 2014; Lima-Becerra et al. 2021) that can be used for the production of meat substitutes. Likewise, the PEF technology can enhance the technological functionality of plant-based proteins and make the production processes of protein alternatives more sustainable (Arshad et al. 2021; Melchior et al. 2020). Furthermore, research reports suggest that treatments with high pressure can, e.g. reduce the activity of allergens in legumes (Dong et al. 2020).

In this study, we considered trust in the mentioned protein alternatives, and processing technologies because, in research, this construct is most often used to explain consumers' risk perceptions or acceptance of food technologies and food hazards. Therefore, trust plays an important role in food acceptance, and it has been shown to influence risk and benefit perceptions of novel food technologies (Siegrist and Hartmann 2020; Siegrist et al. 2007). Roosen et al. (2015) found in an empirical study carried out in Canada and Germany that a higher level of trust in novel foods increases the willingness to

pay for such products. Regarding the functional foods market, Baker et al. (2022) report that willingness to pay can be influenced by trust in products and the technologies used for their production. In this paper, we focused on the effects of meat attachment, food neophobia, social trust and organic preference/attitude on the trust perception of the outlined food (process) innovations.

Before presenting the research method, data collection and results, an overview of selected research findings on meat attachment and the other constructs in research is given.

Research findings: meat attachment, food neophobia, organic preference/attitude, social trust and their interplay

Meat attachment

Graça et al. (2015) argued that holding a pattern of attachment towards meat consumption may hinder society's transition to a more plant-based diet and that the MEAS could be applied to analyse the acceptance of alternatives as, e.g. meat substitutes or lab-grown meat. In their own studies, (Graça et al. 2015, 2016, 2020) they found that meat attachment measured by their developed MEAS is negatively associated with the willingness to reduce meat consumption and to follow a more plant-based diet. Highly meat-attached individuals eat meat more often and hold more positive attitudes towards it.

Likewise, other researchers like Wang et al. (2021) found that Chinese and New Zealand consumers' willingness to consume alternative proteins was significantly linked to all four meat attachment factors (hedonism, affinity, entitlement and dependence). Lentz et al. (2018) demonstrated that the MEAS was found to provide explanatory power above and beyond that of the theory of planned behaviour components alone, and their results support the use of the MEAS as a tool further to understand meat consumption and potential motivations for reduction.

Food neophobia

Food neophobia refers to a reluctance to eat unfamiliar foods (Pliner and Hobden 1992). It has been the subject of many studies across many countries and affects the quality and a variety of foods in the diet (Capiola et al. 2012; Damsbo-Svendsen et al. 2017a; Falciglia et al. 2000; Henriques et al. 2009; Knaapila et al. 2007). According to Apostolidis and McLeay (2016) and Siegrist and Hartmann (2019), low levels of acceptance for meat substitutes have been associated with high levels of the construct food neophobia. The knowledge about population segments with greater or lesser neophobia allows for identifying early adopters of innovative products, e.g. meat substitutes or cultured meat (Vidigal et al. 2015). Food neophobia and unfamiliarity are especially relevant barriers in the case of cultural meat, while they have less relevance in the case of plant-based meat. As a matter of fact, in many countries, a growing number of plant-based meat products are already present on the market. In contrast, cultured meat has not been commercialized yet and is thus often perceived as an unfamiliar food product (Hwang et al. 2020). Similarly, Wilks et al. (2019) identified cognitive factors related to food neophobia and distrust in biotechnology as important negative determinants of consumer willingness to buy cultured meat. Both trust and food neophobia have been regarded as important factors of consumers' functional food acceptance (Dolgopolova et al. 2015).

Organic preference/attitude

Regular consumers of organic food have a higher ratio of plant to animal foods, with a strong relationship between vegetarian/vegan consumers and organic consumption (Baudry et al. 2015; Simões-Wüst et al. 2017). Nonetheless, concerning meat substitutes the results are mixed. Profeta et al. (2020) found that organic consumers in Germany evaluate meat substitutes more negatively than non-organic buyers, whereas Mandolesi et al. (2022) showed that the consumption of plant-based meat alternatives is mainly associated with healthy and sustainable habits, such as organic food consumption. Furthermore, they found that organic consumers negatively evaluated using new plant breeding techniques like Crispr-CAS in organic farming. In this line, Hüppe and Zander (2021) revealed that organic consumers are getting more sceptical when the processing level of a product increases. This holds in particular for so-called organic traditionalists.

Social trust

People differ in their general propensity to trust, whereas some strongly believe that societal actors behave in a way that warrants trust, and others do not. This social trust can be defined as "the belief that others will not deliberately or knowingly do us harm" (Macready et al. 2020; Delhey and Newton 2005). In the literature, alternative terms for social trust are 'general trust' and 'propensity to trust' (Chen and Dhillon 2003). Macready et al. (2020) showed that a person with a higher level of social trust is positively correlated with more trust in food supply chain actors and, based on that, higher confidence that food is safe, healthy, and sustainable. We hypothesize that higher social trust leads to a generally higher trust in the analysed food innovations processes.

Interplay meat attachment and food neophobia

It is to highlight that there are only very few studies that capture the constructs of meat attachment and food neophobia at the same time, whereas both exert an influence on the diet. It can be hypothesized that MEAS and FNS are linked to each other. Therefore, the correlation between both scales is analysed in this paper.

It is to highlight that to our best knowledge, only two studies consider the impact of the psychological constructs meat attachment and food neophobia on the intention to buy, respectively, the acceptance of meat alternatives (cultured meat, plant-based meat) simultaneously. Whereas in China, India, and the US a higher level of food neophobia goes along with a lower acceptance of cultured and plant-based meat, the findings for the effect of the MEAS are mixed (Bryant et al. 2019). In India and China, the MEAS positively affects the intention to purchase clean (cultured) meat, whereas no significant effect could be measured for the US. Concerning plant-based meat in the US with increasing meat attachment, the intention to buy such an alternative falls, whereas in China, the opposite effect and in India, no significant effect can be found. Thus, cultural differences appear in the context of this construct. In a second study, Profeta et al. (2021) analysed the impact of meat attachment and food neophobia on so-called meat hybrids. In meathybrids, only a fraction of the meat product (e.g. 20–50%) is replaced with plant-based proteins.

The idea of such a product is that it may represent an option for the broad consumer segment that is not interested in totally vegan or vegetarian alternatives to meat. The findings show that both MEAS and FNS exert a negative effect on the choice of this product type, whereas the effect of the MEAS is stronger compared to the effect of the level of food neophobia.

Material and methods

Data collection

The online survey was carried out in Germany, and after data cleaning, 896 complete questionnaires could be collected. The sample is representative for Germany concerning age, gender, and federal state for adults in the range ≥ 18 years to 69 years. In the sample, highly educated respondents are slightly overrepresented. Data collection took place in the time period from 17th December 2020 until 5th January 2021 (see Table 1). The questionnaire contained two attention checks. Furthermore, speeders were eliminated,

Table 1 Sociodemographics of the sample (n = 896) versus sociodemographics of German population in per cent

Attribute	Characteristics	% Sample	% German population
Gender	Female	50.2	49.5
	Male	49.8	50.5
Age groups	18–29 years	19.3	19.8
	30–39 years	17.9	19.4
	40–49 years	18.0	18.0
	50–59 years	25.2	23.8
	60–69 years	19.6	19.1
Education level	Low	23.1	36.4
	Middle	34.9	30.1
	High	42.0	33.5
Federal state	Schleswig-Holstein	3.6	3.4
	Hamburg	2.5	2.3
	Niedersachsen	9.9	9.5
	Bremen	0.8	0.8
	Nordrhein-Westfalen	22.0	21.6
	Hessen	6.0	7.6
	Rheinland-Pfalz	5.5	4.9
	Baden-Württemberg	14.2	13.5
	Bayern	14.6	16.0
	Saarland	1.1	1.2
	Berlin	4.0	4.5
	Brandenburg	3.5	3.0
	Mecklenburg-Vorpommern	2.0	1.9
	Sachsen	5.1	4.7
	Sachsen-Anhalt	2.2	2.5
	Thüringen	3.0	2.5

Sources Own survey and www-genesis.destatis.de

The German population per cent shares for gender, age and Federal state are calculated based on the German population between 18 and 69 years in 2020. For the parameter education data was available only for 2019 and the age range from 20 to 65 years

and the data were screened for recognizing strategic answer patterns. Half of the median time needed for answering the questionnaire was chosen to identify speeders.

Consumer data were collected using a quantitative online survey approach. The respondents have been recruited by the market research company GapFish (www.gapfish.com). All participants used a checkbox on the questionnaire to indicate their informed consent. The questionnaire comprised questions about general meat consumption on the one hand and specific questions concerning preferences for meat substitutes on the other. At the end of the questionnaire, participants were asked for demographic information, including age (range 18 to 69 years), gender, and education. Finally, participants were invited to provide any final comments before being debriefed and thanked for their time. For the online questionnaire, the software SoSci was used that is running on the server of the German Institute of Food Technology.

Data analysis

Applied scales

As outlined, we used the MEAS, FNS, a new scale that measures the preference for organic food, and the social trust scale in this study. For all scales, Cronbach's alpha was calculated and reported. In the following, more detailed information is given for each applied scale.

Meat attachment scale (MEAS)

For the MEAS, the participants answered on a five-point response scale (Graça et al. 2015) 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 2 were inversely re-coded.

We selected 15 out of the 16 items of the scale of Graca et al. 2015 for measuring the psychometric MEAS construct (see Table 2). One item of the original MEAS list did not enter into the online survey because a pre-study (Profeta et al. 2021) showed that a shortened

Table 2 Descriptive results MEAS

Statement	std. α	$\bar{\chi}$	σ
i1: I love meals with meat	0.93	3.71	1.15
i2: To eat meat is one of the good pleasures in life	0.93	3.04	1.26
i3: I'm a big fan of meat	0.93	3.28	1.30
i4: A good steak is without comparison	0.94	3.43	1.36
i5: By eating meat I'm reminded of the death and suffering of animals (*r*)	0.94	3.65	1.24
i6: To eat meat is disrespectful towards life and the environment (*r*)	0.94	3.54	1.25
i7: Meat reminds me of diseases (*r*)	0.94	4.22	1.06
i8: To eat meat is an unquestionable right of every person	0.94	3.34	1.27
i9: According to our position in the food chain, we have the right to eat meat	0.94	3.08	1.28
i10: Eating meat is a natural and indisputable practice	0.94	3.50	1.17
i11: I don't picture myself without eating meat regularly	0.93	3.20	1.36
i12: If I couldn't eat meat I would feel weak	0.93	2.95	1.41
i13: I would feel fine with a meatless diet (*r*)	0.94	3.32	1.25
i14: If I was forced to stop eating meat I would feel sad	0.94	2.97	1.39
i15: Meat is irreplaceable in my diet	0.93	3.04	1.34

15-item scale still captures all dimensions sufficiently. The German translation was taken from the mentioned study.

In the study mentioned, the scale was translated from English into German in order to enable the use of the scale for German-language studies. A multi-stage process was used for this (Koller et al. 2012; ICT 2017) (see Appendix for German translation).

When considering that the inclusion of invalid items creates the risk of invalid conclusions (Hartmann et al. 2015), an exploratory factor analysis (Varimax rotation) and confirmatory factor analysis were carried out in order to explain the variability of the MEAS. For the determination of the number of factors to extract in the framework of the exploratory factor analysis, only factors with an eigenvalue greater than one were chosen.

The confirmatory factor analysis was calculated and visualized with the R-package lavaan (Rosseel 2012). Furthermore, a so-called four-factor structure with a second-order dimension was chosen for this purpose, as done by Graca et al. (2015). In this second-order model, the construct of the MEAS consists of the underlying latent factors of entitlement, dependence, affinity and hedonism. The mentioned four factors themselves are derived from the items developed by Graca et al. (2015). The confirmatory factors analysis aimed to confirm the four factors identified by Graca et al. (2015).

Furthermore, the distribution of the summed scale values of the individuals was checked via a QQ-plot for normal distribution.

Food neophobia scale (FNS)

For measuring FNS, the list of Pliner and Hobden (1992) was selected (see Table 6). The wording of the German version has been chosen from a study by Siegrist and Hartmann (2019). The participants answered on a five-point response scale that was verbally and numerically anchored (1 = totally disagree, 2 = disagree, 3 = neither disagree nor agree 4 = agree, and 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) were inversely re-coded.

WFI-OeL organic index

The WFI-OeL organic index (Kühn et al. 2023) is a tested item-set for measuring consumers' attitudes and preferences for organic food with a short five item (see Table). The scale is measured based on a five-point bipolar Likert scale ranging from 1 to 5 ('strongly disagree' = 1, 'disagree' = 2, 'neither agree nor disagree = 3, 'agree' = 4 and 'strongly agree' = 5). The German wording of the items was taken from Kühn et al. (2023), and the items indicated with (*r*) were inversely re-coded.

Social trust scale

Three items from the social trust scale of Gefen and Straub (2004) were selected for measuring social trust. For this purpose, respondents had to indicate how strongly (1 = do not agree at all, 5 = agree completely) they agree with statements on general trust in other people. The German translation was produced following the outlined procedure for the MEAS.

Correlation analysis

A correlation analysis was carried out to reveal relationships across the scales (see Sect. 4.3). For this purpose, for each individual, the summed value for each scale was calculated.

Regression analysis

In the regression analysis, the impact of the considered scales on the trust in seven selected food technologies, respectively, alternative proteins as the dependent variable was analysed. Trust in food technologies was measured on a five-point response scale that was verbally and numerically anchored (1 = no trust at all, 2 = less trust, 3 = neither disagree nor agree 4 = high trust, and 5 = very high trust). Trust has been measured for the following food (processing) technologies: High-pressure approach (Buckow and Heinz 2008), cultured meat, plant-based meat (Smetana et al. 2015), insect-protein-based meat substitutes, Crispr-CAS (Selle and Barrangou 2015), Ohmic heating (Maloney and Harrison 2016) and Pulsed electric fields (Heinz et al. 2001). Before evaluating these technologies, the respondents received a simple explanation of each technology.

The applied formula for the seven regressions was as follows:

$$\text{Trust in food technologies}_i = \text{constant} + \beta_1 \text{MEAS}_i + \beta_2 FNS_i + \beta_3 \text{Social trust}_i + \beta_4 \text{Organic Index}_i \quad (1)$$

In the formula, the subscript $_i$ indicates the individual trust evaluation of participant $_i$ in the indicated food technology, respectively, the z-standardized mean value of participant $_i$ for the applied scale.

Results and discussion

Meat attachment scale (MEAS)

Descriptives

On average, the respondents agreed to all of the statements ($\overline{x} = 3.95$, $\sigma = 0.95$) (see Table 2). The highest means received the statements 'I love meals with meat' (3.71) and the reverse-coded item 'Meat reminds me of diseases'(4.22). This evaluation demonstrates that most German respondents consider meat, not an unhealthy product but an essential part of their diet. The higher the MEAS-score, the higher individual's attachment to meat.

The distribution of individual MEAS-values (see Fig. 1) and the corresponding QQ-plot (see Fig. 2) reveal an approximately normal distribution of the scale.

Exploratory and confirmatory factor analysis

The exploratory factor analysis resulted in a model with four factors which explains 70% of the variance (see Table 3). The findings confirm the research of Graca et al. (2015) and the four underlying factors hedonism, affinity, entitlement and dependence can be identified (see Fig. 3).

It is to highlight that the item "I would feel fine with a meatless diet"(i13) was deleted from the MEAS. In the four-factor solution of the exploratory factor analysis, this item has a similar loading on different factors (factor 2 and factor 3, see Table 3) and its deletion increased the calculated fit indices in the confirmatory factor analysis. The Comparative Fit Index (CFI = 0.961), the Tucker–Lewis Index (TLI = 0.951), and the Root Mean Square Error of Approximation (RMSEA = 0.076) in the confirmatory factor analysis are acceptable. The reliability analysis for the global MEAS (14 items) showed a high internal consistency with a standardized Cronbach α of 0.94 (see Appendix Table 7).

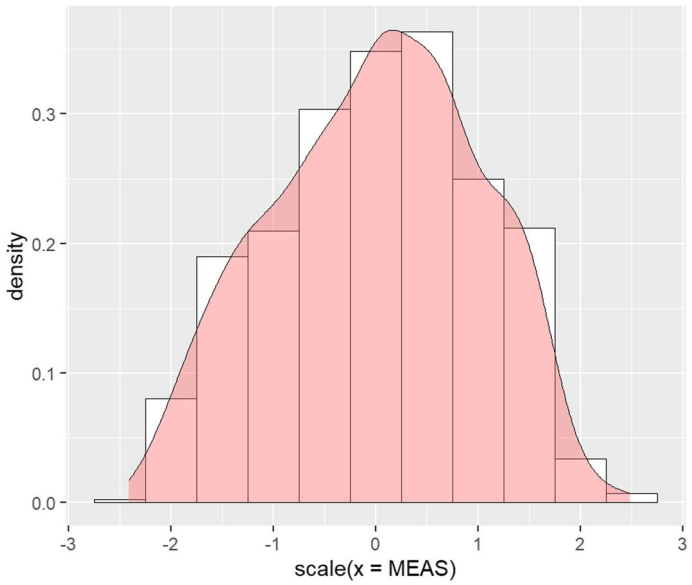

Fig. 1 Distribution standardized MEAS-values

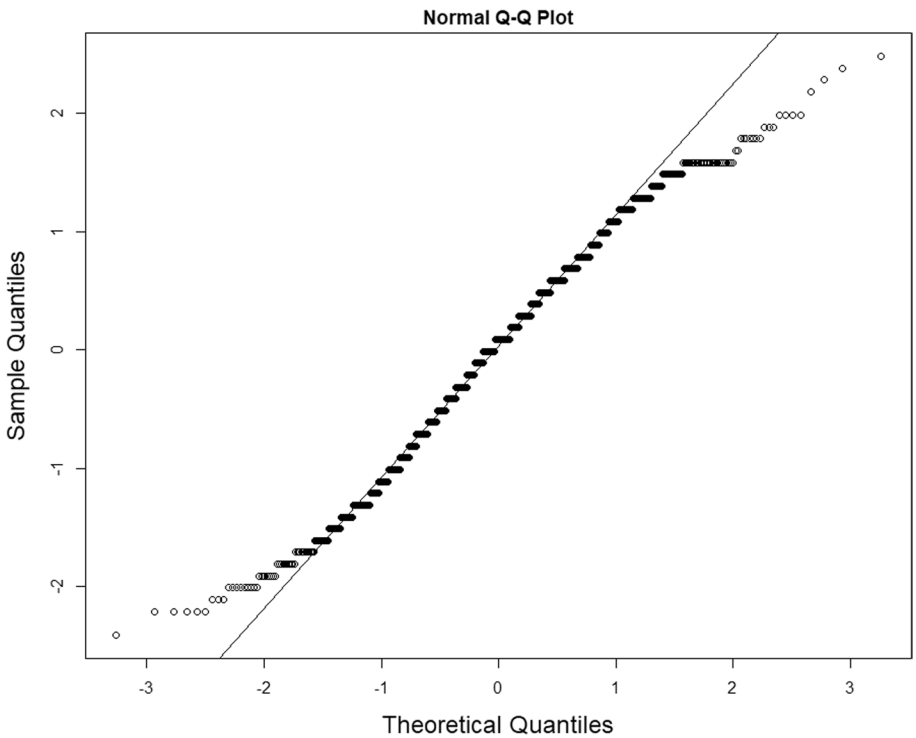

Fig. 2 QQ-plot standardized MEAS-values

Scales-FNS, organic index, social trust

After deleting one item from the original FNS-list due to a low item-correlation in the reliability analysis, FNS showed an acceptable internal consistency with a standardized Cronbach α of 0.83 (see Appendix Tables 6 and). The deleted item was: "I am

Table 3 Explorative factor analysis - MEAS

Statement	Factors				
	1	2	3	4	h^2
i1: I love meals with meat	**0.68**	− 0.31	0.30	0.28	0.73
i2: To eat meat is one of the good pleasures in life	**0.72**	− 0.18	0.36	0.29	0.76
i3: I'm a big fan of meat	**0.81**	− 0.21	0.34	0.27	0.90
i4: A good steak is without comparison	**0.61**	− 0.28	0.28	0.24	0.59
i5: By eating meat I'm reminded of the death and suffering of animals (*r*)	− 0.24	**0.77**	− 0.19	− 0.17	0.71
i6: To eat meat is disrespectful towards life and the environment (*r*)	− 0.14	**0.75**	− 0.18	− 0.24	0.67
i7: Meat reminds me of diseases (*r*)	− 0.15	**0.71**	− 0.07	− 0.04	0.53
i11: I don't picture myself without eating meat regularly	0.43	− 0.26	**0.57**	0.35	0.71
i12: If I couldn't eat meat I would feel weak	0.35	− 0.15	**0.78**	0.27	0.83
i13: I would feel fine with a meatless diet (*r*)	− 0.35	**0.46**	**− 0.48**	− 0.23	0.62
i14: If I was forced to stop eating meat I would feel sad	0.29	− 0.19	**0.82**	0.24	0.86
i15: Meat is irreplaceable in my diet	0.46	− 0.22	**0.61**	0.38	0.77
i8: To eat meat is an unquestionable right of every person	0.19	− 0.09	0.17	**0.62**	0.45
i9: According to our position in the food chain, we have the right to eat meat	0.25	− 0.15	0.24	**0.68**	0.61
i10: Eating meat is a natural and indisputable practice	0.29	− 0.34	0.28	**0.64**	0.69
Cumulative variance	0.20	0.39	0.55	0.70	

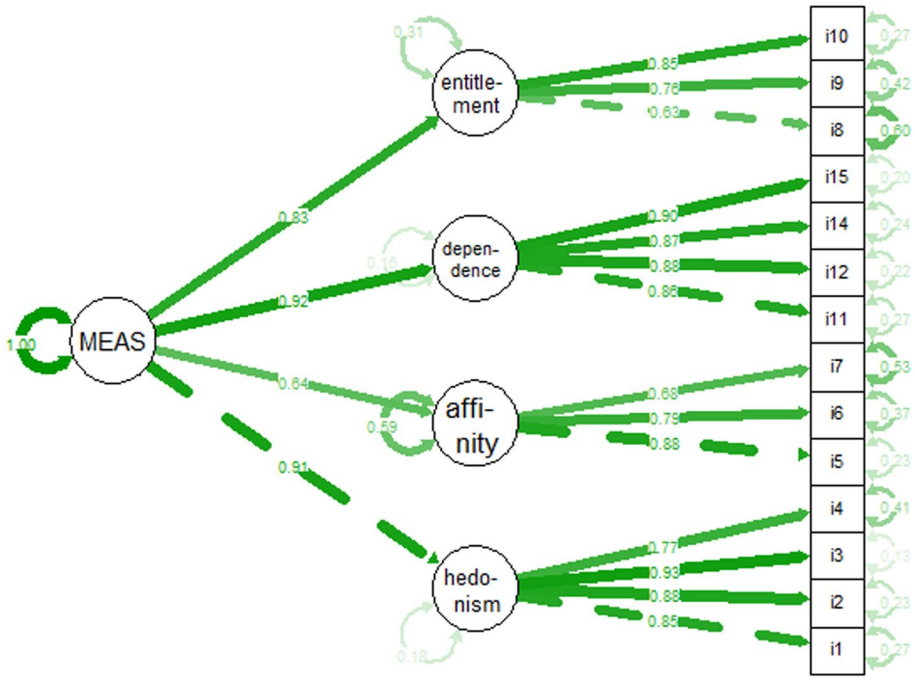

Fig. 3 Graphical presentation of CFA

very particular about the food I eat". Likewise, the social trust scale (α=0.84) and the organic scale (α=0.83) showed acceptable Cronbach α values (see Appendix Tables 7, and).

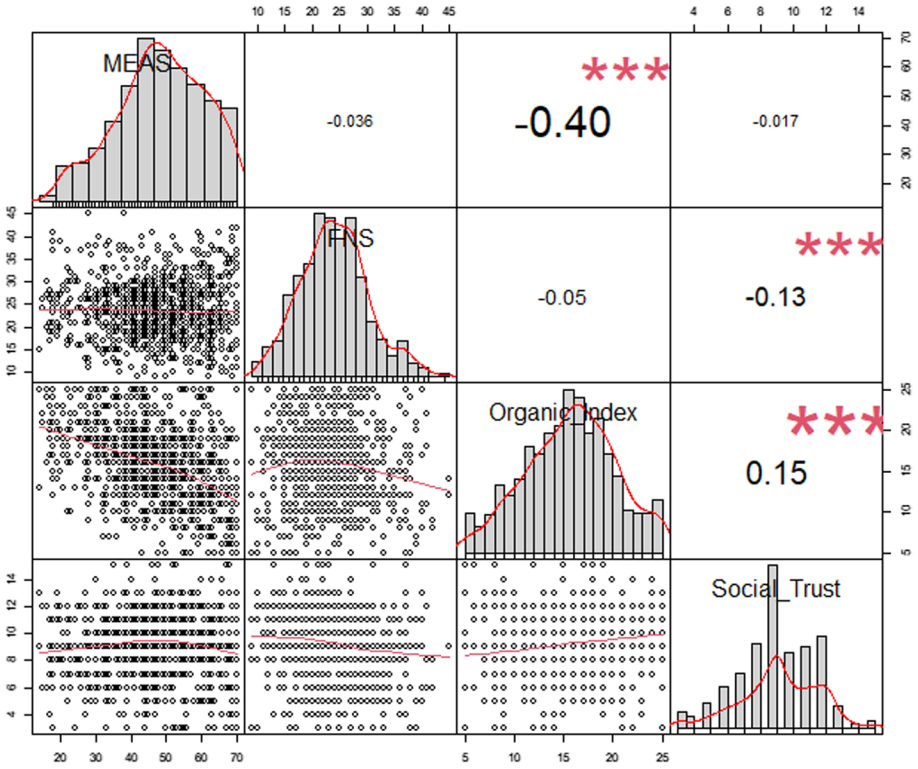

Fig. 4 Distribution, scatter-, correlation plots—MEAS, FNS, organic index, social trust

Distribution of scales and correlations between MEAS, FNS, organic index and social trust

On the diagonal of Fig. 4 based on individual summed scale values, the distributions of the analysed scales are shown. On the left- and right-hand side of Fig. 4 the range of the summed values of the corresponding scales are indicated. In the case of the organic index, e.g. the values reach from 5 (minimum) to 25 (maximum) because each of the five items of this scale could take values from one to five. The MEAS-, FNS-, and organic index scales are visually nearly normally distributed, whereas the social trust scale reveals two peaks.

Concerning the correlations in Fig. 4 to the right of the diagonal, the correlation coefficients are shown, whereas to the left, the scatter plots of the summed scale values of the participants are visualized. Furthermore, the scatter plots include a smoothed regression line.

The correlation analysis (Fig. 4) reveals that the preference for organic foods is negatively linked with respondents' meat attachment (−0.40***). The higher the preference for organic foods, the lower the individual's meat attachment. The correlation can be considered as strong. Contrary to this first finding, no significant correlation between MEAS and FNS can be found.

At first glance, it appears as if there is only a small negative correlation between the organic preference and food neophobia (−0.05). Nonetheless, the inspection of the scatter-plot (Fig. 4) shows that this negative effect is higher in the range from a medium to a high level of food neophobia. Thus higher levels of food neophobia are associated with a lower preference for organic foods.

The social trust scale is positively correlated with the preference for organic products (0.15^{***}) and negatively correlated with food neophobia (-0.13^{***}). Interestingly, there is no correlation between MEAS and social trust.

Impact of MEAS, FNS, organic index, and social trust on trust in food technologies

The survey reveals that consumers trust the high-pressure technology, the ohmic heating and the pulsed electric field technique most, whereas the genome editing approach via Crispr-CAS and cultured meat are trusted least (Fig. 5). Focusing on the meat alternatives, consumers have a significantly higher trust in plant-based foods compared to insect protein-based products and cultured meat.

In the regression analysis, the impact of the considered scales on the selected food technologies, respectively, alternative proteins was analysed (Fig. 6, Table 4). For use in the regression analysis, the individual scores, which is the *z*-standardized mean value across the items of the four scales, were calculated. In Fig. 6, the shown distributions of the coefficients indicate the inner 95% interval.

In this study, meat attachment has negative effects on the trust in all three protein alternatives but no negative effects on the other processing technologies. Interestingly, the negative effect is highest for plant-based proteins and lowest for insect-protein-based products.

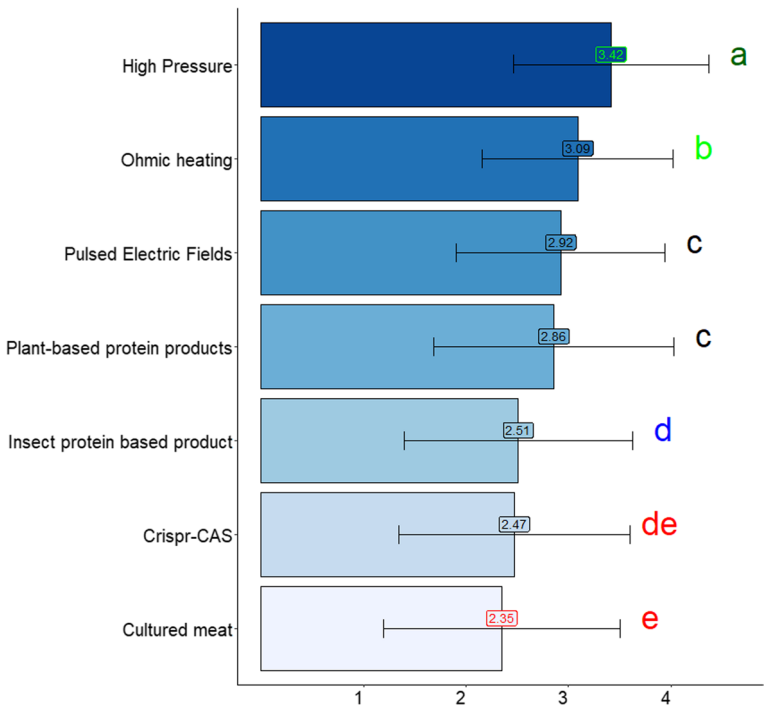

Fig. 5 Trust (1 = 'no trust at all' to 5 = 'very high trust') in different food technologies (Different letters indicate a significant difference in trust perception based on Tukey's test ($p < 0.05$))

In general, it can be stated that food neophobia has significant negative effects on the trust perception of all technologies with the exemption of the Crispr-CAS approach. Contrarily, with increasing social trust, all technologies are trusted more.

Concerning protein alternatives, the organic preference measured by the organic index has no impact on the trust evaluation of cultured meat or insect protein-based products. Only for plant-based meat alternatives and high-pressure technology positive effects can be found. Furthermore, the organic preference negatively influences the trust perception of the genome-editing technique Crispr-CAS.

Discussion

The findings show that the MEAS can be applied in Germany, and a similar structure, as reported by Graça et al. (2015), could be found. For Germany, we received with a mean value of 3.4 ($\sigma = 0.95$) for the MEAS (14 items ⇒ see exploratory and confirmatory factor analysis) similar values as found by Graca et al. (2015) for two Spanish samples (study 1: $\bar{x} = 3.4$, $\sigma = 0.8$; study 2: $\bar{x} = 3.6$, $\sigma = 0.9$). Compared with the findings of Bryant et al. (2019), we found in Germany lower values than in the USA ($\bar{x} = 3.8$, $\sigma = 0.54$) and China ($\bar{x} = 3.7, \sigma = 0.5$) whereas there a higher meat attachment compared to India ($\bar{x} = 3.3, \sigma = 0.7$). The country ranking of the MEAS scale based on the four mentioned countries fits relatively well with their per capita meat consumption. Whereas meat consumption is the highest in the USA, it is the lowest in India (University of Oxford 2020). Nonetheless, even the value for India indicates a high attachment to meat, and for India in the last decade, a sharp rise in meat consumption could be observed (Alae-Carew

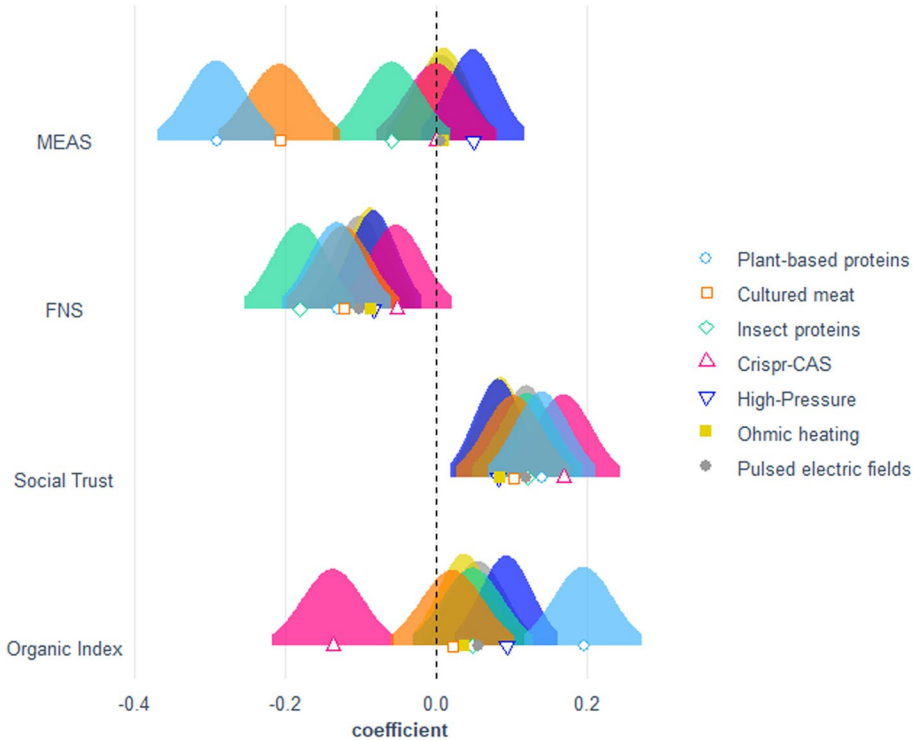

Fig. 6 Regression plots-impact of applied scales on trust in different food (processing) technologies

Table 4 Regression analysis - Impact of applied scales on trust in different food (processing) technologies

	Dependent variable						
	Plant-based proteins	**Cultured meat**	**Insect protein**	**Crispr-CAS**	**High pressure**	**Ohmic heating**	**Pulsed electric fields**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
meas_scale	−0.291***	−0.207***	−0.059	0.0003	0.049	0.010	0.006
	(0.039)	(0.041)	(0.040)	(0.041)	(0.035)	(0.034)	(0.037)
fns_scale	−0.132***	−0.123***	−0.181***	−0.052	−0.083***	−0.087***	−0.102***
	(0.036)	(0.038)	(0.037)	(0.038)	(0.032)	(0.031)	(0.034)
bio_scale	0.195***	0.022	0.049	−0.137***	0.093***	0.037	0.056
	(0.040)	(0.042)	(0.040)	(0.041)	(0.035)	(0.034)	(0.037)
social_trust_scale	0.140***	0.103***	0.121***	0.169***	0.082**	0.085***	0.119***
	(0.037)	(0.038)	(0.037)	(0.038)	(0.032)	(0.032)	(0.034)
Constant	2.857***	2.348***	2.511***	2.471***	3.415***	3.092***	2.924***
	(0.036)	(0.038)	(0.036)	(0.037)	(0.032)	(0.031)	(0.034)
Observations	896	896	896	896	896	896	896
R^2	0.160	0.057	0.051	0.035	0.028	0.022	0.032
Adjusted R^2	0.156	0.053	0.046	0.031	0.024	0.018	0.028
Residual Std. Error (df = 891)	1.077	1.125	1.092	1.111	0.944	0.924	1.003
F Statistic (df = 4; 891)	42.487***	13.430***	11.897***	8.171***	6.517***	5.067***	7.382***

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

et al. 2019). Therefore, it can be hypothesized that meat attachment is not only correlated with meat consumption but even with meat consumption growth rates.

The found trust ranking for alternative proteins (see Sect. 4.4, Fig. 5) aligns with the preference ranking found for these product types in literature (Loo et al. 2020; Escribano et al. 2021). From this, it can be concluded that trust in the analysed meat alternatives is a good predictor and antecedent for the final preference for the same products. A similar relationship between trust and preference for food products was found for short food supply chains by Giampetri et al. (2018). Furthermore, Albertsen et al. (2020) highlight that to increase the acceptance of food innovations on the consumer side, it is necessary to reduce mistrust.

The findings for the impact of meat attachment on trust in the selected food innovations and processes demonstrate that this construct plays a role in trust formation for meat alternatives in Germany. This hypothesis is confirmed by the applied regression analysis. A high level of meat attachment goes along with lower trust in plant-based proteins. Similar holds for cultured meat and insect proteins. Thus it appears that, at least at the moment, cultured meat or proteins from insects are not a logical substitute for the heavily meat attached consumer. This outcome contradicts studies of Circus et al. (2019) and Bryant et al. (2019), which found a positive relationship between meat attachment and the preference for cultured meat.

The correlation analysis demonstrated that FNS and MEAS are not correlated. That is, meat attachment represents an independent and single predictor for trust in food (processing) technologies such as, e.g. plant-based proteins or cultured meat. This is surprising because due to a recent study in Germany (Profeta et al. 2021), both scales showed a negative effect on the choice of meat alternatives. Thus, it appears as if, for Germany, both constructs can be considered independent from each other despite the fact that both negatively affect the consumption of meat alternatives. Furthermore, we showed that whereas the preference for organic products and food neophobia are not correlated, there is a strong and negative correlation between MEAS and the applied organic scale. Therefore, it appears that highly meat-attached consumers reveal a less sustainable consumption behaviour and prefer less organic food products. This result is in line with the behavioural data from Baudry et al. (2015) and Simoes-Wüst et al. (2017), which found that organic consumers have a lower meat consumption compared to non-organic consumers.

Conclusions and limitations

The findings show that the MEAS can be applied in Germany, and a similar structure, as reported by Graça et al. (2015), could be found. Furthermore, meat attachment was identified as a barrier to a transition towards a more plant-based, respectively, alternative protein-based diet. Therefore, future research should focus on analysing appropriate measures to reduce consumers' meat attachment.

Furthermore, when research and policy consider cultured meat as a real option, future studies should analyse why German meat-attached consumers do not trust this option. In this context, the research could test if an appropriate communication and information strategy could reduce the reservations of this consumer segment. Additionally, cross-country studies are necessary because, as outlined in the discussion, higher levels of meat attachment lead to a higher acceptance of cultured meat in other countries.

It is to highlight that in this study, we used trust as a dependent variable and analysed the impact of the MEAS on this construct. Due to the fact that the MEAS provide explanatory power above and beyond that of the theory of planned behaviour components alone, future studies should use intentions, preferences towards a meat-reduced or meat-free diet and, if possible behavioural data for this purpose.

In this study, we applied the FNS because research showed that low acceptance levels for meat substitutes had been associated with high levels of construct food neophobia (Apostolidis and McLeay 2016; Siegrist and Hartmann 2019). Nonetheless, concerning trust in alternative proteins and food technologies, applying the food technology neophobia scale (FTNS) could be more appropriate (Verma et al. 2021; Damsbo-Svendsen et al. 2017b). Furthermore, it is possible that the correlation with meat attachment is different for FNS and FTNS, and this must be tested in a separate study.

In this paper, we reported only the level of meat attachment in a German sample but did not collect data about individuals' meat consumption. Future research should collect this data and quantify the relationship between meat attachment and consumption.

Appendix

See Tables 5, 6, 7, 8 and 9.

Table 5 English and German version of the MEAS

English	German
i1: I love meals with meat	Ich liebe Mahlzeiten mit Fleisch
i2: To eat meat is one of the good pleasures in life	Fleisch zu essen, ist eine der schönsten Freuden im Leben
i3: I'm a big fan of meat	Ich bin ein großer Fan von Fleisch
i4: A good steak is without comparison	Ein gutes Steak ist unvergleichlich
i5: By eating meat I'm reminded of the death and suffering of animals (*r*)	Beim Essen von Fleisch werde ich an den Tod und das Leid der Tiere erinnert
i6: To eat meat is disrespectful towards life and the environment (*r*)	Fleisch zu essen ist nicht respektvoll gegenüber dem Leben allgemein und der Umwelt
i7: Meat reminds me of diseases (*r*)	Fleisch erinnert mich an Krankheiten
i8: To eat meat is an unquestionable right of every person	Fleisch zu essen ist ein in nicht in Frage zu stellendes Recht jeder Person
i9: According to our position in the food chain, we have the right to eat meat	Bezüglich unserer Stellung in der Nahrungskette, haben wir das Recht Fleisch zu essen
i10: Eating meat is a natural and indisputable practice	Fleisch zu essen ist eine natürliche und unstrittige Praxis
i11: I don't picture myself without eating meat regularly	Ich kann mir ein Leben ohne regelmäßigen Fleischkonsum nicht vorstellen
i12: If I couldn't eat meat I would feel weak	Wenn ich Fleisch essen könnte, würde ich mich schwach fühlen
i13: I would feel fine with a meatless diet (*r*)	Ich würde mich gut fühlen mit einer fleischlosen Ernährung
i14: If I was forced to stop eating meat I would feel sad	Wenn ich gezwungen wären, kein Fleisch mehr zu essen, würde ich mich traurig fühlen
i15: Meat is irreplaceable in my diet	Fleisch ist in meiner Ernährung unersetzlich

Table 6 Mean, standard deviation and Cronbach's alpha when item is deleted for food neophobia items

Statement	std. α	$\bar{x}$	σ
I constantly taste new and different foods (*r*)	0.75	3.18	1.06
I do not trust new foods	0.78	3.33	0.99
If I don't know what a food is, I won't try it	0.80	2.94	1.09
I prefer food from different cultures (*r*)	0.76	3.35	1.08
I'm afraid to eat foods that I did not eat before (*r*)	0.76	3.03	1.11
If I go to a buffet, meetings or parties, I'll eat new food	0.74	3.57	1.10
I am very particular about the food I eat	0.83	3.30	0.99
I eat whatever is good (*r*)	0.78	3.31	1.22
I like to try new ethnic restaurants (*r*)	0.75	3.52	1.17
Ethnic food looks to weird to eat	0.78	3.89	1.14

Table 7 Mean, standard deviation and Cronbach's alpha when item is deleted for social trust items

Statement	std. α	$\bar{x}$	σ
I generally trust other people	0.80	3.10	0.92
I feel that people are generally trustworthy	0.75	3.04	0.94
I feel that people are generally reliable	0.78	3.01	0.90

Table 8 Mean, standard deviation and Cronbach's alpha when item is deleted for organic index items

Statement	std. α	$\bar{x}$	σ
When I buy foods I prefer organic products	0.77	3.08	1.19
Organic food is healthier than conventional food	0.80	3.34	1.09
I trust producer of organic foods more than conventional producers	0.78	3.21	1.16
I do not buy organic foods, because they are too expensive (*r*)	0.83	3.02	1.29
I do see only marginal differences between organically and conventionally produced foods (*r*)	0.83	3.16	1.17

Table 9 Cronbach's alpha of the applied scales

Scale	Cronbach's alpha
MEAS	0.94
FNS	0.83
Organic index	0.83
Social trust	0.84

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DK, AP and TK wrote together the first draft of the paper. VH and AP were responsible for the research design, data collection and funding of this research.

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Availability of data and materials

The dataset and the applied R-Script for data analysis will be publicly available on the website www.prokribus.de/research/scientific_papers.

Declarations

Competing interests

The authors declare that they have no competing interests.

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References

Aiking H, J de Boer, Vereijken JM (2006). Sustainable protein production and consumption: pigs or peas? Sustainable protein production and consumption: pigs or peas?. https://doi.org/10.1007/1-4020-4842-4

Alae-Carew C, Bird FA, Choudhury S, Harris F, Aleksandrowicz L, Milner J, Joy EJ, Agrawal S, Dangour AD, Green R (2019) Future diets in India: a systematic review of food consumption projection studies. Glob Food Sec 23:182–190. https://doi.org/10.1016/J.GFS.2019.05.006

Albertsen L, Wiedmann KP, Schmidt S (2020) The impact of innovation-related perception on consumer acceptance of food innovations - development of an integrated framework of the consumer acceptance process. Food Quality Preference 84:103958. https://doi.org/10.1016/J.FOODQUAL.2020.103958

Alexander P, Brown C, Arneth A, Dias C, Finnigan J, Moran D, Rounsevell MDA (2017) Could consumption of insects, cultured meat or imitation meat reduce global agricultural land use? Glob Food Secur. https://doi.org/10.1016/j.gfs.2017.04.001

Apostolidis C, McLeay F (2016) Should we stop meating like this? reducing meat consumption through substitution. Food Policy 65:74–89. https://doi.org/10.1016/J.FOODPOL.2016.11.002

Arshad RN, Abdul-Malek Z, Roobab U, Munir MA, Naderipour A, Qureshi MI, Bekhit AED, Liu ZW, Aadil RM (2021) Pulsed electric field: a potential alternative towards a sustainable food processing. Trends Food Sci Technol 111:43–54. https://doi.org/10.1016/J.TIFS.2021.02.041

Baker MT, Lu P, Parrella JA, Leggette HR (2022) Consumer acceptance toward functional foods: a scoping review. Int J Environ Res Public Health 19:1217. https://doi.org/10.3390/IJERPH19031217
Baudry J, Méjean C, Péneau S, Galan P, Hercberg S, Lairon D, Kesse-Guyot E (2015) Health and dietary traits of organic food consumers: results from the nutrinet-santé study. Br J Nutr 114:2064–2073. https://doi.org/10.1017/S0007114515003761
Boer JD, Schösler H, Aiking H (2014) "meatless days" or "less but better"? exploring strategies to adapt western meat consumption to health and sustainability challenges. Appetite 76:120–128. https://doi.org/10.1016/j.appet.2014.02.002
Bryant C, Szejda K, Parekh N, Desphande V, Tse B (2019) A survey of consumer perceptions of plant-based and clean meat in the USA, India, and china. Front Sustain Food Syst 3:11. https://doi.org/10.3389/FSUFS.2019.00011
Buckow R, Heinz V (2008) High pressure processing—a database of kinetic information. Chem Ing Tech 80:1081–1095. https://doi.org/10.1002/CITE.200800076
Buttlar B, Walther E (2018) Measuring the meat paradox: how ambivalence towards meat influences moral disengagement. Appetite 128:152–158. https://doi.org/10.1016/J.APPET.2018.06.011
Capiola A, Raudenbush B, Capiola A, Raudenbush B (2012) The effects of food neophobia and food neophilia on diet and metabolic processing. Food Nutr Sci 3:1397–1403. https://doi.org/10.4236/FNS.2012.310183
Chen SC, Dhillon GS (2003) Interpreting dimensions of consumer trust in e-commerce. Inform Technol Manag 4(2):303–318. https://doi.org/10.1023/A:1022962631249
Circus VE, Robison R (2019) Exploring perceptions of sustainable proteins and meat attachment. Bt Food J 121:533–545. https://doi.org/10.1108/BFJ-01-2018-0025
Damsbo-Svendsen M, Frøst MB, Olsen A (2017) A review of instruments developed to measure food neophobia. Appetite 113:358–367. https://doi.org/10.1016/J.APPET.2017.02.032
Damsbo-Svendsen M, Frøst MB, Olsen A (2017) A review of instruments developed to measure food neophobia. Appetite 113:358–367. https://doi.org/10.1016/J.APPET.2017.02.032
Delhey J, Newton K (2005) Predicting cross-national levels of social trust: Global pattern or nordic exceptionalism? Eur Sociol Rev 21:311–327. https://doi.org/10.1093/esr/jci022
Dolgopolova I, Teuber R, Bruschi V (2015) Consumers' perceptions of functional foods: trust and food-neophobia in a cross-cultural context. Int J Consum Stud 39:708–715. https://doi.org/10.1111/IJCS.12184
Dong X, Wang J, Raghavan V (2020) Critical reviews and recent advances of novel non-thermal processing techniques on the modification of food allergens. Crit Rev Food Sci Nutr 61:196–210. https://doi.org/10.1080/10408398.2020.1722942
Dowsett E, Semmler C, Bray H, Ankeny RA, Chur-Hansen A (2018) Neutralising the meat paradox: cognitive dissonance, gender, and eating animals. Appetite 123:280–288. https://doi.org/10.1016/J.APPET.2018.01.005
Enneking U, Franz R, Profeta A (2007) Nachhaltige Konsum- und Einstellungsmuster. Metropolis, Marburg
Escribano AJ, Peña MB, Díaz-Caro C, Elghannam A, Crespo-Cebada E, Mesías FJ (2021) Stated preferences for plant-based and cultured meat: a choice experiment study of Spanish consumers. Sustainability 13:8235. https://doi.org/10.3390/SU13158235
Falciglia GA, Couch SC, Gribble LS, Pabst SM, Frank R (2000) Food neophobia in childhood affects dietary variety. J Am Diet Assoc 100:1474–1481. https://doi.org/10.1016/S0002-8223(00)00412-0
Fiddes N (2004) Meat: a natural symbol. Routledge, Milton Park
Gefen D, Straub DW (2004) Consumer trust in b2c e-commerce and the importance of social presence: experiments in e-products and e-services. Omega 32:407–424. https://doi.org/10.1016/J.OMEGA.2004.01.006
Giampietri E, Verneau F, Giudice TD, Carfora V, Finco A (2018) A theory of planned behaviour perspective for investigating the role of trust in consumer purchasing decision related to short food supply chains. Food Qual Prefer 64:160–166. https://doi.org/10.1016/J.FOODQUAL.2017.09.012
Graça J, Calheiros MM, Oliveira A (2015) Attached to meat? (un)willingness and intentions to adopt a more plant-based diet. Appetite 95:113–125. https://doi.org/10.1016/J.APPET.2015.06.024
Graça J, Calheiros MM, Oliveira A (2016) Situating moral disengagement: motivated reasoning in meat consumption and substitution. Person Individ Differ 90:353–364. https://doi.org/10.1016/J.PAID.2015.11.042
Graça J, Cardoso SG, Augusto FR, Nunes NC (2020) Green light for climate-friendly food transitions? Communicating legal innovation increases consumer support for meat curtailment policies. Environ Commun 14:1047–1060. https://doi.org/10.1080/17524032.2020.1764996
Hallström E, Carlsson-Kanyama A, Börjesson P (2015) Environmental impact of dietary change: a systematic review. J Clean Prod 91:1–11. https://doi.org/10.1016/j.jclepro.2014.12.008
Hallström E, Röös E, Börjesson P (2014) Sustainable meat consumption: a quantitative analysis of nutritional intake, greenhouse gas emissions and land use from a Swedish perspective. Food Policy 47:81–90. https://doi.org/10.1016/j.foodpol.2014.04.002
Hartmann C, Shi J, Giusto A, Siegrist M (2015) The psychology of eating insects: a cross-cultural comparison between Germany and china. Food Qual Prefer 44:148–156. https://doi.org/10.1016/J.FOODQUAL.2015.04.013
Heinz V, Alvarez I, Angersbach A, Knorr D (2001) Preservation of liquid foods by high intensity pulsed electric fields-basic concepts for process design. Trends Food Sci Technol 12:103–111. https://doi.org/10.1016/S0924-2244(01)00064-4
Henriques AS, King SC, Meiselman HL (2009) Consumer segmentation based on food neophobia and its application to product development. Food Qual Prefer 20:83–91. https://doi.org/10.1016/J.FOODQUAL.2008.01.003
Hocquette JF (2016) Is in vitro meat the solution for the future? Meat Sci 120:167–176. https://doi.org/10.1016/J.MEATSCI.2016.04.036
Hoek AC, Luning PA, Weijzen P, Engels W, Kok FJ, de Graaf C (2011) Replacement of meat by meat substitutes. a survey on person- and product-related factors in consumer acceptance. Appetite 56:662–673. https://doi.org/10.1016/j.appet.2011.02.001
Hwang J, You J, Moon J, Jeong J (2020) Factors affecting consumers' alternative meats buying intentions: plant-based meat alternative and cultured meat. Sustainability 12:5662. https://doi.org/10.3390/su12145662
Hüppe R, Zander K (2021) Consumer perspectives on processing technologies for organic food. Foods 10:1212. https://doi.org/10.3390/FOODS10061212

ICT. (2017). International test commission itc guidelines for translating and adapting tests, 2nd edn
Jahn S, Furchheim P, Strässner AM (2021) Plant-based meat alternatives: motivational adoption barriers and solutions. Sustainability 13:13271. https://doi.org/10.3390/SU132313271
Knaapila A, Tuorila H, Silventoinen K, Keskitalo K, Kallela M, Wessman M, Peltonen L, Cherkas LF, Spector TD, Perola M (2007) Food neophobia shows heritable variation in humans. Physiol Behav 91:573–578. https://doi.org/10.1016/J.PHYSBEH.2007.03.019
Koller M, Kantzer V, Mear I, Zarzar K, Martin M, Greimel E, Bottomley A, Arnott M, Kuliś D (2012) The process of reconciliation: evaluation of guidelines for translating quality-of-life questionnaires. Expert Rev Pharmacoecon Outcomes Res 12:189–197. https://doi.org/10.1586/ERP.11.102
Kumar P, Chatli MK, Mehta N, Singh P, Malav OP, Verma AK (2016) Meat analogues: health promising sustainable meat substitutes. Crit Rev Food Sci Nutr 57:923–932. https://doi.org/10.1080/10408398.2014.939739
Kühn D, Krikser T, Issa I, Profeta A (2023) The witzenhausen food inventory - organic food (wfi-oel) an itemset for measuring consumers' attitudes and preferences for organic food in germany. Food Quality Pref 103:104708. https://doi.org/10.1016/J.FOODQUAL.2022.104708
Latvala T, Niva M, Mäkelä J, Pouta E, Heikkilä J, Kotro J, Forsman-Hugg S (2012) Diversifying meat consumption patterns: consumers' self-reported past behaviour and intentions for change. Meat Sci 92:71–77. https://doi.org/10.1016/J.MEATSCI.2012.04.014
Lentz G, Connelly S, Mirosa M, Jowett T (2018) Gauging attitudes and behaviours: meat consumption and potential reduction. Appetite 127:230–241. https://doi.org/10.1016/J.APPET.2018.04.015
Lima-Becerra I, María BA, Dorantes-Campuzano F, Mojica L, Loarca-Piña G, Morales-Sánchez E, Ramírez-Jiménez AK, Gaytán-Martínez M (2021) Ohmic heating as an emerging technology for the improvement of the techno-functional properties of common bean flour. Biol Life Sci Forum 6:95. https://doi.org/10.3390/FOODS2021-11000
Loo EJV, Caputo V, Lusk JL (2020) Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter? Food Policy 95:101931. https://doi.org/10.1016/J.FOODPOL.2020.101931
Macready AL, Hieke S, Klimczuk-Kochańska M, Szumiał S, Vranken L, Grunert KG (2020) Consumer trust in the food value chain and its impact on consumer confidence: a model for assessing consumer trust and evidence from a 5-country study in Europe. Food Policy 92:101880. https://doi.org/10.1016/j.foodpol.2020.101880
Maloney N, Harrison M (2016) Advanced heating technologies for food processing. Innov Future Trends Food Manuf Supply Chain Technol. https://doi.org/10.1016/B978-1-78242-447-5.00008-3
Mandolesi S, Dudinskaya EC, Naspetti S, Solfanelli F, Zanoli R (2022) Freedom of choice, organic consumers, discourses on new plant breeding techniques. Sustainability 14:8718. https://doi.org/10.3390/SU14148718
Melchior S, Calligaris S, Bisson G, Manzocco L (2020) Understanding the impact of moderate-intensity pulsed electric fields (mipef) on structural and functional characteristics of pea, rice and gluten concentrates. Food Bioprocess Technol 13:2145–2155. https://doi.org/10.1007/S11947-020-02554-2/FIGURES/4
Michel F, Hartmann C, Siegrist M (2021) Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. Food Quality Pref. https://doi.org/10.1016/j.foodqual.2020.104063
Ogden J, Karim L, Choudry A, Brown K (2007) 6. Understanding successful behaviour change: the role of intentions, attitudes to the target and motivations and the example of diet. Health Educ Res 22:397–405. https://doi.org/10.1093/HER/CYL090
Park TS, Park TS (2023) Invited review-gene-editing techniques and their applications in livestock and beyond zinc-finger nuclease and transcription activator-like effector nuclease restriction enzymes in bacteria act as genetic scissors that cleave and digest specific dna open access. Anim Biosci 36:333–338. https://doi.org/10.5713/ab.22.0383
Pliner P, Hobden K (1992) Development of a scale to measure the trait of food neophobia in humans. Appetite 19:105–120. https://doi.org/10.1016/0195-6663(92)90014-W
Post MJ (2012) Cultured meat from stem cells: challenges and prospects. Meat Sci 92:297–301. https://doi.org/10.1016/j.meatsci.2012.04.008
Profeta A, Balling R (2007). Evaluierung der Übergangsregelung des herkunftsschutzes bei agrarprodukten und lebensmitteln in europa gemäß verordnung (eg) nr. 510/06 und verbesserungsvorschläge für die anstehende modifikation. Germ J Agric Econ. https://doi.org/10.22004/ag.econ.96731
Profeta A, Balling R, Will S (2011). Die bedeutung von gütezeichen und herkunftsangaben beim rindfleischkauf - ergebnisse einer repräsentativen verbraucherstudie in bayern. Germ J Agric Econ. https://doi.org/10.22004/ag.econ.169834
Profeta A, Baune MC, Smetana S, Bornkessel S, Broucke K, Royen GV, Enneking U, Weiss J, Heinz V, Hieke S, Terjung N (2021) Preferences of German consumers for meat products blended with plant-based proteins. Sustainability 13:650. https://doi.org/10.3390/SU13020650
Profeta A, Baune MC, Smetana S, Broucke K, Royen GV, Weiss J, Heinz V, Terjung N (2020) Discrete choice analysis of consumer preferences for meathybrids-findings from Germany and Belgium. Foods 10:71. https://doi.org/10.3390/FOODS10010071
Profeta A, Baune MC, Smetana S, Broucke K, Royen GV, Weiss J, Hieke S, Heinz V, Terjung N (2021) Consumer preferences for meat blended with plant proteins—empirical findings from Belgium. Future Foods 4:100088. https://doi.org/10.1016/J.FUFO.2021.100088
Richi EB, Baumer B, Conrad B, Darioli R, Schmid A, Keller U (2015) Health risks associated with meat consumption: a review of epidemiological studies
Rosseel, Y. 2012. {lavaan}: An { R } package for structural equation modeling. J Stat Softw 48:1–36
Schouteten JJ, Steur HD, Pelsmaeker SD, Lagast S, Juvinal JG, Bourdeaudhuij ID, Verbeke W, Gellynck X (2016) Emotional and sensory profiling of insect-, plant- and meat-based burgers under blind, expected and informed conditions. Food Quality Pref 52:27–31. https://doi.org/10.1016/J.FOODQUAL.2016.03.011
Schröder MJA, McEachern MG (2004) Consumer value conflicts surrounding ethical food purchase decisions: a focus on animal welfare. Int J Consum Stud 28:168–177. https://doi.org/10.1111/J.1470-6431.2003.00357.X

Selle K, Barrangou R (2015) Crispr-based technologies and the future of food science. J Food Sci 80:R2367–R2372. https://doi.org/10.1111/1750-3841.13094
Siegrist M, Cousin ME, Kastenholz H, Wiek A (2007) Public acceptance of nanotechnology foods and food packaging: the influence of affect and trust. Appetite 49:459–466. https://doi.org/10.1016/J.APPET.2007.03.002
Siegrist M, Hartmann C (2019) Impact of sustainability perception on consumption of organic meat and meat substitutes. Appetite 132:196–202. https://doi.org/10.1016/J.APPET.2018.09.016
Siegrist M, Hartmann C (2020) Consumer acceptance of novel food technologies. Nat Food 1:343–350. https://doi.org/10.1038/s43016-020-0094-x
Simões-Wüst AP, Moltó-Puigmartí C, Dongen MCV, Dagnelie PC, Thijs C (2017) Organic food consumption during pregnancy is associated with different consumer profiles, food patterns and intake: the koala birth cohort study. Public Health Nutr 20:2134–2144. https://doi.org/10.1017/S1368980017000842
Smetana S, Mathys A, Knoch A, Heinz V (2015), 7. Meat alternatives: life cycle assessment of most known meat substitutes. *The International Journal of Life Cycle Assessment 2015 20:9* 20: 1254–1267. https://doi.org/10.1007/S11367-015-0931-6
University of Oxford. 2020. Per capita meat consumption by type, 2020. https://ourworldindata.org/grapher/per-capita-meat-type/, Last accessed on 2023-06-30
Varghese KS, Pandey MC, Radhakrishna K, Bawa AS (2014) Technology, applications and modelling of ohmic heating: a review. J Food Sci Technol 51:2304. https://doi.org/10.1007/S13197-012-0710-3
Verma AK, Mandal S, Tiwari A, Monachesi C, Catassi GN, Srivastava A, Gatti S, Lionetti E, Catassi C (2021) Current status and perspectives on the application of crispr/cas9 gene-editing system to develop a low-gluten, non-transgenic wheat variety. Foods 10:2351. https://doi.org/10.3390/foods10102351
Vidigal MC, Minim VP, Simiqueli AA, Souza PH, Balbino DF, Minim LA (2015) 3. Food technology neophobia and consumer attitudes toward foods produced by new and conventional technologies: A case study in brazil. LWT Food Sci Technol 60:832–840. https://doi.org/10.1016/J.LWT.2014.10.058
Wang O, Scrimgeour F (2021) Willingness to adopt a more plant-based diet in China and New Zealand: applying the theories of planned behaviour, meat attachment and food choice motives. Food Quality Pref 93:104294. https://doi.org/10.1016/j.foodqual.2021.104294
Wilks M, Phillips CJC, Fielding K, Hornsey MJ (2019) Testing potential psychological predictors of attitudes towards cultured meat. Appetite 136:137–145. https://doi.org/10.1016/J.APPET.2019.01.027

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