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Willingness to pay for sustainably innovated animal products and plant-based alternative foods – A meta-analysis

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ABSTRACT

Replacing animal-based foods in human diets with innovative alternatives can address concerns regarding health, environmental sustainability and animal welfare. However, whether consumers are willing to pay for such innovations remains unclear.

Here, we review 67 existing studies published between 2010 and 2025 in a systematic way and conduct a quantitative meta-analysis to assess how consumers value food innovations that intend to improve environmental sustainability, animal welfare or human health. We focus on animal-based foods and their innovative alternatives including products made from plants, insects, in laboratory settings or using genetic engineering technologies.

Our findings reveal that willingness to pay (WTP) estimates are highly heterogeneous, product- and context-specific. On average consumers are willing to pay more for innovative alternatives, when they improve animal welfare or environmental sustainability compared to their respective conventional animal products. In contrast, for plant-based options and foods developed in a laboratory or through genetic engineering, consumers require a discount to choose these alternatives over the conventional product.

The higher the level of innovativeness, the less consumers are willing to pay across products. Studies conducted in Europe still show a positive average WTP for the innovative foods, whereas studies from North America or Asia suggest that consumers discount innovative products compared to conventional foods.

Policymaking can leverage these insights to positively influence the perception of innovative products with targeted information treatments and consider subsidies where the WTP for the socially desirable alternative remains low.

1. Introduction

The global food system is under increasing scrutiny for being a major driver of climate change, biodiversity loss and land use change, a situation that could worsen as the population grows. However, technological and sociocultural transformations — both on the demand and supply side — could help food systems reduce their environmental impact while operating within safe planetary boundaries (Gerten et al., 2020; Herrero et al., 2021; Springmann et al., 2018).

Lowering the consumption of animal-based foods, such as meat and dairy products, is recognized as a key strategy for mitigating the environmental impact of food systems. Indeed, animal-based food products tend to have a larger environmental footprint than plant-based foods, their production also raises animal welfare concerns, and dietary guidelines recommend limiting their intake for health reasons (Bryant, 2022; Poore and Nemecek, 2018; Springmann, 2024).

However, animal-based foods are a staple in many cuisines and are deeply ingrained in the culture of many countries (Goel et al., 2024). Other cultural, social, and economic factors, such as income and religion, also influence food preferences in favor of meat (Milford et al., 2019).

The food industry is investing resources into developing innovative

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food products, that attempt to replicate the taste and texture of conventional animal-based products to make them attractive (also) to non-vegetarian consumers (Zhao et al., 2023), while also mitigating environmental, health and animal welfare concerns (Tziva et al., 2020; Zhao et al., 2024).

However, consumer acceptance of these products remains challenging (Siegrist and Hartmann, 2020). This lack of acceptance stems from concerns about the naturalness, healthiness, taste, texture, and appearance of innovative food products (Appiani et al., 2023; Giacalone and Jaeger, 2023). It is also influenced by personality traits such as food neophobia and neophobia of food technology (Barrena and Sánchez, 2013; Siegrist and Hartmann, 2020; Tuorila and Hartmann, 2020). Furthermore, consumer acceptance is influenced by their recognition of potential societal benefits of these innovations, such as improved animal welfare (Tuorila and Hartmann, 2020).

The level of consumer acceptance is strongly linked to consumer willingness to pay (WTP) for the respective product. Considering welfare economic theory, monetary WTP can capture the perceived individual benefits expected, e.g. when switching from a conventional product to an alternative food item (Bala et al., 1999; Flores and Carson, 1997). WTP elicitation is especially useful for products or product attributes that are not (yet) sold in the market so that actual market demand is not observable.

Despite the growing body of research examining the factors influencing consumer acceptance of innovative animal-based food alternatives (e.g., Laureati et al., 2024; Siegrist and Hartmann, 2020), no previous study, to our knowledge, has quantitatively and comprehensively assessed WTP across a broad range of such alternatives while simultaneously considering both the motivations underlying the innovation (e.g., health, sustainability, and animal welfare) and the degree of innovativeness of the products.

Indeed, previous meta-analyses on the WTP for innovative food products have tended to focus on specific categories. For instance, Lusk et al. (2005) and Costa-Font et al. (2008) examined genetically modified foods, while Sun et al. (2024) investigated plant-based and lab-grown meat, and Han et al. (2025) reviewed studies on gene-edited foods. Moreover, most existing meta-analyses on the WTP for products with improved societal benefits have often addressed only a single aspect, such as animal welfare (Clark et al., 2017; Lagerkvist and Hess, 2011), health (Alsubhi et al., 2023; Dolgopolova and Teuber, 2018), nutrition (De Steur et al., 2017), environmental benefits (Katare et al., 2023; White and Brady, 2014), locally produced foods (Printezis et al., 2019), or the influence of sustainability labelling on WTP (Li and Kallas, 2021; Piracci et al., 2024).

In this study, we address this gap by conducting a meta-analysis that compares consumers' WTP for innovative product alternatives to animal-based foods that aim to achieve various societal benefits. We account for (1) the degree of product perceived innovativeness (i.e., how much the alternative product differs from the conventional one and whether innovative ingredients or production technologies are used) and (2) the type of societal benefit provided (i.e., animal welfare, human health, environmental sustainability). We specifically focus on products created and advertised with the aim to replace an established animal-based food product, because they have improved characteristics that are desirable from a societal point of view.

Food product innovations can be introduced at various stages along the food value chain – in this work, we focus on those related to farming (e.g., changed practices in crop production or animal raising) and processing (e.g., food fortification, insect-based foods) neglecting innovations at the utilization and waste management stage (ElHaffara and Dubea, 2024). Within these value chain stages the diversity of what can be framed as innovative alternatives to animal-based foods is large – it ranges from traditional plant-based products available in the market to cutting-edge 'lab-grown' products still under development (McClements, 2024). Unambiguously, what is regarded as new and innovative at a certain point in time can become conventional if established. In this study, we classify a food as "*innovative*" if it clearly differs from the conventional reference product and is framed as innovative, new or novel by the referenced sources.

The data is collected through a comprehensive systematic literature review. We extract monetary WTP estimates and explanatory variables from 67 studies that meet the inclusion criteria and are compared in a descriptive analysis. Of these, 59 studies provide the complete information required for our quantitative meta-analysis. Included food innovations have not been pre-specified but are extracted from the original studies if the product is classified as "*innovative*" in the direction of improving environmental sustainability, animal welfare or human health. The identified innovative alternatives include products made from plants, insects, lab-grown cell cultures, or using genetic engineering. Furthermore, due to recent increases in investment in alternative foods (McClements and Grossmann, 2022) and the growing market availability of meat alternatives, we also investigate how consumers weigh societal benefits against new technologies across time and geographical contexts.

We contribute to this growing body of literature in several ways. First, we look at a range of alternatives to animal-based food products without limiting ourselves to a pre-defined set of products. Moreover, we explore the role of innovativeness, accounting for the motivation underlying the product innovations, and quantify the average WTP for these products. Through this analysis we reveal and disentangle the potential tradeoffs consumers are facing when they are confronted with a choice promising individual and societal benefits but that also carries unfamiliar, high-tech or other novel traits.

Our findings reveal that consumers are willing to pay a price premium for products with a comparably low level of innovativeness, and for those that improve animal welfare and environmental sustainability. These products seem to have the highest market potential without additional interventions.

Product marketing and policymaking can leverage these findings to identify which products are (already) competitive in the market on average, and where consumers may need additional incentives to reduce remaining aversions and to consider these options for their societal benefits.

2. Methods

2.1. Systematic data collection

We conduct a systematic literature review to collect data on the WTP for sustainably innovated animal products and plant-based alternatives to animal-based foods. The search strategy and protocol have been developed and pre-registered at Open Science Foundation (OSF, accessible under https://doi.org/10.17605/OSF.IO/YDMA2) to provide transparency about the research process. The search and selection process are presented in the Page et al. (2021) flow diagram in Fig. 1.

The search for relevant publications has consulted the following databases: MEDLINE (Pubmed), Springer Link, Scopus, Wiley, Taylor and Francis, Science Direct, Web of Science and Ageconsearch. The search terms and adjustments to the pre-registered workflow are summarized in Appendix A, Table A.1 and A.2. The search query captures i) a WTP estimate or similar, ii) for an alternative to a conventional animal-based product, iii) that is innovative, iv) for sustainability, health, or animal welfare reasons, v) targeted to consumers, and vi) limited to food items.

For this procedure, the databases are divided among members of the author team. Each author excludes misfitting studies based on pre-defined exclusion criteria before pooling the studies.

The 469 publications identified for full screening contain 55 duplicates that are detected and removed. The papers are screened for eligibility according to pre-defined inclusion and exclusion criteria (Appendix A, Table A.3). Included studies meet the following criteria: i) assessment of WTP for sustainably innovated animal products and plant-

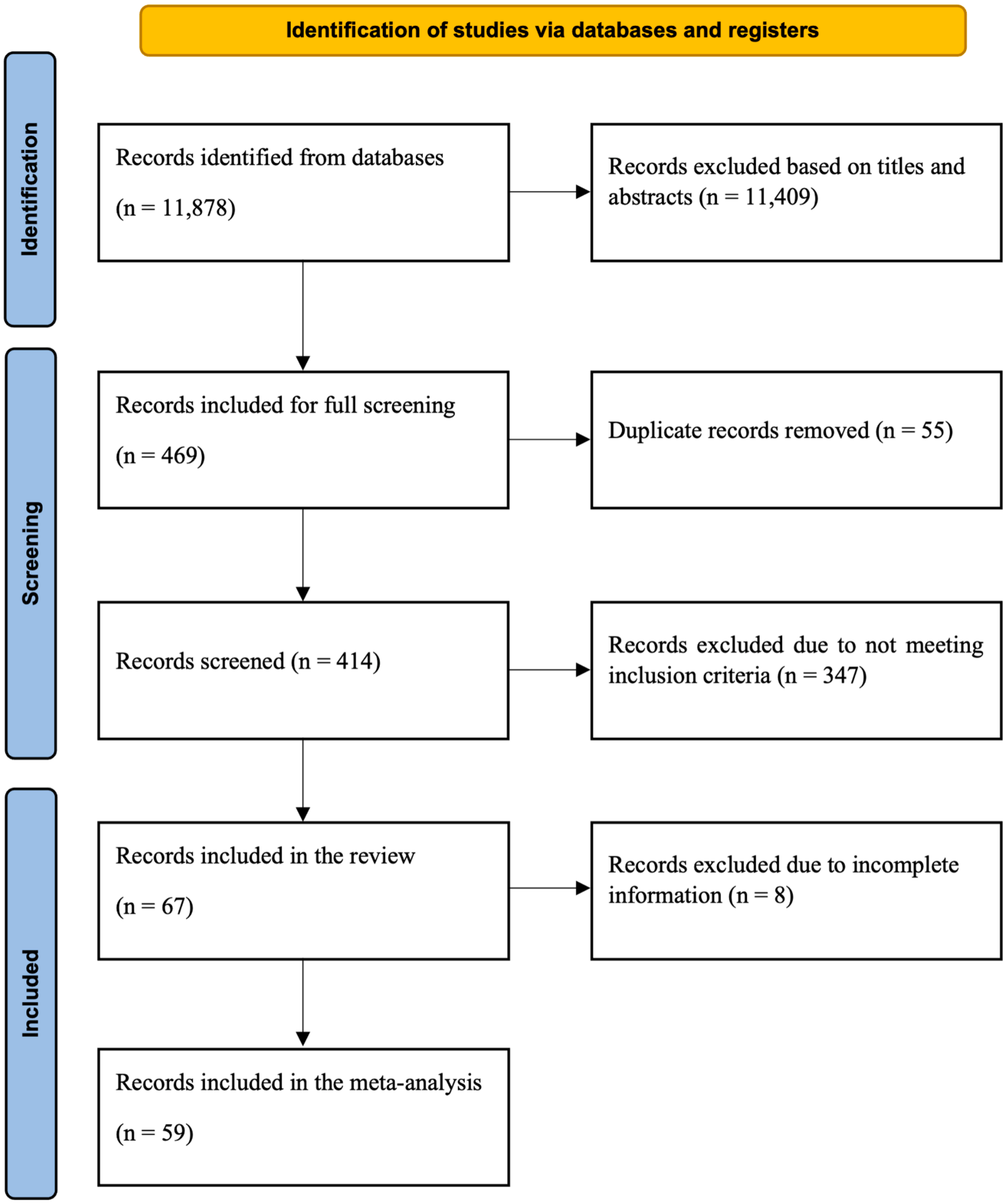

Fig. 1. PRISMA flow chart of systematic literature search.

based alternatives, ii) publication between 2010 and 2025, iii) written in English language. January 2010 is the chosen cut-off to capture the recent advances in meat alternatives, interest in sustainability topics, and investment in next-generation plant-based alternative products (McClements and Grossmann, 2022).

After this step, the remaining records are reviewed and finally we extract monetary WTP estimates and further data from 67 studies (included in the descriptive analysis) of which 59 provide the complete information we need to conduct our meta-analysis. Reasons for excluding the remaining studies are provided in Table 1.

In specific, we extract publication year, location, study design, sample size (i.e., the number of study group participants), product, consumer types, WTP estimate, standard error, and the different motivations for the innovation mentioned in the respective study (i.e., animal welfare, environmental sustainability, human health). In two cases, the data collection year is retrieved through correspondence with the authors. Still, four studies drop out of the meta-analysis because we could not gather information about the year of data collection, even though they could have been included otherwise. We could not retrieve a precision estimate for WTP estimates from eight studies, which are therefore excluded from the meta-analysis. For eight records, the average WTP estimate of the full sample is not provided in the article but is calculated as a weighted average for the reported consumer groups.

Table 1
Reasons for exclusion of records.

Reasons for exclusion	Frequency
Does not address sustainability, health, and animal welfare	2
Monetary WTP is unfeasible to extract/categorical	11
No consumer perspective (e.g., farmer technology adoption)	13
No direct relation to animal-based foods	37
No link to innovativeness/novelty	75
No product-specific monetary WTP estimate or similar	178
Review/meta-analysis	31
Turns out not to be in English language	1
Missing year of data collection	5

Note: In some cases, multiple reasons are assigned.

A key difficulty in following the inclusion criteria is the subjectivity underlying the assessment of innovativeness. We rely on the framing used in the respective studies for the alternative product as new, novel or innovative. To account for varying degrees of perceived innovativeness in the analysis, a binary variable is created to indicate a high level of perceived innovativeness, e.g. products created in the laboratory or under the use of technology affecting the consumable product, or where uncommon ingredients (e.g. insects) or ingredients with scientific names (e.g. carnosine, nitrite) that consumers are likely unfamiliar with have been added. The study design is captured in a binary variable that indicates one if the study applies a choice experiment, and zero otherwise (i.e., contingent valuation, auction-based experiments, direct statements about WTP in questionnaires or surveys).

Several studies provide multiple WTP estimates. We extract several if these estimates refer to multiple innovative products (14 studies) or if they refer to different study populations (six studies). In these cases, each of the estimates is included in our analysis. In total, we extract 142 WTP estimates for the respective average study populations from the included studies in the review. If estimates are provided based on different models, we focus on the model that is framed as the main one by the authors of the respective study. If information or labelling interventions are tested, we include the WTP estimation for the least invasive treatment, ideally the control group. While we acknowledge the relevance of understanding such treatments, reviewing this aspect is beyond the scope and focus of this study. Descriptive statistics for the occurrence of product categories and variables are summarized in Appendix A, Table A.4.

While the core of this review is based on WTP estimates for the average study population, we also collect consumer group-specific estimates where the assessed groups are generalizable beyond the study context. Based on the information provided in the study, we re-classify the groups to recurring consumer types found across studies (see Appendix A, Table A.4 and Appendix B, Supplementary Data).

2.2. Data transformation

In order to achieve comparability between the studies included in this meta-analysis, we extract the alternative animal-based products from the studies and identify six aggregate product categories, according to which we group the products evaluated in the studies. In the first step, if one of these categories applies, products are classified as a) plant-based alternatives, b) products that contain insects, c) products created in a laboratory or using genetic engineering technologies.[1] The remaining products, that do not clearly belong to one of these three groups, are classified in three additional categories based on the main motivational framing used in the study, i.e. d) products with improvements for animal welfare (e.g., due to less painful castration methods), e) products with a reduced environmental footprint (e.g., due to feed additives in animal production), f) products targeted to improve human health (e.g., functional foods). The resulting six product groups are mutually exclusive – every product is classified to exactly one of these categories. A comprehensive list of this mapping is provided in Appendix B, Supplementary Data. Since *all* included products are innovated to generate one or more societal benefits, we additionally create binary variables, that indicate whether the product innovation is driven by animal welfare, environmental sustainability, or human health reasons. Several motivations can be indicated for a single product.

We extract WTP information from all studies. Since units differ substantially, we transform the estimates to represent the marginal willingness to pay (MWTP), i.e. a relative share of additional WTP compared to the WTP or price of the conventional animal-based product used in the same study. This helps to obtain uniform effect sizes and enables us to compare studies conducted in various currencies. A similar approach is for example used in Dolgopolova & Teuber (2018).

For studies that report WTP estimates relative to a no-buy option, we extract information on the WTP for the innovative product and the conventional animal-based product. We calculate the MWTP as:

$$MWTP_{innov} = \frac{(WTP_{innov} - WTP_{conv})}{|WTP_{conv}|} \tag{1}$$

In case the WTP of the innovative product is provided as the difference relative to the conventional product, we adjust the WTP for the innovative product before computing the MWTP according to Eq. (1).

$$WTP_{innov}^{adj} = WTP_{innov} + WTP_{conv} \tag{2}$$

We are foremost collecting the MWTP estimates for the average study population. If studies do not provide an average estimate, we collect data for the subgroups and create a weighted average. Consumer-group specific estimates are extracted in addition, where available. We also collect the standard errors (SE) to account for the precision with which the WTP is estimated. Where provided, the SE estimates are directly taken. In other cases, the SE are calculated based on the information provided about the statistics of the respective estimation model (see Appendix A for more details on standard error adjustment).

2.3. Meta-analysis

We conduct a random-effects (RE) meta-analysis based on the *metafor* package in R using a restricted maximum likelihood estimator suitable in the presence of heterogeneity and small sample sizes (Viechtbauer, 2010). Standard errors enter the estimation in terms of inverse variance weights and higher weights are assigned to more precisely estimated MWTP observations (Borenstein et al., 2010; Viechtbauer, 2010). We explore Cochran's Q, I^2 statistics and τ^2 to assess heterogeneity between studies (Harrer et al., 2021; Higgins et al., 2003). Cook's distance and studentized residuals serve to detect outliers (Viechtbauer and Cheung, 2010). To check the presence of publication bias in our data, we use the Egger's test and inspect the funnel plot, a graphical method used to detect bias in meta-analyses (Bom and Rachinger, 2019; Egger et al., 1997; Ioannidis et al., 2017; Stanley, 2008). The underlying assumption is that selective reporting is based on the size of the reported estimate rather than the p-value.

We estimate the RE meta-analysis regressions in which we add different moderators (i.e., explanatory variables in meta-analysis context (Borenstein et al., 2010)). All moderators or moderator groups are — for better interpretability and to account for multicollinearity concerns — included in separate models, but also jointly in a full model. The models have the following specification:

$$MWTP_{innov} = X\beta + u + \varepsilon, \tag{3}$$

where $MWTP_{innov}$ is the $k \times 1$ vector of outcomes, X is the $k \times p$ matrix of moderating explanatory variables, β is the $p \times 1$ vector of model coefficients, $u \sim \mathcal{N}(0, \tau^2 \mathrm{I}_k)$ is a $k \times 1$ vector of random effects and $\varepsilon \sim \mathcal{N}(0, V)$ is a $k \times 1$ vector of sampling errors with V capturing the sampling variance. X varies by specification; it is a vector of 1 in the intercept-only model without moderators which provides the pooled effect size across studies. As moderators, we add product category and continent as categorical variables – the latter to disentangle potential regional or cultural differences. For these models, the intercept is omitted to avoid collinearity, and to represent each category by its own coefficient. To test for the effect of high levels of innovativeness or whether the study was carried out as a choice experiment or not, dummies are used so that the effect is relative to the reference category represented by the intercept. Similarly, we add binary variables for the motivation mentioned in the study that is driving the innovation. In contrast to the product categories, the motivation dummies are not mutually exclusive. The year of data collection is controlled for by the continuous trend variable time, and the earliest year of data collection is

[1] In this group, we summarize all kind of cultured, cell-based, genetically modified, gene-edited or RNAi-based products.

captured as reference category in the intercept.

Following Dolgopolova and Teuber (2018) who show heterogeneity between studies identifying positive and negative MWTP, we split our data along these lines. Then we run the estimations separately for i) the group of studies that find consumers being willing to pay more for the innovative alternative than for the conventional reference product and ii) studies that show a negative MWTP where consumers would need a discount on the innovative product's price to choose it over the conventional product.

3. Results

3.1. Descriptive analysis

In Fig. 2, the average MWTP estimates are sorted by the six product categories considered in this study and represented in a modified forest plot. The figure reveals that positive and negative MWTP estimates are found within each product category. The collected estimates overall suggest a mixed picture on whether consumers are willing to pay more or less for innovative alternatives compared to conventional animal-based food products. The collected estimates range from a MWTP for the innovative product of 2.6 times the value of the conventional animal reference product to requiring a discount of 5.7 times the value of the animal reference product in order to accept the innovative product.

As depicted by Fig. 3, the regional coverage is very heterogeneous. Only one study conducted in South America and four studies conducted in Africa provide sufficient information to be included in the meta-analysis. For Asia 12 studies are included, for North America 13 studies and for Europe 39 studies. No study on Oceania remains in the selected pool. Most included studies have been carried out after 2010 (91 %). Indicated by Figs. 2 and 3, most MWTP are estimated with considerable precision and based on sample sizes of 790 observations at the median.

Overall, we classify 44 % of the alternative products were perceived as highly innovative, 81 % of our observations are based on studies for which the data has been collected online (instead of in-person) and 72 % are derived from choice experiments (see Appendix A, Table A.4). Among the included studies, 13 also report consumer group-specific MWTP. Those groups with at least 6 observations are highlighted to explore the heterogeneity among consumer groups (i.e., ecological, intermediate, neophobia, price-sensitive, technology-open, traditionalist consumers, see Appendix A, Table A.5). Fig. 4 shows that there is quite some heterogeneity within groups regarding the captured products and their MWTP effect sizes and directions. While consumers that are technology-open appear to have a positive MWTP across tested product categories, consumers classified under "neophobia" or as "traditionalist" often have negative MWTP (as expected by their categorization). The picture is mixed for consumers classified as ecological and intermediate. With one exception, price-sensitive consumers have a very low MWTP mostly around zero. Given the limited number of observations and their large heterogeneity regarding product categories, consumer group specific MWTP are not included in the meta-analysis regressions.

3.2. Meta-analysis

The visual inspection suggests substantial heterogeneity between studies. This is supported by our random-effects meta-analysis regression without moderators ($Q = 141{,}982$, $I^2 = 99.98$ %). The estimated between-study variance suggests that there is considerable variation in true effect sizes across studies ($\tau^2 = 0.64$).

We test for outliers and two studies are flagged based on Cook's distance and studentized residuals (Table A.6). As the estimated between-study variance decreased from 0.64 to 0.52, these two studies are removed for the further analysis.

The funnel plots in Fig. 5 do not reveal strong asymmetry between negative and positive estimates and there is no evidence of potential publication bias based on the Egger's test.

In the next step, moderators are added to the model to explore the heterogeneity between studies. Including all potentially relevant moderators helps to explain some of the heterogeneity between studies indicated by τ^2 being reduced to 0.31 (Table A.6). However, the product categories are moderately multicollinear with other moderators such as continent or motivations (i.e. shown by a variance inflation factor above 5) (Appendix A, Table A.7). In addition, interpreting intercepts and reference categories becomes difficult. Therefore, we focus on reduced models for exploring the different moderators in the following.

Table 2 shows the results of random effects models where different moderators are added. For the intercept-only model, the overall effect suggests no statistically significant MWTP for innovative foods relative to their conventional animal-based reference product. In the second model we assess MWTP by product category. For products that are innovative in a way that animal welfare or environmental sustainability is improved, consumers are willing to pay 78 % and 35 % more than for the reference product, respectively.

Products based on insects or those that are innovated to improve healthiness (e.g. functional foods) do not relate to a significantly larger WTP than the reference products, on average. Lastly, across studies we find that consumers require a discount of 43 % for products in the plant-based group and of 45 % for products from a laboratory or using genetic engineering.

In the third model, we control for the level of innovativeness and across product categories consumers' MWTP is 51 % lower for products with a high level of perceived innovativeness than for those that are not classified as highly innovative. The average MWTP for products with a low level of perceived innovativeness is 23 % higher compared to the conventional product. According to the fourth model, studies conducted in Europe suggest a higher WTP (+20 %) for innovative foods compared to their reference animal products on average. On average, studies in North America and Asia report that consumers require a discount of 31 % and 39 %, respectively, to choose the innovative product. Finally, the fifth model indicates that the MWTP for innovative products has slightly declined over time (indicated by the year when the data for the underlying study has been collected).

Furthermore, we compare studies that find positive and negative MWTP quantitatively with distinct models. Table 3 shows these separate models for studies that report positive and negative MWTP estimates.

Subject to finding a positive effect, we see an average MWTP of 44 % for innovative alternative to conventional animal-based foods. Complementarily, studies suggesting that consumers require a financial discount to choose the innovative product over the conventional reference food item demand a 54 % discount on average. For the product types, the separated models support the largest and significant average MWTP estimates for animal welfare and environmental sustainability improving foods among the positive estimates, and for plant-based foods and those produced in laboratories or using genetic engineering for negative estimates.

A high level of innovativeness reduces the MWTP in the studies that find a positive MWTP as well as in studies that find a negative MWTP (increasing the level of required discount in the latter case). Regarding regional differences, among the positive-estimate studies, the largest MWTP of 48 % is found for European consumers, while the largest MWTP in the negative-estimate studies is calculated for Africa (−78 %) closely followed by North America with –75 %.

Additional regressions controlling for motivation dummies and study design are reported in the Appendix (Appendix A, Table A.7). Studies that focus on innovations aiming to improve environmental sustainability, show on average negative MWTP values. This motivational framing is often used for innovative products created in the laboratory, plant-based foods and those made of insects, for which negative MWTP estimates are often reported. We find that studies using choice experiments tend to report smaller MWTP estimates on average. This is not

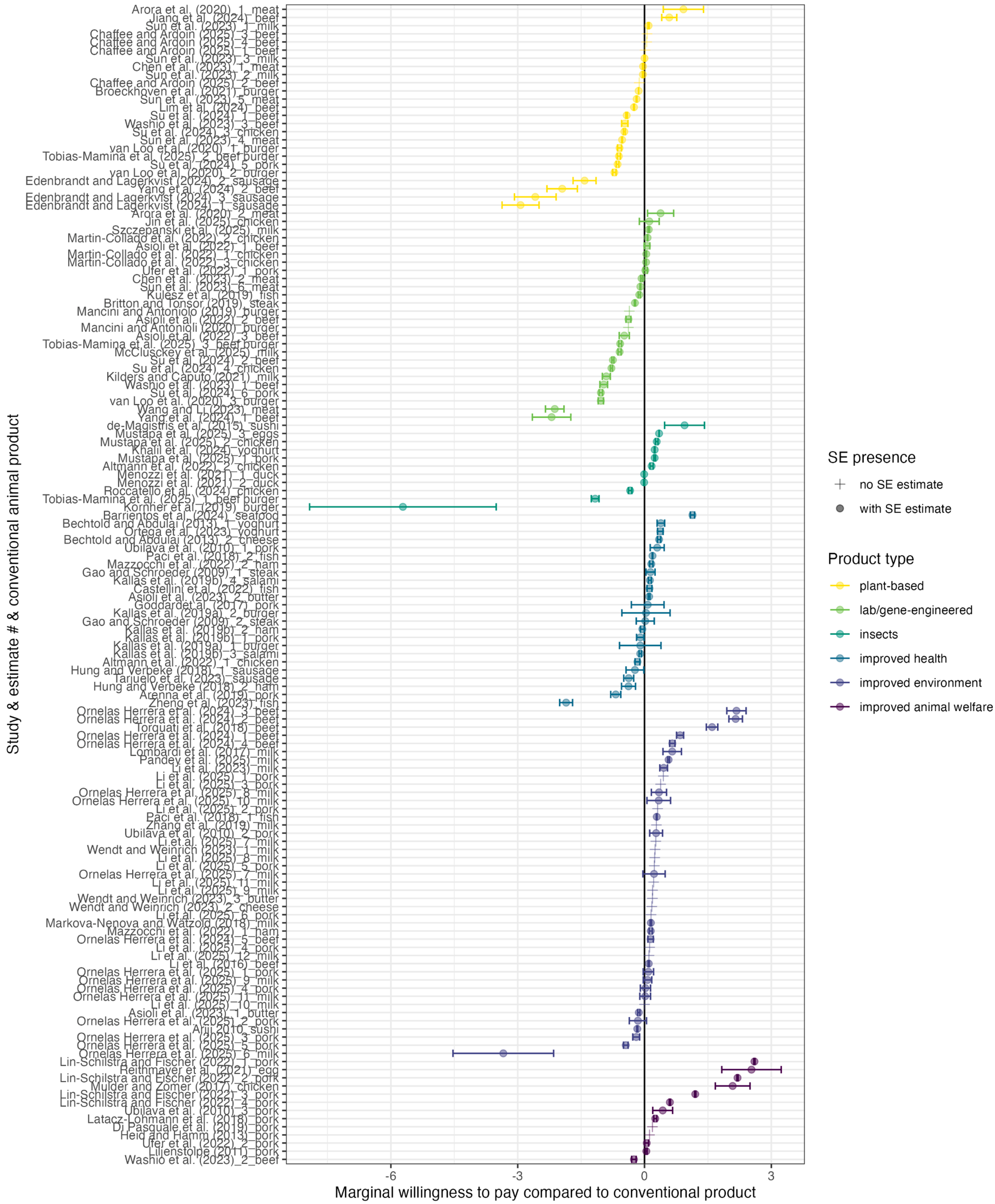

Fig. 2. MWTP for average consumer by study and product category. Multiple estimates by a study are numbered. The reference animal product is indicated as described in the underlying study. Error bars represent adjusted SE.

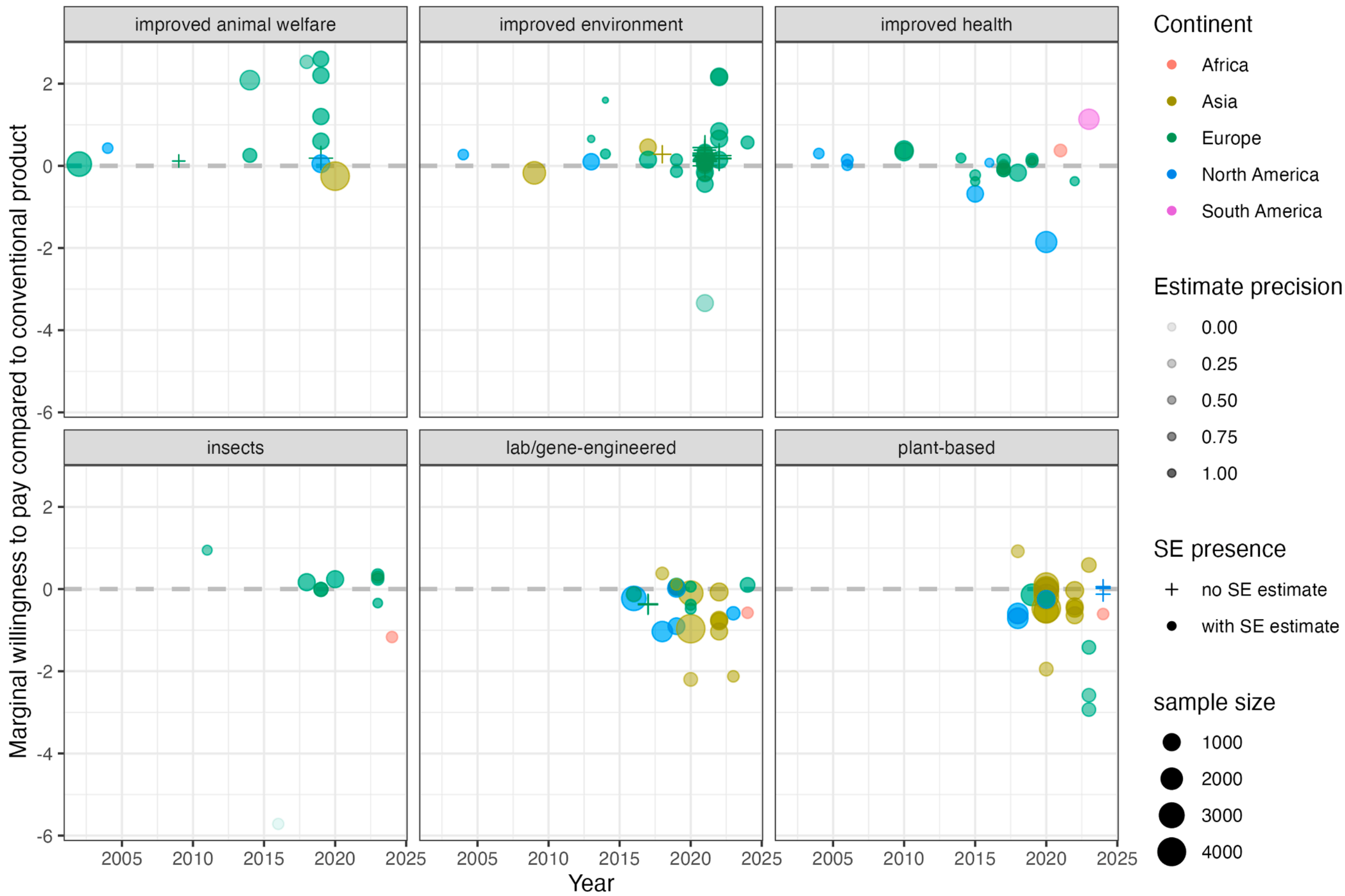

Fig. 3. MWTP estimates by year of data collection, product category, continent, sample size and precision. Precision is based on a rescaled version of the SE (1=high precision and low SE (opaque points), 0=low precision and high SE relative to MWTP (transparent points)).

surprising as choice experiments help to reduce the hypothetical bias compared to other approaches (e.g. contingent valuation) (Grutters et al., 2008).

4. Discussion

Our results show that consumers tend to be willing to pay a price premium for innovative alternatives to animal-based products if they carry environmental and animal welfare benefits. Furthermore, the results indicate a negative correlation between the level of innovativeness and the WTP for the animal-based product alternative, and that consumers require a discount to choose plant-based, lab-based, or genetically engineered products. This implies that a product framing focusing on the technology rather than on the societal benefits such technology brings might be rather discouraging to consumers (Paci et al., 2018; Van Loo et al., 2020).

Results for the average MWTP estimates for health-improving and insect-based products are insignificant. This result is in line with previous literature which found mixed results for the MWTP for insect-based products (de-Magistris et al., 2015; Kornher et al., 2019) as well as for innovative foods with enhanced health attributes (e.g., Kallas et al., 2019; Paci et al., 2018; Tarjuelo et al., 2023). Moreover, our results reveal large heterogeneity between consumer groups in terms of their MWTP. For example, consumers with high levels of disgust, food neophobia, and general aversion toward insects and those unfamiliar with insect-based foods reveal a negative MWTP for these alternatives (Altmann et al., 2022; de-Magistris et al., 2015; Kornher et al., 2019). Consumer groups with strong interests in nutrition and the environment indicate openness to lab-based meat substitutes (Ufer et al., 2022). Such heterogeneity is not only observed for highly innovative foods. For example, food alternatives classified as environmentally beneficial due to feed additives (hence with low perceived innovativeness) are met with strong aversion by traditionalist consumer segments, but younger and more educated consumers express a positive MWTP (Asioli et al., 2023).

These findings imply that emphasizing the environmental sustainability, animal welfare or health attributes rather than the technological details in the product framing makes consumers more receptive to the innovative products. The review highlights that not all innovative products will become the average consumers' preferred option, but this will likely be true for some consumer segments only. Identifying and targeting these groups well is key to establishing innovative products that are socially desirable alternatives to animal products.

Studies conducted in Europe show on average a significant and positive MWTP, whereas studies from Asia and North America show negative MWTP estimates for innovative food products based on our sample. Our findings conclude with a negative but very small trend regarding how the MWTP develops over time. While more innovative products have appeared in recent years, this might have been accompanied by increased acceptance and familiarity with such products, so that these effects potentially offset each other.

4.1. Comparison to existing research

The aim of this review and meta-analysis is to provide an overview of the existing knowledge on the WTP for innovative foods intending to replace animal-based products driven by health, environmental sustainability or animal welfare concerns. This research is complementary to a number of existing studies.

Laureati et al. (2024) focus their review on novel foods not limited to

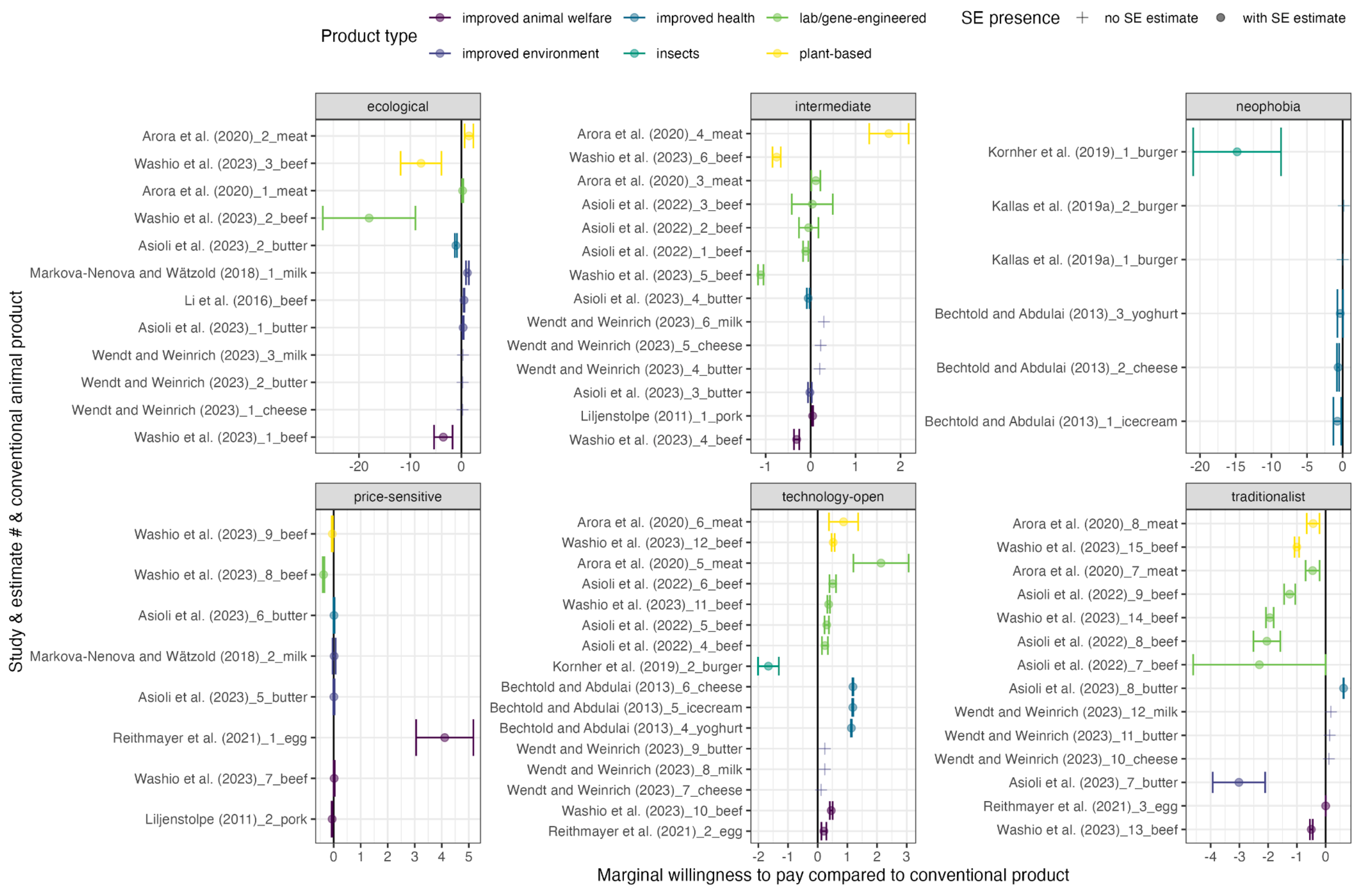

Fig. 4. MWTP by consumer groups and product category. Multiple estimates by a study are numbered. The reference animal product is indicated. Error bars represent adjusted SE.

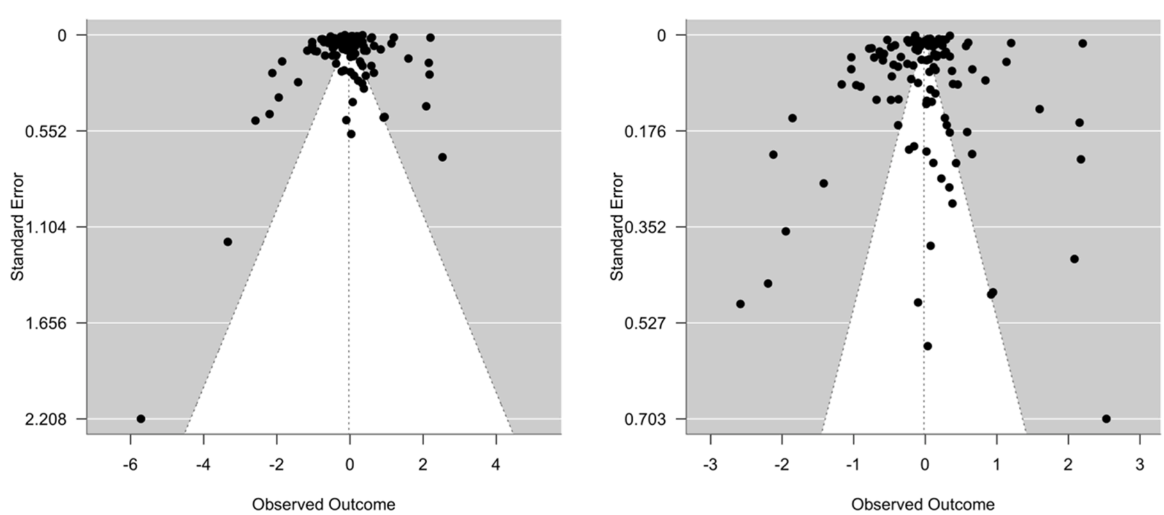

Fig. 5. Funnel plots. Left panel based on full sample, right panel based on regression excluding two estimates with relative standard error above 1 (see also Table A.5) leading to a change in the axes while everything else remains unchanged. In both cases, the Egger's test suggests no evidence for potential publication bias (model in left panel: $z = -1.63$, $p = 0.10$; model in right panel: $z = 0.35$, $p = 0.73$).

alternatives to animal-based foods. Included studies are more diverse than in our analysis regarding the methodological approaches since they do not restrict themselves to WTP analyses nor extract quantitative estimates for a meta-analysis. Across groups, food (technology) neophobia and sensory concerns are identified as barriers, while expected health and environmental benefits drive the acceptance of novel foods. The authors stress the heterogeneity between studies which is also reflected in the different effect signs for MWTP that we find between and within product categories. Focusing only on MWTP allows us to do a more direct study comparisons and quantitative aggregation.

Li and Kallas (2021) and Piracci et al. (2024) present meta-analyses on the WTP for sustainable food products. Different to our analysis, these comprehensive meta-analyses are not limited to products that are considered alternatives to animal-based products or framed as novel, as

Table 2
Regression results of models with moderators.

	Random effects (RE)	RE + Product category	RE + High innovativeness	RE + Continent	RE + Time
Intercept	−0.03 (0.07)		0.23* (0.09)		0.49. (0.26)
Animal welfare		0.78*** (0.20)			
Environment		0.35** (0.12)			
Health		−0.02 (0.13)			
Insects		−0.00 (0.20)			
Lab/ gene-engineered		−0.45*** (0.13)			
Plant-based		−0.43** (0.14)			
High innovativeness			−0.51*** (0.13)		
Europe				0.20* (0.08)	
Africa				−0.49 (0.33)	
Asia				−0.39** (0.13)	
North America				−0.31* (0.16)	
South America				1.13. (0.65)	
Time					−0.03* (0.01)
Num.Obs.	116	116	116	116	116
AIC	283.2	253.4	270.7	268.9	280.7
BIC	288.7	272.7	278.9	285.5	289.0
τ^2	0.52	0.37	0.45	0.42	0.51
Cochran's Q	115,129	23,980	60,282	107,130	82,617
I^2 (%)	99.98	99.90	99.94	99.97	99.97

Note: $p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$. Standard errors in parentheses.

long as they are regarded as sustainable foods. Still, there is a considerable topical overlap, and our findings align in that the MWTP for sustainable foods in a broader framing (e.g., those defined as animal welfare and environmental sustainability improving) tends to be positive and regional differences become evident. However, given that the products captured in our analysis must contain some kind of innovative element, we conclude that consumers often face a tradeoff if they consider choosing a product for sustainability reasons but are hesitant because of unfamiliarity or food technology neophobia. We assume such a tradeoff exists for example for health-improving products which could explain our insignificant estimate that differs from the positive MWTP for health claims identified in the meta-analysis by Dolgopolova and Teuber (2018).

This tradeoff seems to be mildest when looking at products that are improved in terms of animal welfare concerns, which is driven by a low level of innovativeness in these products. The meta-analysis on animal welfare by Clark et al. (2017) also concludes an overall positive WTP for this attribute, even though their effect is interpreted as relatively small. However, we do not share a similar focus on the reduction of production diseases as in that study. An earlier review on farm animal welfare by Lagerkvist and Hess (2011) looked in depth into different animal welfare practices, but could not conclude a clear direction in terms of WTP effects at that time.

Another meta-analysis with a focus on biofortified or genetically modified foods, finds a generally positive WTP for biofortified crops (De Steur et al., 2017). The product range differs substantially to what we include in terms of genetically engineered products that must be some alternative to conventional animal-based foods in our analysis. The negative MWTP that we find might reveal larger skepticism of consumers when it comes to genetical engineering in animals as opposed to crops.

An additional line of research does not focus on WTP assessments but looks at consumers' attitudes toward innovative meat alternatives, the elasticity of their demand, and whether the new products are used as substitutes or complements to their conventional reference products (Caputo et al., 2025; Jahn et al., 2024; Neill and Britton, 2024; Tonsor et al., 2023; Zhao et al., 2023). While these studies offer an important perspective to understand consumer preferences for alternatives to animal-based foods, they have not been incorporated in our quantitative meta-analysis due to the differences in methods and outcome variables used.

4.2. Limitations

Being systematic but broad allows us to gather a wide range of different studies. Certainly, this is accompanied by collecting a variety of studies with limited comparability of the results. For example, previous research shows that when a discrete choice experiment approach is used to estimate WTP for a product, the study-specific choice of price vectors and price ranges affects the choice outcomes and in turn the WTP for a product (Mørkbak et al., 2010). As our analysis does not report the absolute WTP but the MWTP for an innovative product relative to the conventional animal reference product we partially reduce the bias of the comparison. Nonetheless, we cannot completely counterbalance the differences resulting from the choice of underlying methods and even the software used which, to some degree, affects resulting WTP estimates and reported standard errors (Schmidt and Bijmolt, 2020). Furthermore, while trying to use objective criteria, it remains a

Table 3
Random effects regression results comparing positive and negative MWTP estimates.

			Product category		High innovativeness		Continent	
	pos	neg	pos	neg	pos	neg	pos	neg
Intercept	0.44***	−0.54***			0.56***	−0.35***		
	(0.07)	(0.07)			(0.09)	(0.11)		
Animal welfare			0.88***	−0.25				
			(0.18)	(0.50)				
Environment			0.53***	−0.32				
			(0.11)	(0.22)				
Health			0.27.	−0.41*				
			(0.14)	(0.17)				
Insects			0.32	−0.44.				
			(0.22)	(0.25)				
Lab/ gene-engin.			0.09	−0.71***				
			(0.19)	(0.13)				
Plant-based			0.46	−0.55***				
			(0.33)	(0.13)				
High innovative.					−0.32*	−0.28*		
					(0.14)	(0.13)		
Europe							0.48***	−0.35**
							(0.08)	(0.11)
Africa							0.37	−0.78**
							(0.53)	(0.27)
Asia							0.39.	−0.58***
							(0.24)	(0.11)
North America							0.15	−0.75***
							(0.19)	(0.16)
South America							1.13*	
							(0.53)	
Num.Obs.	61	55	61	55	61	55	61	55
AIC	109.4	106.1	107.8	112.2	106.4	104.1	113.0	106.2
BIC	113.6	110.1	122.6	126.2	112.7	110.1	125.7	116.2
τ^2	0.28	0.24	0.26	0.25	0.26	0.22	0.28	0.21
Cochran's Q	25,203	6544	11,622	5812	22,437	6124	24,453	4744
I^2 (%)	99.92	99.89	99.82	99.86	99.90	99.84	99.92	99.78

Note: $p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$. Standard errors in parentheses.

somewhat subjective decision what to classify as an innovative product. Innovation was restricted to the farming and processing value chain stage (ElHaffara and Dubea, 2024). We kept this as a required key word in our search terms and based our inclusion decision on the framing in the underlying studies. Nonetheless, the degree of innovativeness varies considerably across the included records.

While the review aims to make general statements, the studies found have a regional focus on analyses based in Europe, Asia and North America. This bias reflects not only the research landscape, but also where the topics of innovative foods, sustainability and WTP analyses predominate. Still, the generalizability of the findings is limited in this regard.

Even though the keywords for the systematic literature search were tested and chosen to be very inclusive, we might have missed some relevant studies that have not met all criteria (e.g., Lemken (2021), Vural et al. (2023)).

5. Conclusions

Excessive consumption and production of animal products impact the global food system, making innovative food alternatives a potential strategy to reduce the reliance on conventional animal-based foods (Herrero et al., 2021). Our meta-analysis assesses how consumers value food innovations that intend to improve environmental sustainability, animal welfare or human health. We focus on animal-based foods and their innovative alternatives including products made from plants, insects, in laboratory settings or using genetic engineering.

Our findings reveal that the WTP estimates are heterogeneous, product- and context-specific even within product groups. In line with previous review studies focusing on innovative foods in general and studies indicating a food technology neophobia of consumers (e.g., Monaco et al. (2024), Giordano et al. (2018)), we find that a higher level of innovativeness reduces the MWTP significantly across products.

Policymakers need to be aware of the acceptance of specific innovative foods and the contextual differences, when implementing policies that direct consumers toward reducing their consumption of conventional animal-based foods. On average the consumer is willing to pay less than for the conventional product if the alternative product is plant-based, stems from a laboratory setting or was created using genetic engineering technologies. For alternatives related to improved health, and those based on insects, insignificant and very small average MWTP estimates result from our meta-analysis. Consumers are, in particular, willing to pay a price premium for products with a comparably low level of innovativeness, that improve animal welfare and environmental sustainability. These products seem to have the highest market potential without additional interventions. Certainly, production costs will differ by innovative product and producers should be aware of the attainable price premium. At the same time, policymaking has the power to pave the way for innovative products by shaping the perception of socially desirable foods among consumers. In addition, policymaking can encourage food innovations guided toward improving societal well-being by creating an innovation-friendly regulatory environment. Nonetheless, innovative alternatives need to be price-competitive, especially if they replace often consumed products and if they shall be an option also for price-sensitive consumers. Finally, even if consumers are willing to pay less for sustainable and healthy but innovative foods than for conventional animal-based products, policymaking can steer consumption by targeted subsidies that lower the prices for these socially desirable alternatives.

Ethical statement

This article is a review of previously published literature and does not involve any new studies with human participants or animals performed by any of the authors. Therefore, ethical approval and informed consent were not required.

Data and code availability

The data is available as online supplementary file and the code is available on GitHub (https://github.com/CatharinaLatka/MetaAnalysis_WTPinnovFoods).

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CRediT authorship contribution statement

Catharina Latka: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Samuel Ahado:** Writing – original draft, Visualization, Investigation, Conceptualization. **Tereza Pilarova:** Writing – original draft, Visualization, Investigation, Conceptualization. **Ayat Ullah:** Writing – original draft, Investigation, Conceptualization. **Linda Arata:** Writing – review & editing, Conceptualization. **Mirta Casati:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2025.100892.

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