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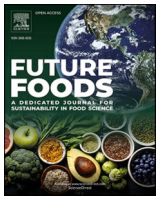

Sustainability of insect-based feed and consumer willingness to pay for novel food: A stated preference study

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ABSTRACT

In recent years, numerous studies have highlighted insects as a promising protein source for poultry feed, offering environmental benefits and improved animal welfare. However, insects are still considered unconventional in Western diets, limiting their acceptance among consumers. This study examines to what extent information on animal welfare and environmental benefits of insect-based feed can counteract factors like neophobia and established food habits, hence enhancing consumer acceptability of novel poultry products from animals fed with insect-based feed. A contingent valuation survey involving 512 Italian consumers divided into four groups was conducted: a control group with no information, an animal welfare information group, an environmental information group, and a group receiving both sets of information. Results indicate that providing information about the advantages of insect-based feed can reduce consumer reluctance towards the innovative product. Moreover, information on environmental benefits affects consumer preferences more than information on animal welfare.

1. Introduction

The use of alternative feed in animal production is pivotal in the discussion regarding the (un)sustainability of future food systems that is happening at the international level. A sustainable food system "delivers food and nutrition security for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised'' (Lindgren et al., 2018). If the UN Food Systems Summit of 2021 had the aim of delivering more sustainable, equitable, and healthier food systems by raising public awareness of the problem (United Nations, 2023), the more recent meeting of July 2023 (UN Food Systems Summit +2) has brought to the attention the importance of science, technology and innovation as accelerators of a transformation towards more sustainable models (News detail | UN Food Systems Coordination Hub WWW Document, 2023). Hence the urgency of shifting global food production into a more sustainable framework, where the aim is to produce "better" rather than "more" food (Willett et al., 2019).

At this juncture, animal feed production significantly impacts the environment. Currently, soybean cultivation for animal feed is rapidly expanding, especially for poultry feed, which constitutes 53 % of total soy production (Dalgaard et al., 2007; Fraanje and Garnett, 2020). This expansion is linked to extensive deforestation, clearing of natural vegetation, and water pollution (Dreoni et al., 2022). Additionally, global soy trade has substantial implications for Earth's climate, emitting significant greenhouse gases and further impacting the environment (Song et al., 2021). Another important component of poultry feed production is fishmeal (Hardy and Tacon, 2002), which also has significant environmental implications. The production of fish meal, traditionally derived from wild fish, can lead to local population collapses and affect other marine life, causing environmental and social problems. This practice raises concerns about the sustainability and ethics of using wild-caught fish for feed production (Hasan and Halwart, 2009).

As the world's population is expected to exceed 10 billion by 2060 (United Nations, 2023; United Nations Department for Economic And Social Affairs, 2023) and meat consumption alone is projected to rise by 76 % between 2005/2007 and 2050 (Godfray et al., 2018), animal feed production pressure on the environment is likely to increase in the near future.

Given these premises, it is crucial to find alternative protein-rich resources for the feed sector to meet market demand while reducing the use of environmentally impactful inputs such as soybean meal and

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fishmeal (Olsen and Hasan, 2012; Mottet et al., 2017). In recent years, numerous technological innovations have emerged to expedite the shift towards more sustainable food systems, focusing on alternative proteins (Herrero et al., 2020). These include developments in microalgae, cyanobacteria, and seaweed (Henchion et al., 2017; Parodi et al., 2018), microbial proteins (Pikaar, et al., 2018a; Pikaar et al., 2018b), plant- and dairy-based meat substitutes (Smetana et al., 2015), and bioactive aquafeed ingredients (Sellars et al., 2015; Simon et al., 2019). Among these, insects have emerged as a potential solution to enhance the productivity and efficiency of the food chain (Van Huis et al., 2013). With their high protein content (37–63 %), fats (20–40 %) and well-balanced profiles of amino acids, fatty acids, minerals and vitamins (Van Huis et al., 2013), insects represent a viable new source of protein. Insects rearing requires minimal space, exhibits a high bioconversion ratio (Oonincx and Boer, 2012) and can be accomplished using organic waste streams, thereby reducing the environmental footprint and maximizing the value of refuse (Smetana et al., 2016). Alongside their environmental benefits, the use of insects as feed provides various advantages for animal welfare. These include enhancing growth performances and improving gut health. Insects are ethically suitable as feed since they are lower on the sentience scale compared to vertebrates commonly used in feed production. By promoting the use of insects as feed, there is an opportunity to improve animal welfare by reducing the demand for conventional feed sources (Biasato et al., 2022; Bongiorno et al., 2022).

Recognizing the urgent need to address food security and food sustainability challenges, the regulatory framework concerning the production and marketing of insect-based feed has undergone extensive reform by EU legislators. These reforms align with the Sustainable Development Goals (SDGs) and promote responsible consumption and production practices. The EU regulations provide a framework to ensure the safety, quality, and traceability of insect-based feed and promote the transition towards more sustainable and resource-efficient food systems (Vauterin et al., 2021). In this context, insect rearing falls under the category of 'farmed animals' as defined in the EU Animal By-Products' (ABP) legislation (Commission Regulation (EC) No 1169/2009, 2009). All-related manufacturing processes have the potential to provide tools to help biowaste reduction and conversion, following the so-called WISE (Witfull - Indicative - Societal demands - Enforceable) principle (van Raamsdonk et al., 2017).

A potential issue with the use of insect-based feed in animal production is its low consumer acceptability. Consumers' dietary choices are critical to driving the transition to a sustainable food system (Towards Sustainable Food Consumption – SAPEA, 2023) and can determine the market success of transformative innovations (Heinola et al., 2023). In general, there appears to be a greater acceptance of indirect entomophagy among consumers, particularly among younger adults and those exploring alternative food sources, compared to direct entomophagy (La Barbera et al., 2021). Indirect entomophagy involves consuming products derived from animals that have been fed with insect-based feed, while direct entomophagy entails the consumption of food directly integrated with insect proteins. For instance, consumer acceptance of animals raised on insect meal varies across Brazilians, with poultry and fish being more favoured over beef and pork (Domingues et al., 2020). Furthermore, Norwegian consumers tend to exhibit higher acceptance of insect-based feed compared to their counterparts in Portugal (Ribeiro et al., 2022). Another study shows that meat from animals fed with insect meal tends to receive lower acceptance scores compared to meat from free-range animals, with the disparity largely attributed to a general aversion to insects. This study underscores the necessity of highlighting the advantages of incorporating insect meal into animal feed as a means to bolster awareness and acceptance among consumers (Szendrő et al., 2020).

Either way, the nature of attitudes towards insect consumption is generally complex, with younger individuals and males expressing more favourable views. Overcoming, the hurdle of disgust is identified as crucial for mainstream acceptance of insects as a food choice in Western societies (Videbæk and Grunert, 2020). It has also been demonstrated that initial exposure to insects positively influences sensory expectations and the intention to try, serving as a strong predictor of behaviour (Sogari et al., 2019). Additionally, a novel self-report instrument, the Entomophagy Attitude Questionnaire (EAQ), has been developed to address the shortcomings of existing measures. The EAQ encompasses three key dimensions: negative evaluation of direct entomophagy (associated with disgust), positive evaluation of direct entomophagy (related to novelty and openness to new foods), and attitude towards indirect entomophagy (the use of insects as feed for animals destined for human consumption). Results indicate the instrument's efficacy in predicting intentions related to both direct and indirect entomophagy (La Barbera et al., 2020).

Another important factor that is proven to play a role in consumers acceptance of insect-based products is information. Baldi et al. (2021), Menozzi et al. (2021) and Sogari et al. (2022) demonstrated that acceptance of fish and duck farmed using insect-based feed is higher among consumers who are informed about environmental benefits related to the use of insect-based feed. The same tendency has been found in German (Altmann et al., 2022) and Dutch consumers (Naranjo-Guevara et al., 2021). Similarly, Spartano and Grasso (2021) found a positive impact of information about the animal welfare benefits of using eggs derived from laying hens fed with insect-based feed on consumers' acceptability. From the perspective of novel food instead, Lombardi et al. (2019) demonstrated that providing information about health and environmental benefits of using insects in products such as cookies, pasta, and chocolate increases consumers' willingness to pay (WTP). For chocolate chip cookies with insect-based flour as ingredient, it appears that having strong convictions about the health benefits of eating insects, coupled with an awareness of positive environmental effects, exerts a positive influence on the attitude and intention to consume such products (Menozzi et al., 2017). In the end, for Michel and Begho (2023), high levels of eco-consciousness and perceived agency, coupled with low levels of food neophobia, are correlated with higher valuations of cricket-based sausages.

This study contributes to this literature by investigating the relative weight that consumers place on information regarding animal welfare and carbon footprint benefits due to the use of insect-based feed in animal production and the relative impact of this information on their WTP for insect-fed poultry products. In addition, the paper explores whether the joint provision of this information generates a synergic effect that may inflate WTP for these products or not. The pattern used in our study has also been employed to investigate consumers' WTP for various types of sustainability claims (Van Loo et al., 2014; Realini et al., 2023) and even for more sustainable meat (e.g., pork) (De Valck et al., 2023; Denver et al., 2023).

The emphasis on the poultry industry is driven by its substantial role, constituting 79 % of global livestock production (Herrero et al., 2013). According to the Food and Agriculture Organization (FAO) of the United Nations, global poultry meat production reached 136 million tons in 2022, growing annually at a rate of 2.6 %, making it the primary contributor to the meat industry. Whitin this framework, chickens are the most widely raised for meat globally (Mottet and Tempio, 2017). Chicken meat is a popular choice among consumers due to its favourable muscle fibre composition and nutritional attributes. Compared to other poultry species, chicken breast meat is known for its lean nature and relatively high protein content (Ali et al., 2007). It is often preferred by health-conscious individuals seeking a lean source of animal protein (Farrell, 2013).

The decision to focus on the provision of animal welfare and carbon footprint benefits stems from the fact that European consumers appear to be rather sensitive to these issues when it comes to purchase food products. There has been a noticeable increase in European citizens' interest in animal welfare, with the percentage of people expressing concern about this issue rising from 34 % in 2006 to 57 % in 2016 (Alonso et al., 2020). According to the Eurobarometer survey platform

of the European Union, at the moment, a significant 84 % of Europeans express the belief that the welfare of farmed animals should receive better protection in their country than it currently does (Attitudes of Europeans towards animal welfare - ottobre 2023). Recent research show that animal welfare labels can increase consumer WTP for animal products (Miranda-de la Lama et al., 2017; Gross et al., 2021; Cerroni et al., 2022). At the same time, over three-quarters (77 %) of European citizens consider climate change to be a very serious problem nowadays (Climate change - Luglio 2023), and likewise, following the pattern previously presented for animal welfare concerns, several studies demonstrate that consumers are willing to pay a higher premium for foods with a lower carbon footprint (Macdiarmid et al., 2021; Pink et al., 2022; Asioli et al., 2023).

This study aims to investigate how providing information affects consumer acceptance of poultry products derived from animals fed with insect-based feed. Specifically, it explores whether emphasizing benefits related to animal welfare and/or environmental sustainability can counteract the negative influence of factors like neophobia and dietary habits on consumer acceptance of insect-fed poultry products. The primary hypothesis suggests that exposure to information about insect-based feed will positively impact consumer acceptance. Secondary hypotheses propose that information on animal welfare and environmental aspects of insect-based feed will decrease food neophobia and bolster consumer acceptance. Additionally, it's hypothesized that the combined effect of information on both animal welfare and environmental aspects of insect-based feed will have a greater impact on consumer acceptance compared to either aspect alone. This research seeks to empirically validate these hypotheses through a survey involving Italian consumers.

2. Materials and methods

2.1. Sample and data collection

The questionnaire was web-programmed using Qualtrics (Qualtrics, Provo, UT) and it was distributed among a representative sample of 512 Italian consumers who are older than 18 years, responsible for grocery shopping in their family unit, and meat consumers[1]. Treatment groups are balanced in terms of age and gender. The survey was conducted between January 24th and February 1st, 2023. All participants were aware that their answers would be used for scientific purposes only. After a pilot test to determine the length and overall understanding of the questions, the survey was revised prior to administration. We, then, conducted two quality checks: initially, we excluded all participants who completed the questionnaire in less than 5 minutes. Subsequently, we verified participants' responsibility for grocery shopping in their household through the screening question Q0 (see footnote 1).

Table 1 provides an overview of the main sociodemographic characteristics of our panel in comparison with the equivalent Italian population. It includes gender, age, education level, net annual income, and geographical area of residence. A total of 512 subjects (50 % men), aged between 18 and 82 with an average age of 48.9, completed the survey. These two data points align with the statistics of the Italian population. Most respondents declared to have a high level of education, with 58 % declaring they had completed the high school education cycle and 17 % obtaining a Master's degree, a result that does not deviate significantly from what is reported by the majority of the Italian population. The 35 % of our respondents declared a net annual income between 15,001€ and 28,000€, which is in line with the average annual income calculated in 2020 for the Italians of 21,570€ *Press Release of April 13th, 2022, from the Ministry of Economy and Finance* (Press Release, 2022). Regarding the geographical area of residence, 30 % of the sample lived in a city with more than 100,000 inhabitants, while 19.7 % lived in the northern Italian region of Lombardy (101 participants out of 512). This is also consistent with the statistics of the country.

In terms of occupation, 68.7 % of participants claimed a job category not included in the list proposed (i.e., Agriculture, Trade, Large-scale retailers, Education and Research, Food services, Zootechnic). Moreover, the average number of people per family unit is declared to be 2.8. Regarding purchasing and eating habits, most respondents declared to follow an omnivorous diet (88.8 %), while 72.2 % reported consuming poultry meat once or twice per week. Finally, the panel's purchasing habits are framed as follows: 66.9 % buy poultry products at the supermarket, while the weekly average cost for groceries is 110.09€, and 18.04€ is specifically spent on poultry products.

Table 1
Demographic and socio-economic distribution in the sample and in the Italian population.

	Survey sample	Italian population[a]
Male (%)	50	49
Age (years)	49	46
Education (%)[b]		
Primary school	1	15
Lower secondary	10	30
Upper secondary	58	35
Bachelor's degree	9	20[c]
Master's degree	17	
Post graduate degree	5	
Income (net annual income) (%)[d]		
< 15,000 €	24	NA
15,001 – 28,000 €	35	NA
28,001 – 55,000 €	33	NA
55,001 – 75,000 €	6	NA
> 75,000 €	2	NA
Geographical area (%)[e]		
Town with less than 5,000 inhabitants	11	25[f]
Town with less than 10,000 inhabitants	16	
City with population between 10,000 and 30,000 inhabitants	22	41
City with population between 30,000 and 100,000 inhabitants	21	34[g]
City with more than 100,000 inhabitants	30	

[a] Values from Italian National Institute of Statistics (ISTAT).
[b] Report ISTAT of December 15th, 2022.
[c] Data include the sum from Bachelor's, Master's and Post graduate degree.
[d] The average annual income for Italian population, in 2020, is 21,570€ (source: Ministry of Economy and Finance, press release of April 13th, 2022).
[e] Values from Statistical office of the European Union (Eurostat) which refers to 2018.
[f] Data include the sum of the first two categories (Town), reported as "Rural area".
[g] Data include the of the last two categories (City), reported as "Major city".

2.2. Questionnaire design

The survey was divided into five sections, categorized as follows: i) familiarity questions about chicken nutrition and the use of feed for poultry farming; ii) information provision and willingness to pay (WTP) elicitation; iii) behavioural questions; iv) attitudinal questions; and v) socio-demographic questions. The full survey can be found in Appendix 1.

In Section 1, respondents were asked to rate their degree of agreement on a 7-point Likert scale with four statements related to current chicken dietary patterns and poultry feeding processes. Responses to these questions allow for the creation of a participant-specific familiarity index. Following, the full text for each statement is reported:

[1] The evaluation of these two criteria was conducted by analysing the responses to the following questions: question Q0 "*Who typically handles grocery shopping in your family?*" and question Q5 "*Which of the following best describes your eating habits? Select the one where you better identify yourself among those proposed.*" Each question, whit its complete list of response items, is available in Appendix 1.

1. Chickens are omnivorous animals: the omnivore eats without distinction both animal-derived products (e.g., meat, insects, etc.) and plant-based products (e.g., leaves, roots, algae, microflora) (Wan et al., 2021);
2. The conventional feed used for poultry nutrition includes insect meal or insect live larvae (Bosch et al., 2019);
3. The European Union, in July 2021, stated that it is allowed to use insects to produce poultry feed (Commission Regulation (EU) 2021/1372, 2021);
4. Using insects to produce poultry feed has beneficial effects on animal welfare (Dabbou et al., 2018).

All four assumptions were then included in a scale renamed the Poultry Farming Scale (PFS), with the aim of assessing consumer perceptions and attitudes towards different aspects of poultry farming practices. The affirmations included in this scale are all true. They are related to the research objectives and the literature presented on poultry farming practices and consumer perceptions of insect-based feed. The reliability of the PFS was evaluated using Cronbach's alpha, to ensure high internal consistency between scale items: the scale can be considered reliable as the value corresponds to 0.7.

The second section of the questionnaire focused on the elicitation of respondents' WTP for two different 400 g chicken breasts. We used the contingent valuation method (CVM), a popular stated preference elicitation technique that has been recently used to elicit WTP for insect-based feed and food products (e.g., Giotis and Drichoutis, 2021). Initially, we provided each respondent with brief definitions of the products under consideration. The "conventional product" was described as a chicken breast in a portion of 400g derived from animals fed with conventional feed, while the "innovative product" was described as a chicken breast in portion of 400g derived from animals fed with innovative feed. Both definitions included descriptions of "conventional" and "innovative" feeds. The "conventional" feed mainly consisted of corn, soybean meal, and other grains supplemented with necessary nutrients for animal growth (e.g., calcium and sodium). The "innovative" feed, on the other hand, consisted of conventional feed integrated with a maximum of 10 % insect meal or insect live larvae, as reported by the consistent literature on the use of Black soldier fly (*Hermetia illucens*) as an ingredient for insect-based feed (Dabbou et al., 2018; Cullere et al., 2019; Schiavone et al., 2019; Bellezza Oddon et al., 2021), considering the daily feed intake, i.e., the amount of feed that is eaten when the animal has access to feed on a truly ad-lib basis. Both descriptions reported that all animals involved were raised in Italy, according to the ground breeding system. In the following question, we asked respondents to indicate their maximum WTP for both conventional and innovative products using a payment scale ranging from 0 € to 4 €, with a €0.25 price increments based on the price of chicken meat per kilogram in supermarkets (approximately 8€/kg). The sample was randomly split into four group: i) a control group receiving no information about potential benefits; ii) an animal welfare informational group receiving information about animal welfare benefits; iii) a carbon footprint informational group receiving information about carbon footprint benefits; and iv) an information group receiving information about both animal welfare and carbon footprint benefits.

The third, fourth and fifth sections presented behavioural, attitudinal and socio-economic questions. More details are provided below.

The third section presented a set of behavioural questions investigating respondents' current food purchasing and consumption behaviour. For example, we collected data on the frequency of poultry meat consumption, and the degree of sustainability of respondents' diets. The latter was elicited using a revised version of the Food Consumption Sustainability (FCS) scale developed by Endrizzi et al. (2021).

The fourth section consisted of attitudinal questions exploring respondents' degree of food neophobia, their beliefs regarding the impact of food quality on animal welfare and the impact of poultry farming on climate change, and the perceived impact that animal welfare, environmental sustainability and price of food products have food on purchasing decisions. Food neophobia was elicited using the food neophobia (FN) scale developed by Pliner and Hobden (1992).

Finally, sociodemographic data were collected from each respondent, including education level, geographical area of residence, and net annual income.

2.3. Informational treatments

Respondents were randomly assigned to one of the four information treatments. These are balanced in terms of gender and age.

1. Control group: consisting of 128 individuals who received no information treatment and were directly sent to the willingness to pay question;
2. Welfare information treatment group: consisting of 124 individuals, this group received information on the welfare benefits (Ipema et al., 2020; Colombino et al., 2021; Biasato et al., 2022) associated with the use of insect-based feed in poultry diets;
3. Carbon footprint information treatment group: consisting of 130 individuals, this group received information on the environmental benefits (Salomone et al., 2017; Dörper et al., 2021; Smetana et al., 2021; Kuepper and Stravens, 2022) associated with the use of insect-based feed in poultry diets;
4. Both information treatment group: consisting of 130 individuals, this group received information that included both welfare and carbon footprint treatments, offered in a randomized order.

The full version of each information treatment is provided in Appendix 1. Treatment groups were balanced in terms of gender and age by design.

3. Statistical analysis

3.1. Econometrics models

For all statistical analysis, we used the statistical software R (version 4.2.3). To test whether informational treatments have an effect on consumers' acceptability of the innovative product, the following model (Model 1) was estimated using an ordinary least square (OLS) estimator:

$$PP_i = \alpha + \beta_{welfare} WELFARE_i + \beta_{carbon\_footprint} CARBON\_FOOTPRINT_i + \beta_{both} BOTH_i + \boldsymbol{\beta X_i} + \varepsilon_i \quad (1)$$

Where PP_i is the price premium of the respondent i for the innovative product calculated by subtracting the WTP for innovative products (IP) from the WTP for conventional products (CP): $PP = WTP_{IP} - WTP_{CP}$. The categorical variable *WELFARE, CARBON_FOOTPRINT*, and *BOTH* indicate whether respondent i belongs to the welfare, carbon footprint or both information treatment, respectively. The vector variable $\boldsymbol{X}$ consists of two variables. *AGE* is a continuous variable indicating respondents' age, while *EI_PURCHASE* is a continuous variable indicate the perceived influence of the environmental impact on food purchasing. The latter was elicited using a Likert scale asking respondents to state their level of agreement, on a scale from 1 to 7, with the following statement, "How much does the environmental impact related to food production affect your food buying choices?". These two variables were included into the model as control because they differed across treatment groups, based on the estimation of a multinomial logit model testing difference in subsample compositions. More information on the model is available in Appendix 2.

To test whether information had an impact on the relationships between different drivers of consumer preferences and the premium price for the innovative product, Model 1 was enriched by incorporating additional variables. Model 2 – Neophobia test whether incorporate the following additional variables: i) *NEOPHOBIA* that indicates the level of

respondents' neophobia; ii) *Welfare X NEOPHOBIA* that interacts the treatment variables *WELFARE* with the variable *NEOPHOBIA* and capture whether the impact of neophobia on price premium varies in the welfare information treatment with respect to the control group; iii) *Carbon footprint X NEOPHOBIA* that interacts the treatment variables *CARBON_FOOTPRINT* with the variable *NEOPHOBIA* and capture whether the impact of neophobia on price premium varies in the carbon footprint informational treatment with respect to the control group; iv) *Both X NEOPHOBIA* that interacts the treatment variables *BOTH* with the variable *NEOPHOBIA* and capture whether the impact of neophobia on price premium varies in the both information treatment with respect to the control group. The variable *NEOPHOBIA* is a continuous variable that is elicited in the questionnaire using the food neophobia (FN) scale by Pliner and Hobden (1992). The internal validity of the FN scale is relatively good with a Cronbach's alpha value equal to 0.8 (Ursachi et al., 2015a).

Model 2 - Feed Welfare and Model 2 - Poultry Climate Change have a very similar structure. These models replace the variable *NEOHOPBIA* with the variable *AW_FEED* and the variable *CC_POULTRY*, respectively. *AW_FEED* and *CC_POULTRY* indicate respondents' beliefs regarding the extent to which animal feed quality influences animal welfare and poultry farming activity contributes to climate change, respectively. Likert scales from 1 to 7 were used to elicit these beliefs.

To identify factors driving consumers' acceptability of the innovative product, an additional model was estimated. Model 3 regresses *PP* for the innovative product for all the treatments on a set of potential behavioural, attitudinal and socio-economic drivers, as it follows:

$$PP_i = \alpha + \boldsymbol{\beta}_{behaviour}\boldsymbol{BEHAVIOUR}_i + \beta_{attitude}\boldsymbol{ATTITUDE}_i + \beta_{SOCIO\_ECON}\boldsymbol{SOCIOECON}_i + \varepsilon_i \quad (2)$$

Among behavioural drivers, we included the following variables. The categorical variables *CONS_FREQ_MEDIUM* and *CONS_FREQ_HIGH* refers to respondents who moderately (one per month) and regularly (more than once per month) consume chicken products, respectively. The baseline *CONS_FREQ_LOW* indicate those respondents that rarely (less than once per month) consumer chicken products. In addition we included *CONS_SUST*, a continuous variable referring to the degree of sustainability of respondents' diets elicited using a revised version of the Food Consumption Sustainability (FCS) scale developed by Endrizzi et al. (2021), which internal validity is deemed acceptable, as indicated by Cronbach's alpha values equal to 0.7 (Ursachi et al., 2015a).

Among attitudinal drivers, the following variables were incorporated into the model. *KNOW_PF* is a continuous variable indicating respondents' level of knowledge regarding farmed chickens' diets elicited via the PFS. The internal validity of PFS is acceptable according to Cronbach's alpha values equal to 0.7 (Ursachi et al., 2015b)[2]. *NEOPHOBIA* is the same variable used in Model 2 – Neophobia. *PRICE_PURCHASE, EI_PURCHASE*, and *AW_PURCHASE* refer to respondents' perceived impact of price, environmental sustainability and animal welfare influence their grocery shopping, respectively. These variables were elicited by asking respondents how much price, environmental sustainability and animal welfare affect their grocery shopping using Likert scales ranging from 1 to 7.

Among socio-economic drivers, the following variables are considered. *AGE* is a continuous variable referring to respondents' age in years, *MALE* is categorical variable indicating gender, *INCOME* is a continuous variable indicating the household's net income in 2022, and *EDU* is a continuous variable showing respondents' level of education. *LARGE_CITY and MEDIUM_CITY* are categorical variables referring to respondents who live in cities with more than 100,000 inhabitants and cities between 10,000 and 100,000 inhabitants, respectively. The baseline is *SMALL_CITY* indicating respondents who live in towns with less than 10,000 inhabitants. Summary statistics for all variables included in our models are reported in Table 2. The column labelled "Question ID" contains the code assigned to the question from which the variable was derived in Appendix 1.

4. Results

4.1. Effects of information on premium price for the innovative product

The average *PP* price for the innovative product is -0.58€ (SD = 1.29). This suggests that our sample is generally not willing to purchase the innovative chicken product based on the use of insect feed. This is consistent with previous empirical literature showing that the acceptability of insect-based food is low among western consumers (Caparros Megido et al., 2016; Giotis and Drichoutis, 2021; Wendin and Nyberg, 2021). While studies indicate a significant proportion of respondents in Western countries are willing to consume meat produced from insect-based feed, there remain barriers such as disgust, lack of familiarity, and concerns about food safety that discourage consumers from trying these products (Bunker and Zscheischler, 2023). However, our results, reported in Fig. 1, suggest that informational treatments have an impact on *PP*. The average *PP* in the control group is -1.09€ (SD = 1.46), in the welfare information treatment group is -0.49€ (SD = 1.25), in the carbon footprint information treatment group is -0.35€ (SD = 1.17), and in both information treatment group is -0.43€ (SD = 1.16). A non-parametric Kruskal-Wallis test suggest that such differences are statistically significant at the 1 % level.

These results are confirmed by the estimation of Model 1 using the OLS estimator. Results reported in Table 3 indicate that respondents exposed to the carbon footprint information treatment are willing to pay 0.40€ more than respondents who did not receive the treatment. At the same time, respondents who received welfare information and both information treatments are willing to pay, respectively, 0.27€ and 0.32€ more than respondents who received no treatment. These results suggest that respondents' reluctance towards the use of insect-based feeds can be partially mitigated by informational treatments that highlight the environmental and animal welfare benefits of using insect as animal feed. Also, our results show that information about environmental benefits is more impactful than information on animal welfare benefits. This is consistent with previous empirical literature showing that information on the positive externalities generated by the use of insect-based feed can reduce respondents' negative responses to novel food products based on the use of insect feeds (Baldi et al., 2021; Giotis and Drichoutis, 2021; Menozzi et al., 2021). Simultaneously, the greater impact of environmental information on willingness to pay compared to animal welfare information might stem from our panel of consumers exhibiting a heightened interest in the sustainability aspects of their food choices. Recent literature on Italian consumers indeed indicates an increasing concern for environmental sustainability in food expenditures (Laureti and Benedetti, 2018; Predieri et al., 2023; De Marchi et al., 2024), extending beyond innovative products to conventional ones. This factor likely played a significant role in influencing our findings regarding willingness to pay.

These results shed light on the role that information on animal welfare of animal raised using insect feed. While information on animal welfare per se reduces negative responses to the innovative product, it appears to diminish the positive impact on environmental benefit when the two information are jointly provided. A similar, but opposite, pattern is found in the study by Ankamah-Yeboah et al. (2019), where a discrete choice experiment was employed to investigate the preferences of German consumers for farmed rainbow trout. In this case, when the information emphasizes both environmental and animal welfare concerns, respondents' marginal utility is greater than in the control sample but less than in the animal welfare-focused sample. This suggests that the environmental information seems to reduce the positive influence of

[2] A Cronbach's alpha value above 0.6 is considered acceptable, while a value above 0.7 is considered good to optimal, as reported by Ursachi et al. (2015).

Table 2
Summary of statistics of dependent and independent variables of Model 3.

Variable	Question ID	Definition	M	SD	Min	Max
PP	Q3-Q4	= WTP_{IP} – WTP_{CP}	-.588	1.298	- 4€	3.50€
AGE	Q15	Age in years	48.97	16.03	18	82
MALE	Q14	= 1 if Male, = 0 otherwise	.500	.500	0	1
INCOME [a]	Q20	= 1 if <15,000€, = 2 if 15,001€ – 28,000€, = 3 if 28,001€ – 55,000€, = 4 if 55,001€ – 75,000€, = 5 if >75,000€	2.271	.954	1	5
LARGE_CITY		= 1 if city with more than 100,000 inhabitants = 0 otherwise	.300	.459	0	1
MEDIUM_CITY	Q19	= 1 if cities between 10,000 and 100,000 inhabitants = 0 otherwise	.427	.495	0	1
SMALL_CITY		= 1 if town with less than 5,000 inhabitants = 0 otherwise	.271	.455	0	1
CONS_FREQ_HIGH		= 1 if consumption of chicken products is more than once per month = 0 otherwise	.052	.223	0	1
CONS_FREQ_MEDIUM	Q6	= 1 if consumption of chicken products is once per month = 0 otherwise	.087	.283	0	1
CONS_FREQ_LOW		= 1 if consumption of chicken products is less than once per month = 0 otherwise	.859	.347	0	1
EDU	Q17	= 1 if Primary school, = 2 if Lower secondary, = 3 if Upper secondary, = 4 if Bachelor's degree, = 5 if Master's degree, = 6 if Post graduate degree	3.461	1.055	1	6
KNOW_PF	Q1	Index related to Poultry Farming Scale (PFS) = the average score of the 4 items of the PFS scale.	4.299	1.392	1	7
FOOD_NEOPHOBIA	Q12	Index related to Food Neophobia Scale (FNS) = the average score of the 10 items of the FNS scale (some of which were reverse coded as opposites).	3.798	1.068	1	7
CONS_SUST	Q10	Index related to Food Consumption Sustainability (FCS) = the average score of the 10 items of the FCS scale (some of which were reverse coded as opposites).	3.886	1.071	1	7
AW_FEED	Q11	Agreement with the assumption "How much do you think feed quality has an impact on animal welfare?" (at 7 levels) [b]	5.906	1.254	1	7
CC_POULTRY	Q11	Agreement with the assumption "How much do you think poultry farming has an impact on climate change?" (at 7 levels)	4.834	1.576	1	7
PRICE_PURCHASE	Q11	Agreement with the assumption "How much does the price affect your grocery shopping?" (at 7 levels)	5.365	1.210	1	7
EI_PURCHASE	Q11	Agreement with the assumption "How much does the environmental impact related to food production affect your buying choices?" (at 7 levels)	4.885	1.495	1	7
AW_PURCHASE	Q11	Agreement with the assumption "How much does animal welfare affect your buying choices?" (at 7 levels)	5.385	1.363	1	7

M = Mean, SD = Standard deviation.
[a] The values were divided by 100 to set the variable as continuous.
[b] From 1 = very little to 7 = a lot.

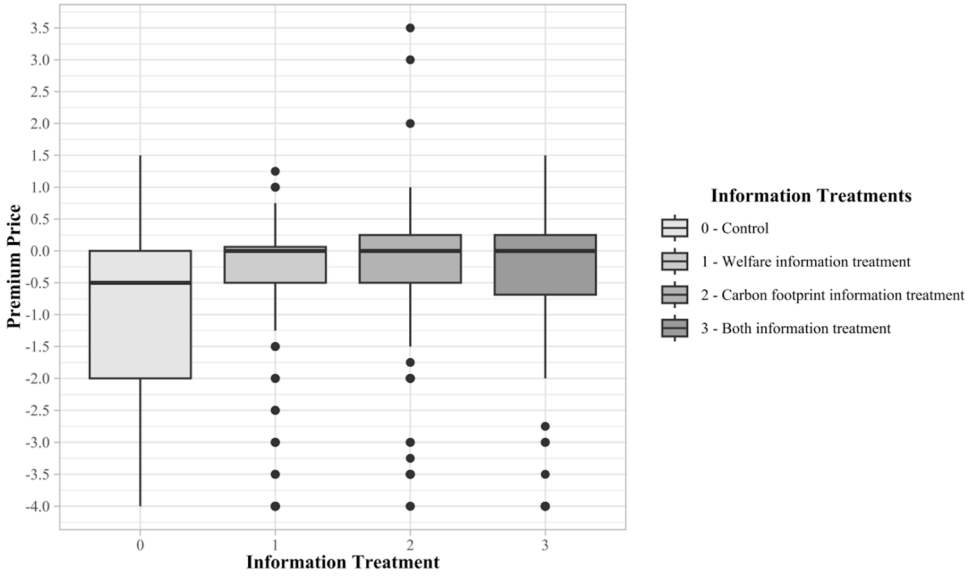

Fig. 1. Variability of values for premium price according to information treatments.

Table 3
Ordinary least square regression model for the effect of each treatment on premium price.

Dep. Variable: *PP*	Model 1[a]
Carbon footprint	.4027**
	(0.166)
Welfare	.2778*
	(0.165)
Both	.3266**
	(0.166)
AGE	-.0194**
	(0.003)
EI_PURCHASE	.0756**
	(0.367)
Constant	-.2601
	(0.322)
R^2	.1071
Wald Post-estimation Test	
Carbon footprint VS Welfare	**
Welfare VS Both	**
Carbon footprint VS Both	**

** $p < 0.01$.
* $p < 0.05$.
[a] Robust standard errors in brackets.

the animal welfare information treatment. A pattern that is perfectly symmetrical to our results and suggests the need for further in-depth research in this context.

4.2. Effects of information on potential drivers of preferences for the innovative product

Table 4 shows results from the estimation of Model 2 – Neophobia, Model 2 – Feed Welfare, and Model 2 - Poultry Climate Change.

Results from the estimation of Model 2 – Neophobia show that, despite neophobia negatively affecting participants' willingness to pay a premium price for the innovative food, all interaction terms are not statistically different from zero. This suggests that the relationship between *NEOPHOBIA* and *PP* does not change between any of the informational treatments and the control group. Hence, we conclude that the difference in WTP for innovative products with respect to the traditional products detected across groups cannot be explained by variations in the level of neophobia across groups. This is also confirmed by the fact that the level of neophobia elicited via the FNS is not statistically different across groups according to the non-parametric Kruskal-Wallis test (Fig. 2).

Similar results are obtained estimating Model 2 – Feed Welfare. All interaction terms are not statistically different from zero, meaning that the relationship between *AW_FEED* and *PP* does not change between any of the informational treatment and the control group. Hence, difference in WTP for the innovative products with respect to the traditional detected across groups cannot be due to variations in the perceptions of the impact of feed quality on animal welfare across groups. This is also confirmed by the fact that perceptions do not statistically differ across group according to the non-parametric Kruskal-Wallis test (Fig. 3).

Results from the estimation of Model 2 – Poultry Climate Change provide slightly different results. The interaction terms *Both X CC_POULTRY* is positive and statistically significant at the 1 % level, meaning the provision of the full set if information has an impact on the relationship between *CC_POULTRY* and *PP*. Specifically, an increase in the perception of the impact of poultry farming on climate change inflates the price premium for innovative products when the full set of information is provided compared to when no information is provided. Our first hypotheses would be that the provision of information makes respondents more aware of the impact of the poultry sector on climate change, but our boxplot in Fig. 4 and results from the non-parametric Kruskal-Wallis test do not support this hypothesis. Respondents have the same level of awareness across groups. Hence, we argue that other

Table 4
Ordinary least square regression models for the effects of interactions between *NEOPHOBIA, AW_FEED* and *CC_POULTRY* with each information treatment on premium price.

Dep. Variable: *PP*	Model 2 – Neophobia[a]	Model 2 – Feed Welfare[a]	Model 2 – Poultry Climate Change[a]
Carbon footprint	.7490	.3620	-.2610
	(0.580)	(0.698)	(0.506)
Welfare	.1033	.0537	.0831
	(0.562)	(0.810)	(0.493)
Both	.7444	.1287	-.6220
	(0.544)	(0.793)	(0.471)
AGE	-.0147**	-.0192**	-.0197**
	(0.003)	(0.003)	(0.003)
EI_PURCHASE	.0379	.0935**	.0451
	(0.365)	(0.038)	(0.046)
NEOPHOBIA	-.2473**	-	-
	(0.095)		
Carbon footprint X *NEOPHOBIA*	-.0858	-	-
	(0.144)		
Welfare X *NEOPHOBIA*	.0505	-	-
	(0.140)		
Both X *NEOPHOBIA*	-.1092	-	-
	(0.134)		
Constant	.6219	-	-
	(0.488)		
AW_FEED	-	-.1171	-
		(0.086)	
Carbon footprint X *AW_FEED*	-	.0027	-
		(0.114)	
Welfare X *AW_FEED*	-	.0366	-
		(0.131)	
Both X *AW_FEED*	-	.0311	-
		(0.129)	
Constant	-	.3460	-
		(0.602)	
CC_POULTRY	-	-	-.0434
			(0.069)
Carbon footprint X *CC_POULTRY*	-	-	.1341
			(0.097)
Welfare X *CC_POULTRY*	-	-	.0421
			(0.097)
Both X *CC_POULTRY*	-	-	.1978**
			(0.091)
Constant	-	-	.1092
			(0.416)
R^2	.1588	.1168	.1886

** $p < 0.01$, *$p < 0.05$.
[a] Robust standard errors in brackets.

behavioural mechanisms are at work here.

Collectively, there are various studies that illustrate the influence of emotions on individuals' WTP for various products and experiences. If Bates et al. (2023) demonstrated that emotions are critical in influencing WTP for meat alternatives, such as insect-based food, other studies indicate that consumers' awareness of climate change can impact their willingness to choose and pay for climate-smart food products (Predieri et al., 2023). In general, people are willing to pay more to experience positive emotions than to avoid negative ones (Lau et al., 2013), hence the analysis of multiple factors simultaneously could be the key to thoroughly understanding which mechanisms, in synergy, most influence WTP.

Overall, we find that the provision of information has an impact on price premiums for the innovative products. However, this impact is not driven by an increase in the level of awareness stimulated by information. Rather information seems to stimulate some behavioural mechanisms that somehow increase acceptability of the innovative products. Further research is definitively needed on the mechanism that drive the positive impact of information on acceptability of innovative products.

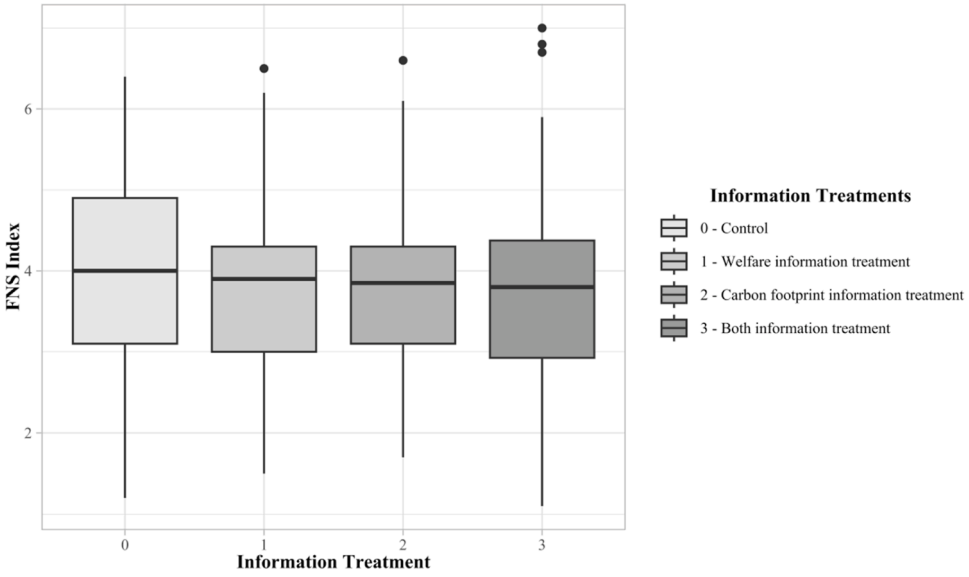

Fig. 2. Variability of values for FNS index according to information treatments.

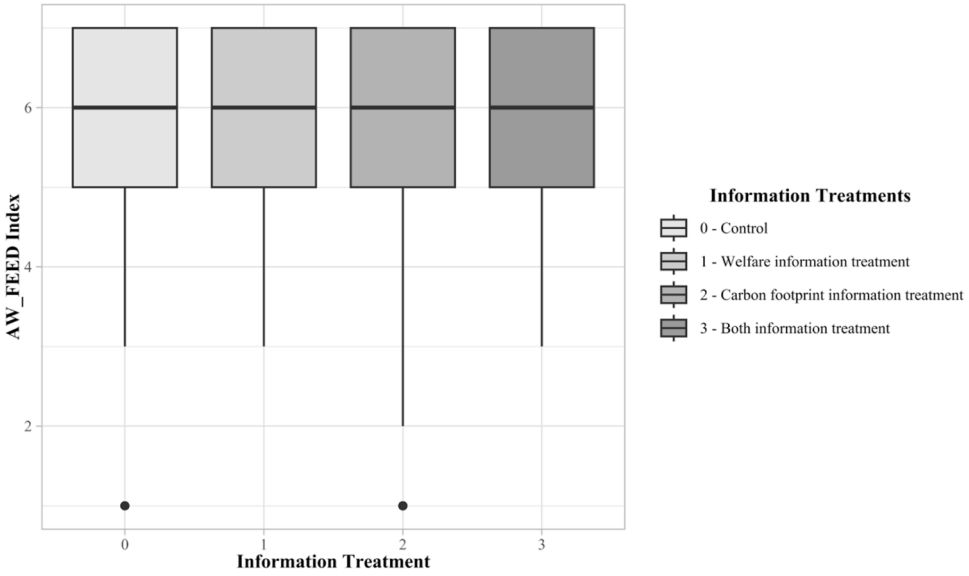

Fig. 3. Variability of values for AW_FEED index according to information treatments.

4.3. Factors driving respondents' acceptability of the innovative product

Table 5 shows results from Model 3. Results show that on average the *PP* decreases with age as suggested by the negative and statistically significant ($p < 0.01$) coefficient related to the variable *AGE*. There is evidence in the literature that older consumers are less inclined to purchase novel food (Bazoche and Poret, 2021; Giotis and Drichoutis, 2021). When it comes to insect-based feed, a similar situation arises: while it's generally more likely to be accepted by consumers, younger individuals tend to be more inclined to accept it compared to the elderly (Baldi et al., 2021; Roccatello et al., 2024). Females display lower *PP* than males as implied by the statistically significant ($p < 0.01$) coefficient related to the variable *MALE*. Males are willing to pay nearly 0.25€ more than females. This can be explained by the fact that females, in general, tend to be less inclined to accept innovative technologies (Nocella et al., 2023), as they are often more risk-averse compared to males (Jianakoplos and Bernasek, 1998; Eckel and Grossman, 2008). Moreover, given that women tend to exhibit higher disgust sensitivity towards insects for food production, it could be assumed that they find the proposed innovative product more disgusting, and consequently, they may be less willing to pay for it (Hartmann and Siegrist, 2016; Egolf et al., 2018; Kröger et al., 2022).

The negative and statistically significant coefficient *LARGE_CITY* ($p < 0.05$) indicates that respondents living in urban areas larger than 100,00 inhabitants are less willing to accept and to pay for the innovative product. While previous research suggests that urban areas are generally associated with higher levels of acceptability towards innovations compared to rural areas (Aryal et al., 2018), our results could be related to the fact that consumers living in rural areas are aware of the fact that avian species commonly eats insects.

This is confirmed by the fact that *PP* increases with the PFS's score as indicated by the statically significant coefficient *KNOW_PF* ($p < 0.01$). This implies that respondents who have a better knowledge regarding farmed chickens' diets pay higher PPs as previously observed by La Barbera et al. (2016) in their study on functional food. Another study, which examines the willingness to pay of smallholders Kenyan farmers

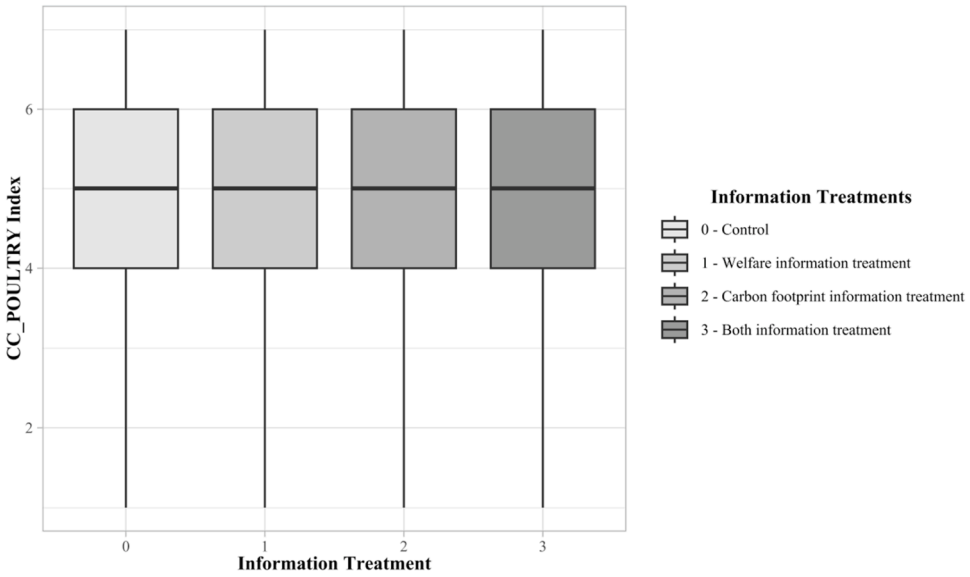

Fig. 4. Variability of values for CC_POULTRY index according to information treatments.

Table 5
Ordinary least square regression model to test the effect of determinants on premium price for all respondents.

Dep. Variable: *PP*	Model 3[a]
AGE	-.0122**
	(0.004)
MALE	.2487**
	(0.117)
INCOME	-.0031
	(0.003)
MEDIUM_CITY	-.1681
	(0.138)
LARGE_CITY	-.2764*
	(0.151)
CONS_FREQ_MEDIUM	-.4469
	(0.316)
CONS_FREQ_HIGH	-.4405*
	(0.252)
EDU	.0169
	(0.062)
KNOW_PF	.1645**
	(0.043)
CONS_SUST	-.0229
	(0.056)
FOOD_NEOPHOBIA	-.2267**
	(0.060)
AW_FEED	-.0844
	(0.048)
CC_POULTRY	.0737
	(0.048)
PRICE_PURCHASE	.0292
	(0.052)
EI_PURCHASE	.0570
	(0.051)
AW_PURCHASE	-.0833
	(0.052)
Constant	1.010
	(0.637)
R^2	.2083

** $p < 0.01$.
* $p < 0.05$.
[a] Robust standard errors in bracket.

for insect-based feed to nourish poultry, pigs, and fish reveals that a comprehensive understanding of the subject positively influences the willingness to pay (Chia et al., 2020).

The negative and statistically significant coefficient *CONS_FREQ_HIGH* ($p < 0.05$) indicates that respondents who consume more chicken are less willing to accept and to pay the innovative products.

Finally, we find that food neophobia has a substantial negative impact on PP for the innovative product. The coefficient related to the variable *FOOD_NEOPHOBIA* is negative and statistically significant ($p < 0.01$). This result is clearly in line with the substantial literature on the subject. As pointed out by Lombardi et al. (2019), higher levels of food neophobia negatively impact WTP for insect-based food. This also true for other novel products such as functional pasta (Palmieri et al., 2021), patties enriched with healthier ingredients (Kallas et al., 2019), and eggs enriched with Omega-3 fatty acids (Palmieri et al., 2022). Similarly, insect-based feed is no exception: high levels of food neophobia make consumers more reluctant to consume these products, even in the context of indirect entomophagy (Bazoche and Poret, 2021). Additionally, food technology neophobia, a personality trait that influences consumers' willingness to accept new food technologies, has been found to have a mixed impact on attitudes toward new food technologies (Siegrist and Hartmann, 2020).

5. Discussion

New technologies for the development of alternative proteins become crucial for the transition towards more sustainable food systems (Prause et al., 2021). Among others, the use of insect in human and animal production has captured the attention of policy makers and it is a pivotal part of the food policy agenda (Mylan et al., 2023). However, among western consumers, acceptability of insect-based food is rather low (e.g., Caparros Megido et al., 2016; House, 2016; Tan and House, 2018), and hence the public and private sector should find solutions to overcome this issue and make these product more acceptable. Our study acts in this direction, exploring the extent to which information can facilitate purchasing and consumption of food products manufactured using insect-based feeds in Italy.

In the present study, the term "innovative" was used to characterize a chicken breast derived from animals fed Black Soldier Fly meal or live larvae. This innovation is in line with emerging trends in sustainable agriculture and new alternative protein sources (Schiavone et al., 2019). By describing or labelling the product as "innovative," our aim was to underline its potential environmental and nutritional benefits, as well as its role in addressing challenges in conventional animal feed production. However, it is important to consider the potential impact of the term

"innovative" on consumer perceptions and willingness to pay (WTP) for the product. The term "innovative" may evoke notions of novelty and potentially improved breast meat quality compared to conventional products. Consequently, consumers' WTP for the innovative product could be influenced, as it is perceived to offer unique benefits or addressing specific preferences or concerns. Nevertheless, it is important to recognize that consumer acceptance and WTP for novel feed products may be influenced by various factors, including cultural aspects, individual preferences, the perceived balance of risks and benefits, and regulations concerning novel feed ingredients (Nazzaro et al., 2019).

A relatively distinct profile of Italian consumers and their preferences for food products manufactured using insect-based feed can be drawn based on our results. On one hand, there is an apparent hesitance to pay a premium for chicken breasts from animals fed with insect-based feed. This is consistent with previous empirical findings related to innovative meat, e.g. cultured meat and farmed duck fed with insect-based feed (Mancini and Antonioli, 2019; Menozzi et al., 2021). In our study, we also investigate whether consumer preferences and WTP are mediated by other factors regardless of the information provision. Consumer prior knowledge about poultry farming practices, specifically about the use of feed in poultry farming, is positively correlated with WTP for poultry products manufactured using insect-feed. Consumers who are more knowledgeable about chicken diets, feeding procedures in the poultry sector, and the possible use of insect as feed in poultry production are less reluctant to purchase the novel food product. Previous empirical research has demonstrated that prior knowledge about novel food products or technology generally has a positive impact on WTP for the product themselves (e.g., Macdiarmid et al., 2021; Nocella et al., 2023).

Other variables with a considerable influence on WTP are age and gender. Males are willing to pay more than females for the novel food products consistently with the vast majority of previous empirical research (Laureati et al., 2016; Baldi et al., 2021; Bazoche and Poret, 2021; Giotis and Drichoutis, 2021). WTP decreases with respondents' age, as reported in many other studies about insect-based food acceptability (Verbeke, 2015; Lombardi et al., 2019). It also is possible to argue that young consumers are generally more concerned about sustainability (Mohd Suki, 2013; Clayton and Karazsia, 2020), and therefore, they are more willing to pay for sustainable novel food products. Moreover, our sample is characterized by a high level of food neophobia. This result is in line with previous empirical evidence suggesting that food neophobia negatively affects the intention to eat insect-containing food (Roma et al., 2020; Bazoche and Poret, 2021; Zamparo et al., 2022). Understanding the factors that influence consumer behaviour is crucial in a rapidly evolving food market (Mancini et al., 2019) where consumer behaviour is influenced by a complex interplay of factors, and that a one-size-fits-all approach to marketing and product development is unlikely to be successful (Asioli et al., 2023).

On the other hand, it has been reaffirmed that providing consumers with information on the benefits in terms of sustainability of using insect-based feeds in animal production can alleviate their reluctance to purchase the novel product (Ankamah-Yeboah et al., 2019; Spartano and Grasso, 2021; Altmann et al., 2022) The latter result is consistent with a very broad stream of research demonstrating that providing information about nutritional, environmental and animal welfare benefits provided by novel foods and ingredients increases their acceptance and WTP (Asioli and Grasso, 2021; Baldi et al., 2021; Weinrich and Busch, 2021; Altmann et al., 2022).

Our study focuses on information related to animal welfare and carbon footprint benefits associated to the use of insect-based feed in animal production and finds that information on environmental sustainability benefits has a higher impact on food preferences and WTP for novel products than information on animal welfare benefits. Despite a growing number of studies have recently shown that consumers are responsive to animal welfare claims when purchasing food products (Van Loo et al., 2014; Miranda-de la Lama et al., 2017), our results suggests that the public and private sectors should prioritize the delivery of information on carbon footprint benefits rather than animal welfare benefits. Our results are consistent with a recent study conducted in Australia by De Valck et al. (2023) and they might be driven by the fact that there is still a general lack of knowledge and awareness in relation to animal welfare. While this topic is deemed as important by the average consumer, there is not clear understanding of its meaning and implications (Sweeney et al., 2022).

In our study, consumers are not exposed to food labels but with an informational message that describe concisely but exhaustively the animal welfare and carbon footprint benefits associated to the novel food. This message could be provided via an app that is activated via a QR code displayed on the package, thus affecting consumer behaviour at the point-of-purchase, or, via a mass-media channel (e.g. radio, television, newspaper and social media) as a social marketing campaign. In this case, the issue of information overload (Bawden and Robinson, 2020) is not as evident as with food labels, where researchers suggest a more judicious use of information (Gracia and Barreiro-Hurlé, 2019; Zou and Liu, 2019; Bogliacino et al., 2023).

Interestingly, in our study, despite information positively influences preference and WTP for the novel food, it does not enhance consumer awareness about animal welfare and carbon footprint benefits. We speculate that information may activate other behavioural mechanisms (other than knowledge and awareness) that lead consumers to increase their acceptability of poultry products manufactured using insect-based feed. Emotions could be identified as a potential driver of preference change that do not necessarily affect knowledge and information. Research has shown that emotions can indeed influence individuals' preferences and WTP for products and experiences. Emotions experienced at the time of decision-making can profoundly impact choices, leading to different decisions compared to a neutral emotional state (Vanderlind et al., 2021; Bogliacino et al., 2023; Luan and Phan, 2023).

If information affects behaviour but it does not increase knowledge and awareness, doubts might arise about whether information can stimulate a permanent or, at least, long-term behavioural change. Nudging and taxation have been often criticized using the same argument: these fail to induce lasting behavioural change and, once removed, their effects dissipate (Galizzi, 2014, 2012; Hagmann et al., 2018). If information does not contribute to awareness and education, its impact may similarly fade over time. This is a line of research that could be further investigated in the future. Based on or results, government may need to find more appropriate ways and channels to promote educational initiatives that do not only shift behaviour in the short term but raise a deeper awareness about the benefits of sustainable and ethical food choices, including those utilizing insect-based feed. NGOs and the private sector can collaborate with public institutions and bodies to provide information and resources about their products and the positive impacts of their practices in a more coherent way (Wongprawmas et al., 2022).

In the end, this study contributes to the growing body of research within food science by providing a nuanced understanding of consumer preferences and the factors influencing their WTP for novel food products, such as those incorporating insect-based feed. It highlights the importance of information dissemination as a key driver in shaping consumer attitudes and WTP. In an era of increasing interest in sustainable and environmentally conscious food choices, these findings underscore the need for accurate, science-based information to educate consumers and influence their decisions.

6. Conclusions

By employing a contingent valuation survey and providing various pieces of information regarding animal welfare and environmental benefits associated with insect-based feed, the research sheds light on consumer behaviour towards this innovative approach in poultry production.

The findings underscore the importance of effective information dissemination in influencing consumer perceptions and acceptance of novel products. Particularly, information regarding environmental benefits emerges as a significant driver of increased acceptability, surpassing the impact of details about animal welfare. While the study reveals promising insights, it also highlights the need for further exploration to understand the long-term effects of such information and to mitigate potential "fad effects" associated with novel food trends.

Moreover, the research identifies demographic factors, such as age and social traits, as influential in shaping consumer predisposition towards embracing innovation in dietary habits. Legislative interventions to facilitate the affordability and accessibility of insect-based feed could further stimulate consumer acceptance by ensuring budget-friendly end products.

However, it's important to note the limitations of this study, particularly its focus on the Italian market. Further research across Europe and other Western countries is recommended to validate the observed trends and determine their broader applicability. Understanding consumer attitudes towards unconventional ingredients such as insects is crucial for shaping future food and feed production practices towards sustainability and reducing environmental footprints on a global scale.

CRediT authorship contribution statement

Rosalba Roccatello: Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Simone Cerroni:** Writing – review & editing, Validation, Supervision, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Sihem Dabbou:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Data curation, Conceptualization.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Ethical statements

The data protection of human subjects involved in this study was ensured by Qualtrics ©. The reference number ID: BD6E6571-2E0E-450B-BB39-CD30F767E590 relates to the contract concluded on 30/11/2022, with regards to a panel of respondents acquisition package. The provider guarantees the processing of personal data is in accordance with the *General Data Protection Regulation* (GDPR), Reg. (EU) n. 2016/679.

Participants gave informed consent via the statement "I am aware that my responses are confidential and I agree to participate in this survey" where an affirmative reply was required to enter the survey. They were able to withdraw from the survey at any time without giving a reason.

The study was explained to consumers previous to the questionnaire. They were informed that all data will be anonymously recorded and only reported in the aggregate. All participants acknowledged an informed consent statement in order to participate in the study.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2024.100336.

References

Ali, M.S., Kang, G.-H., Yang, H.-S., Jeong, J.-Y., Hwang, Y.-H., Park, G.-B., Joo, S.-T., 2007. A comparison of meat characteristics between duck and chicken breast. Asian-Australas J. Anim. Sci. 20, 1002–1006.

Alonso, M.E., González-Montaña, J.R., Lomillos, J.M., 2020. Consumers' concerns and perceptions of farm animal welfare. Animals 10, 385. https://doi.org/10.3390/ani10030385.

Altmann, B.A., Anders, S., Risius, A., Mörlein, D., 2022. Information effects on consumer preferences for alternative animal feedstuffs. Food Policy 106, 102192. https://doi.org/10.1016/j.foodpol.2021.102192.

Ankamah-Yeboah, I., Jacobsen, J.B., Olsen, S.B., Nielsen, M., Nielsen, R., 2019. The impact of animal welfare and environmental information on the choice of organic fish: an empirical investigation of German trout consumers. Marine Resour. Econ. 34, 247–266. https://doi.org/10.1086/705235.

Aryal, G., Mann, J., Loveridge, S., Joshi, S., 2018. Exploring innovation creation across rural and urban firms: analysis of the national survey of business competitiveness. J. Entrep. Public Policy 7, 357–376. https://doi.org/10.1108/JEPP-D-18-00026.

Asioli, D., Grasso, S., 2021. Do consumers value food products containing upcycled ingredients? The effect of nutritional and environmental information. Food Qual. Prefer. 91, 104194 https://doi.org/10.1016/j.foodqual.2021.104194.

Asioli, D., Zhou, X., Halmemies-Beauchet-Filleau, A., Vanhatalo, A., Givens, D.I., Rondoni, A., Turpeinen, A.M., 2023. Consumers' valuation for low - carbon emission and low – saturated fat butter. Food Qual. Prefer. 108, 104859 https://doi.org/10.1016/j.foodqual.2023.104859.

Attitudes of Europeans towards animal welfare - ottobre Attitudes of Europeans towards animal welfare - ottobre2023 - - Eurobarometer survey [WWW Document], 2023. URL https://europa.eu/eurobarometer/surveys/detail/2996 (accessed 11.6.23).

Baldi, L., Mancuso, T., Peri, M., Gasco, L., Trentinaglia, M.T., 2021. Consumer attitude and acceptance toward fish fed with insects: a focus on the new generations. J. Insect Food Feed 1–16. https://doi.org/10.3920/JIFF2021.0109.

Bates, Z.-L., Mesler, R.M., Chernishenko, J., MacInnis, C., 2023. Open to experiencing… meat alternatives? The HEXACO personality model and willingness to try, buy, and pay among omnivores. Food Qual. Prefer. 107, 104830 https://doi.org/10.1016/j.foodqual.2023.104830.

Bawden, D., Robinson, L., 2020. Information Overload: An Overview. Oxford University Press, Oxford. https://doi.org/10.1093/acrefore/9780190228637.013.1360.

Bazoche, P., Poret, S., 2021. Acceptability of insects in animal feed: a survey of French consumers. J. Consum. Behav. 20, 251–270. https://doi.org/10.1002/cb.1845.

Bellezza Oddon, S., Biasato, I., Imarisio, A., Pipan, M., Dekleva, D., Colombino, E., Capucchio, M.T., Meneguz, M., Stefania, B., Barbero, R., Gariglio, M., Dabbou, S., Fiorilla, E., Gasco, L., Schiavone, A., 2021. Black soldier fly and yellow mealworm live larvae for broiler chickens: effects on bird performance and health status. J. Anim. Physiol. Anim. Nutr. Jpn. 13567 https://doi.org/10.1111/jpn.13567.

Biasato, I., Bellezza Oddon, S., Chemello, G., Gariglio, M., Fiorilla, E., Dabbou, S., Pipan, M., Dekleva, D., Macchi, E., Gasco, L., Schiavone, A., 2022. Welfare implications for broiler chickens reared in an insect larvae-enriched environment: focus on bird behaviour, plumage status, leg health, and excreta corticosterone. Front. Physiol. 13, 930158 https://doi.org/10.3389/fphys.2022.930158.

Bogliacino, F., Charris, R., Codagnone, C., Folkvord, F., Gaskell, G., Gómez, C., Liva, G., Montealegre, F., 2023. Less is more: information overload in the labelling of fish and aquaculture products. Food Policy 116, 102435. https://doi.org/10.1016/j.foodpol.2023.102435.

Bongiorno, V., Gariglio, M., Zambotto, V., Cappone, E.E., Biasato, I., Renna, M., Forte, C., Coudron, C., Bergagna, S., Gai, F., Schiavone, A., 2022. Black soldier fly larvae used for environmental enrichment purposes: can they affect the growth, slaughter performance, and blood chemistry of medium-growing chickens? Front. Vet. Sci. 9.

Bosch, G., van Zanten, H.H.E., Zamprogna, A., Veenenbos, M., Meijer, N.P., van der Fels-Klerx, H.J., van Loon, J.J.A., 2019. Conversion of organic resources by black soldier fly larvae: legislation, efficiency and environmental impact. J. Clean. Prod. 222, 355–363. https://doi.org/10.1016/j.jclepro.2019.02.270.

Bunker, I., Zscheischler, J., 2023. Societal acceptability of insect-based livestock feed: a qualitative study from Europe. J. Agric. Environ. Ethics 36, 23. https://doi.org/10.1007/s10806-023-09917-7.

Caparros Megido, R., Gierts, C., Blecker, C., Brostaux, Y., Haubruge, É., Alabi, T., Francis, F., 2016. Consumer acceptance of insect-based alternative meat products in Western countries. Food Qual. Prefer. 52, 237–243. https://doi.org/10.1016/j.foodqual.2016.05.004.

Cerroni, S., Derbyshire, D., Hutchinson, W.G., Nayga, R.M., 2022. A choice matching approach for discrete choice analysis: an experimental investigation in the lab. Land. Econ. https://doi.org/10.3368/le.012621-0009R1.

Chia, S.Y., Macharia, J., Diiro, G.M., Kassie, M., Ekesi, S., van Loon, J.J.A., Dicke, M., Tanga, C.M., 2020. Smallholder farmers' knowledge and willingness to pay for insect-based feeds in Kenya. PLoS One 15, e0230552. https://doi.org/10.1371/journal.pone.0230552.

Clayton, S., Karazsia, B.T., 2020. Development and validation of a measure of climate change anxiety. J. Environ. Psychol. 69, 101434 https://doi.org/10.1016/j.jenvp.2020.101434.
Climate Change - Luglio Climate change - Luglio 2023 - - Eurobarometer survey [WWW Document], 2023 URL https://europa.eu/eurobarometer/surveys/detail/2954 (accessed 11.6.23).
Colombino, E., Biasato, I., Ferrocino, I., Bellezza Oddon, S., Caimi, C., Gariglio, M., Dabbou, S., Caramori, M., Battisti, E., Zanet, S., Ferroglio, E., Cocolin, L., Gasco, L., Schiavone, A., Capucchio, M.T., 2021. Effect of insect live larvae as environmental enrichment on poultry gut health: gut mucin composition, microbiota and local immune response evaluation. Animals 11, 2819. https://doi.org/10.3390/ani11102819.
Commission Regulation (EC) No 1169/2009 Commission Regulation (EC) No 1169/2009 of 30 November 2009 amending Regulation (EC) No 353/2008 establishing implementing rules for applications for authorisation of health claims as provided for in Article 15 of Regulation (EC) No 1924/2006 of the European Parliament and of the Council (Text with EEA relevance), 2009., OJ L.
Commission Regulation (EU) 2021/1372 Commission Regulation (EU) 2021/1372 of 17 August 2021 amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals (Text with EEA relevance), 2021., OJ L.
Cullere, M., Schiavone, A., Dabbou, S., Gasco, L., Dalle Zotte, A., 2019. Meat quality and sensory traits of finisher broiler chickens fed with black soldier fly (Hermetia Illucens L.) larvae fat as alternative fat source. Animals 9, 140. https://doi.org/10.3390/ani9040140.
Dabbou, S., Gai, F., Biasato, I., Capucchio, M.T., Biasibetti, E., Dezzutto, D., Meneguz, M., Plachà, I., Gasco, L., Schiavone, A., 2018. Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on growth performance, blood traits, gut morphology and histological features. J. Animal Sci. Biotechnol. 9, 49. https://doi.org/10.1186/s40104-018-0266-9.
Dalgaard, R., Halberg, N., Hermansen, J.E., 2007. Danish Pork Production: An Environmental Assessment.
De Marchi, E., Scappaticci, G., Banterle, A., Alamprese, C., 2024. What is the role of environmental sustainability knowledge in food choices? A case study on egg consumers in Italy. J. Clean. Prod. 441, 141038 https://doi.org/10.1016/j.jclepro.2024.141038.
De Valck, J., Rolfe, J., Star, M., Rajapaksa, D., Burton, M., 2023. Who cares about meat carbon footprint? Exploring preferences for credence factors among Australian consumers. J. Clean. Prod. 418, 138157 https://doi.org/10.1016/j.jclepro.2023.138157.
Denver, S., Christensen, T., Lund, T.B., Olsen, J.V., Sandøe, P., 2023. Willingness-to-pay for reduced carbon footprint and other sustainability concerns relating to pork production – A comparison of consumers in China, Denmark, Germany and the UK. Livest. Sci. 276, 105337 https://doi.org/10.1016/j.livsci.2023.105337.
Domingues, C.H., de, F., Borges, J.A.R., Ruviaro, C.F., Guidolin, D.G.F., Carrijo, J.R.M., 2020. Understanding the factors influencing consumer willingness to accept the use of insects to feed poultry, cattle, pigs and fish in Brazil. PLoS One 15, e0224059. https://doi.org/10.1371/journal.pone.0224059.
Dörper, A., Veldkamp, T., Dicke, M., 2021. Use of black soldier fly and house fly in feed to promote sustainable poultry production. J. Insects Food Feed 7, 761–780. https://doi.org/10.3920/JIFF2020.0064.
Dreoni, I., Matthews, Z., Schaafsma, M., 2022. The impacts of soy production on multi-dimensional well-being and ecosystem services: a systematic review. J. Clean. Prod. 335, 130182 https://doi.org/10.1016/j.jclepro.2021.130182.
Eckel, C.C., Grossman, P.J., 2008. Chapter 113 Men, women and risk aversion: experimental evidence. In: Plott, C.R., Smith, V.L. (Eds.), Handbook of Experimental Economics Results. Elsevier, pp. 1061–1073. https://doi.org/10.1016/S1574-0722(07)00113-8.
Egolf, A., Siegrist, M., Hartmann, C., 2018. How people's food disgust sensitivity shapes their eating and food behaviour. Appetite 127, 28–36. https://doi.org/10.1016/j.appet.2018.04.014.
Endrizzi, I., Cliceri, D., Menghi, L., Aprea, E., Gasperi, F., 2021. Does the 'mountain pasture product' claim affect local cheese acceptability? Foods 10, 682. https://doi.org/10.3390/foods10030682.
Farrell, D., 2013. The Role of Poultry in Human Nutrition, 2–9. Poultry Development Review. Rome: Food and Agriculture Organization.
Fraanje, W., Garnett, T., 2020. Soy: Food, Feed, and Land Use Change. Foodsource: Building Blocks). Food Climate Research Network. University of Oxford.
Galizzi, M.M., 2014. What is really behavioral in behavioral health policy? And does it work? Appl. Econ. Perspect. Policy 36, 25–60. https://doi.org/10.1093/aepp/ppt036.
Galizzi, M.M., 2012. Label, nudge or tax? A review of health policies for risky behaviours. J. Public Health Res. 1 https://doi.org/10.4081/jphr.2012.e5 jphr.2012.e5.
Giotis, T., Drichoutis, A.C., 2021. Consumer acceptance and willingness to pay for direct and indirect entomophagy. Q. Open. 1, qoab015. https://doi.org/10.1093/qopen/qoab015.
Godfray, H.C.J., Aveyard, P., Garnett, T., Hall, J.W., Key, T.J., Lorimer, J., Pierrehumbert, R.T., Scarborough, P., Springmann, M., Jebb, S.A., 2018. Meat consumption, health, and the environment. Science 361, eaam5324. https://doi.org/10.1126/science.aam5324.
Gracia, A., Barreiro-Hurlé, J., 2019. Making sense of information overload: consumer ranking of nutritional claims in cereal based products. Nutrients 11, 2858. https://doi.org/10.3390/nu11122858.
Gross, S., Waldrop, M.E., Roosen, J., 2021. How does animal welfare taste? Combining sensory and choice experiments to evaluate willingness to pay for animal welfare pork. Food Qual. Prefer. 87, 104055 https://doi.org/10.1016/j.foodqual.2020.104055.
Hagmann, D., Siegrist, M., Hartmann, C., 2018. Taxes, labels, or nudges? Public acceptance of various interventions designed to reduce sugar intake. Food Policy 79, 156–165. https://doi.org/10.1016/j.foodpol.2018.06.008.
Hardy, R.W., Tacon, A.G.J., 2002. Fish meal: historical uses, production trends and future outlook for sustainable supplies. Responsible Marine Aquaculture, pp. 311–325.
Hartmann, C., Siegrist, M., 2016. Becoming an insectivore: results of an experiment. Food Qual. Prefer. 51, 118–122. https://doi.org/10.1016/j.foodqual.2016.03.003.
Hasan, M.R., Halwart, M., 2009. Fish as Feed Inputs for Aquaculture: Practices, Sustainability and Implications, FAO Fisheries and Aquaculture Technical Paper. FAO, Rome.
Heinola, K., Latvala, T., Niemi, J.K., 2023. Consumer trust and willingness to pay for establishing a market-based animal welfare assurance scheme for broiler chickens. Poult. Sci. 102, 102765 https://doi.org/10.1016/j.psj.2023.102765.
Henchion, M., Hayes, M., Mullen, A.M., Fenelon, M., Tiwari, B., 2017. Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. Foods 6, 53. https://doi.org/10.3390/foods6070053.
Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M.C., Thornton, P.K., Blümmel, M., Weiss, F., Grace, D., Obersteiner, M., 2013. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proc. Natl. Acad. Sci. 110, 20888–20893. https://doi.org/10.1073/pnas.1308149110.
Herrero, M., Thornton, P.K., Mason-D'Croz, D., Palmer, J., Benton, T.G., Bodirsky, B.L., Bogard, J.R., Hall, A., Lee, B., Nyborg, K., Pradhan, P., Bonnett, G.D., Bryan, B.A., Campbell, B.M., Christensen, S., Clark, M., Cook, M.T., de Boer, I.J.M., Downs, C., Dizyee, K., Folberth, C., Godde, C.M., Gerber, J.S., Grundy, M., Havlik, P., Jarvis, A., King, R., Loboguerrero, A.M., Lopes, M.A., McIntyre, C.L., Naylor, R., Navarro, J., Obersteiner, M., Parodi, A., Peoples, M.B., Pikaar, I., Popp, A., Rockström, J., Robertson, M.J., Smith, P., Stehfest, E., Swain, S.M., Valin, H., van Wijk, M., van Zanten, H.H.E., Vermeulen, S., Vervoort, J., West, P.C., 2020. Innovation can accelerate the transition towards a sustainable food system. Nat. Food 1, 266–272. https://doi.org/10.1038/s43016-020-0074-1.
House, J., 2016. Consumer acceptance of insect-based foods in the Netherlands: academic and commercial implications. Appetite 107, 47–58. https://doi.org/10.1016/j.appet.2016.07.023.
Ipema, A.F., Bokkers, E.A.M., Gerrits, W.J.J., Kemp, B., Bolhuis, J.E., 2020. Long-term access to live black soldier fly larvae (Hermetia illucens) stimulates activity and reduces fearfulness of broilers, without affecting health. Sci. Rep. 10, 17428. https://doi.org/10.1038/s41598-020-74514-x.
Jianakoplos, N.A., Bernasek, A., 1998. Are women more risk averse? Econ. Inq. 36, 620–630. https://doi.org/10.1111/j.1465-7295.1998.tb01740.x.
Kallas, Z., Vitale, M., Gil, J.M., 2019. Health innovation in patty products. The role of food Neophobia in Consumers' Non-hypothetical willingness to pay, Purchase Ìntention and Hedonic Evaluation. Nutrients. https://doi.org/10.3390/nu11020444.
Kröger, T., Dupont, J., Büsing, L., Fiebelkorn, F., 2022. Acceptance of insect-based food products in Western Societies: a systematic review. Front. Nutr. 8.
Kuepper, B., Stravens, M., 2022. Mapping the European Soy Supply Chain. Profundo, Commissioned by WWF European Policy Office, Amsterdam, The Netherlands.
La Barbera, F., Amato, M., Fasanelli, R., Verneau, F, 2021. Perceived risk of insect-based foods: an assessment of the entomophagy attitude questionnaire predictive validity. Insects 12, 403. https://doi.org/10.3390/insects12050403.
La Barbera, F., Amato, M., Sannino, G., 2016. Understanding consumers' intention and behaviour towards functionalised food: The role of knowledge and food technology neophobia. British Food Journal 118, 885–895. https://doi.org/10.1108/BFJ-10-2015-0354.
La Barbera, F., Verneau, F., Videbæk, P.N., Amato, M., Grunert, K.G, 2020. A self-report measure of attitudes toward the eating of insects: construction and validation of the entomophagy attitude questionnaire. Food Qual. Prefer. 79, 103757 https://doi.org/10.1016/j.foodqual.2019.103757.
Lau, H.P.B., White, M.P., Schnall, S., 2013. Quantifying the value of emotions using a willingness to pay approach. J. Happiness. Stud. 14, 1543–1561. https://doi.org/10.1007/s10902-012-9394-7.
Laureati, M., Proserpio, C., Jucker, C., Savoldelli, S., 2016. New sustainable protein sources: consumers'willingness to adopt insects as feed and food. Italian J. Food Sci. 28.
Laureti, T., Benedetti, I., 2018. Exploring pro-environmental food purchasing behaviour: an empirical analysis of Italian consumers. J. Clean. Prod. 172, 3367–3378. https://doi.org/10.1016/j.jclepro.2017.11.086.
Lindgren, E., Harris, F., Dangour, A.D., Gasparatos, A., Hiramatsu, M., Javadi, F., Loken, B., Murakami, T., Scheelbeek, P., Haines, A., 2018. Sustainable food systems—a health perspective. Sustain. Sci. 13, 1505–1517. https://doi.org/10.1007/s11625-018-0586-x.
Lombardi, A., Vecchio, R., Borrello, M., Caracciolo, F., Cembalo, L., 2019. Willingness to pay for insect-based food: the role of information and carrier. Food Qual. Prefer. 72, 177–187. https://doi.org/10.1016/j.foodqual.2018.10.001.
Luan, C.-C., Phan, T.A., 2023. The effect of emotion type and similarity of experience on consumers' willingness to pay for cause-related products: construal level perspective. J. Consum. Behav. https://doi.org/10.1002/cb.2245.
Macdiarmid, J.I., Cerroni, S., Kalentakis, D., Reynolds, C., 2021. How important is healthiness, carbon footprint and meat content when purchasing a ready meal? Evidence from a non-hypothetical discrete choice experiment. J. Clean. Prod. 282, 124510 https://doi.org/10.1016/j.jclepro.2020.124510.

Mancini, M.C., Antonioli, F., 2019. Exploring consumers' attitude towards cultured meat in Italy. Meat. Sci. 150, 101–110. https://doi.org/10.1016/j.meatsci.2018.12.014.
Mancini, S., Sogari, G., Menozzi, D., Nuvoloni, R., Torracca, B., Moruzzo, R., Paci, G., 2019. Factors predicting the intention of eating an insect-based product. Foods 8, 270. https://doi.org/10.3390/foods8070270.
Menozzi, D., Sogari, G., Mora, C., Gariglio, M., Gasco, L., Schiavone, A., 2021. Insects as feed for farmed poultry: are Italian consumers ready to embrace this innovation? Insects 12, 435. https://doi.org/10.3390/insects12050435.
Menozzi, D., Sogari, G., Veneziani, M., Simoni, E., Mora, C., 2017. Eating novel foods: an application of the Theory of Planned Behaviour to predict the consumption of an insect-based product. Food Qual. Prefer. 59, 27–34. https://doi.org/10.1016/j.foodqual.2017.02.001.
Michel, P., Begho, T., 2023. Paying for sustainable food choices: the role of environmental considerations in consumer valuation of insect-based foods. Food Qual. Prefer. 106, 104816 https://doi.org/10.1016/j.foodqual.2023.104816.
Miranda-de la Lama, G.C., Estévez-Moreno, L.X., Sepúlveda, W.S., Estrada-Chavero, M. C., Rayas-Amor, A.A., Villarroel, M., María, G.A., 2017. Mexican consumers' perceptions and attitudes towards farm animal welfare and willingness to pay for welfare friendly meat products. Meat. Sci. 125, 106–113. https://doi.org/10.1016/j.meatsci.2016.12.001.
Mohd Suki, N, 2013. Young consumer ecological behaviour: the effects of environmental knowledge, healthy food, and healthy way of life with the moderation of gender and age. Manag. Environ. Qual.: Int. J. 24, 726–737. https://doi.org/10.1108/MEQ-02-2013-0010.
Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C., Gerber, P., 2017. Livestock: on our plates or eating at our table? A new analysis of the feed/food debate. Glob. Food Secur. 14, 1–8. https://doi.org/10.1016/j.gfs.2017.01.001. Food Security Governance in Latin America.
Mottet, A., Tempio, G., 2017. Global poultry production: current state and future outlook and challenges. World's Poultry Sci. J. 73, 245–256. https://doi.org/10.1017/S0043933917000071.
Mylan, J., Andrews, J., Maye, D., 2023. The big business of sustainable food production and consumption: exploring the transition to alternative proteins. Proc. Natl. Acad. Sci. 120, e2207782120 https://doi.org/10.1073/pnas.2207782120.
Naranjo-Guevara, N., Fanter, M., Conconi, A.M., Floto-Stammen, S., 2021. Consumer acceptance among Dutch and German students of insects in feed and food. Food Sci. Nutr. 9, 414–428. https://doi.org/10.1002/fsn3.2006.
Nazzaro, C., Lerro, M., Stanco, M., Marotta, G., 2019. Do consumers like food product innovation? An analysis of willingness to pay for innovative food attributes. Br. Food J. 121, 1413–1427. https://doi.org/10.1108/BFJ-06-2018-0389.
News detail | UN Food Systems Coordination Hub [WWW Document], (2023) . UNFoodSystems. URL https://www.unfoodsystemshub.org/latest-updates/news/detail/science–technology-and-innovation-approaches-in-paving-the-way-forward-for-food-systems-transformation/en (accessed 8.30.23).
Nocella, G., Wu, J., Cerroni, S., 2023. The use of smart biosensors during a food safety incident: consumers' cognitive-behavioural responses and willingness to pay. Int. J. Consum. Stud. 47, 249–266. https://doi.org/10.1111/ijcs.12833.
Olsen, R.L., Hasan, M.R., 2012. A limited supply of fishmeal: impact on future increases in global aquaculture production. Trends Food Sci. Technol. 27, 120–128. https://doi.org/10.1016/j.tifs.2012.06.003.
Oonincx, D.G.A.B., Boer, I.J.M.de, 2012. Environmental impact of the production of mealworms as a protein source for humans – a life cycle assessment. PLoS One 7, e51145. https://doi.org/10.1371/journal.pone.0051145.
Palmieri, N., Stefanoni, W., Latterini, F., Pari, L., 2022. Factors influencing italian consumers' willingness to pay for eggs enriched with omega-3-fatty acids. Foods 11, 545. https://doi.org/10.3390/foods11040545.
Palmieri, N., Stefanoni, W., Latterini, F., Pari, L., 2021. An Italian explorative study of willingness to pay for a new functional pasta featuring Opuntia ficus indica. Agriculture 11, 701. https://doi.org/10.3390/agriculture11080701.
Parodi, A., Leip, A., De Boer, I.J.M., Slegers, P.M., Ziegler, F., Temme, E.H.M., Herrero, M., Tuomisto, H., Valin, H., Van Middelaar, C.E., Van Loon, J.J.A., Van Zanten, H.H.E., 2018. The potential of future foods for sustainable and healthy diets. Nat. Sustain. 1, 782–789. https://doi.org/10.1038/s41893-018-0189-7.
Pikaar, I., de Vrieze, J., Rabaey, K., Herrero, M., Smith, P., Verstraete, W., 2018a. Carbon emission avoidance and capture by producing in-reactor microbial biomass based food, feed and slow release fertilizer: potentials and limitations. Sci. Total Environ. 644, 1525–1530. https://doi.org/10.1016/j.scitotenv.2018.07.089.
Pikaar, I., Matassa, S., Bodirsky, B.L., Weindl, I., Humpenöder, F., Rabaey, K., Boon, N., Bruschi, M., Yuan, Z., van Zanten, H., Herrero, M., Verstraete, W., Popp, A., 2018b. Decoupling livestock from land use through industrial feed production pathways. Environ. Sci. Technol. 52, 7351–7359. https://doi.org/10.1021/acs.est.8b00216.
Pink, A.E., Stylianou, K.S., Ling Lee, L., Jolliet, O., Cheon, B.K., 2022. The effects of presenting health and environmental impacts of food on consumption intentions. Food Qual. Prefer. 98, 104501 https://doi.org/10.1016/j.foodqual.2021.104501.
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.
Prause, L., Hackfort, S., Lindgren, M., 2021. Digitalization and the third food regime. Agric. Hum. Values 38, 641–655. https://doi.org/10.1007/s10460-020-10161-2.
Predieri, S., Cianciabella, M., Daniele, G.M., Gatti, E., Lippi, N., Magli, M., Medoro, C., Rossi, F., Chieco, C., 2023. Italian consumers' awareness of climate change and willingness to pay for climate-smart food products. Sustainability 15, 4507. https://doi.org/10.3390/su15054507.
Press Release, 2022, Press release of April 13th, 2022 from the Ministry of Economy and Finance.
Realini, C.E., Driver, T., Zhang, R., Guenther, M., Duff, S., Craigie, C.R., Saunders, C., Farouk, M.M., 2023. Survey of New Zealand consumer attitudes to consumption of meat and meat alternatives. Meat. Sci. 203, 109232 https://doi.org/10.1016/j.meatsci.2023.109232.
Ribeiro, J.C., Gonçalves, A.T.S., Moura, A.P., Varela, P., Cunha, L.M., 2022. Insects as food and feed in Portugal and Norway – cross-cultural comparison of determinants of acceptance. Food Qual. Prefer. 102, 104650 https://doi.org/10.1016/j.foodqual.2022.104650.
Roccatello, R., Endrizzi, I., Aprea, E., Dabbou, S., 2024. Insect-based feed in aquaculture: a consumer attitudes study. Aquaculture 582, 740512. https://doi.org/10.1016/j.aquaculture.2023.740512.
Roma, R., Ottomano Palmisano, G., De Boni, A., 2020. Insects as novel food: a consumer attitude analysis through the dominance-based rough set approach. Foods 9, 387. https://doi.org/10.3390/foods9040387.
Salomone, R., Saija, G., Mondello, G., Giannetto, A., Fasulo, S., Savastano, D., 2017. Environmental impact of food waste bioconversion by insects: application of life cycle assessment to process using Hermetia illucens. J. Clean. Prod. 140, 890–905. https://doi.org/10.1016/j.jclepro.2016.06.154.
Schiavone, A., Dabbou, S., Petracci, M., Zampiga, M., Sirri, F., Biasato, I., Gai, F., Gasco, L., 2019. Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on carcass traits, breast meat quality and safety. Animal 13, 2397–2405. https://doi.org/10.1017/S1751731119000685.
Sellars, M.J., Rao, M., Polymeris, N., Irvin, S.J., Cowley, J.A., Preston, N.P., Glencross, B. D., 2015. Feed containing novacq improves resilience of black tiger shrimp, Penaeus monodon, to gill-associated virus-induced mortality. J. World Aquac. Soc. 46, 328–336. https://doi.org/10.1111/jwas.12190.
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.
Simon, C.J., Blyth, D., Ahmad Fatan, N., Suri, S., 2019. Microbial biomass (Novacq™) stimulates feeding and improves the growth performance on extruded low to zero-fishmeal diets in tilapia (GIFT strain). Aquaculture 501, 319–324. https://doi.org/10.1016/j.aquaculture.2018.11.052.
Smetana, S., Mathys, A., Knoch, A., Heinz, V., 2015. Meat alternatives: life cycle assessment of most known meat substitutes. Int. J. Life Cycle Assess. 20, 1254–1267. https://doi.org/10.1007/s11367-015-0931-6.
Smetana, S., Palanisamy, M., Mathys, A., Heinz, V., 2016. Sustainability of insect use for feed and food: life cycle assessment perspective. J. Clean. Prod. 137, 741–751. https://doi.org/10.1016/j.jclepro.2016.07.148.
Smetana, S., Spykman, R., Heinz, V., 2021. Environmental aspects of insect mass production. J. Insects Food Feed 7, 553–571. https://doi.org/10.3920/JIFF2020.0116.
Sogari, G., Menozzi, D., Mora, C., 2019. The food neophobia scale and young adults' intention to eat insect products. Int. J. Consum. Stud. 43, 68–76. https://doi.org/10.1111/ijcs.12485.
Sogari, G., Menozzi, D., Mora, C., Gariglio, M., Gasco, L., Schiavone, A., 2022. How information affects consumers' purchase intention and willingness to pay for poultry farmed with insect-based meal and live insects. J. Insects Food Feed 8, 197–206. https://doi.org/10.3920/JIFF2021.0034.
Song, X.-P., Hansen, M.C., Potapov, P., Adusei, B., Pickering, J., Adami, M., Lima, A., Zalles, V., Stehman, S.V., Di Bella, C.M., Conde, M.C., Copati, E.J., Fernandes, L.B., Hernandez-Serna, A., Jantz, S.M., Pickens, A.H., Turubanova, S., Tyukavina, A., 2021. Massive soybean expansion in South America since 2000 and implications for conservation. Nat. Sustain. 4, 784–792. https://doi.org/10.1038/s41893-021-00729-z.
Spartano, S., Grasso, S., 2021. UK consumers' willingness to try and pay for eggs from insect-fed hens. Future Foods 3, 100026. https://doi.org/10.1016/j.fufo.2021.100026.
Sweeney, S., Regan, Á., McKernan, C., Benson, T., Hanlon, A., Dean, M., 2022. Current consumer perceptions of animal welfare across different farming sectors on the Island of Ireland. Animals 12, 185. https://doi.org/10.3390/ani12020185.
Szendrő, K., Nagy, M.Z., Tóth, K., 2020. Consumer Acceptance of meat from animals reared on insect meal as feed. Animals 10, 1312. https://doi.org/10.3390/ani10081312.
Tan, H.S.G., House, J., 2018. Consumer acceptance of insects as food: integrating psychological and socio-cultural perspectives. In: Halloran, A., Flore, R., Vantomme, P., Roos, N. (Eds.), Edible Insects in Sustainable Food Systems. Springer International Publishing, Cham, pp. 375–386. https://doi.org/10.1007/978-3-319-74011-9_23.
Towards sustainable food consumption – SAPEA, 2023 URL https://sapea.info/topic/food-consumption/ (accessed 11.6.23).
United Nations (2023). The Food Systems Summit- A New Deal for People, Planet and Prosperity [WWW Document]. United Nations. URL https://www.un.org/en/food-systems-summit/news/food-systems-summit-new-deal-people-planet-and-prosperity (accessed 8.30.23).
United Nations Department For Economic And Social Affairs, 2023. World population prospects 2022: summary of results. United Nations, S.l.
Ursachi, G., Horodnic, I.A., Zait, A., 2015a. How reliable are measurement scales? External factors with indirect influence on reliability estimators. Proc. Econ. Finance 20, 679–686. https://doi.org/10.1016/S2212-5671(15)00123-9. Globalization and Higher Education in Economics and Business Administration - GEBA 2013.
Ursachi, G., Horodnic, I.A., Zait, A., 2015b. How reliable are measurement scales? External factors with indirect influence on reliability estimators. Proc. Econ. Finance 20, 679–686. https://doi.org/10.1016/S2212-5671(15)00123-9.
Van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., Vantomme, P., 2013. Edible Insects: Future Prospects for Food and Feed Security. Food and Agriculture Organization of the United Nations.

Van Loo, E.J., Caputo, V., Nayga, R.M., Verbeke, W., 2014. Consumers' valuation of sustainability labels on meat. Food Policy 49, 137–150. https://doi.org/10.1016/j.foodpol.2014.07.002.

van Raamsdonk, L.W.D., van der Fels-Klerx, H.J., de Jong, J., 2017. New feed ingredients: the insect opportunity. Food Addit. Contam.: Part A 34, 1384–1397. https://doi.org/10.1080/19440049.2017.1306883.

Vanderlind, W.M., Everaert, J., Caballero, C., Cohodes, E.M., Gee, D.G., 2021. Emotion and emotion preferences in daily life: the role of anxiety. Clin. Psychol. Sci. 10, 109–126. https://doi.org/10.1177/21677026211009500.

Vauterin, A., Steiner, B., Sillman, J., Kahiluoto, H., 2021. The potential of insect protein to reduce food-based carbon footprints in Europe: the case of broiler meat production. J. Clean. Prod. 320, 128799 https://doi.org/10.1016/j.jclepro.2021.128799.

Verbeke, W., 2015. Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. Food Qual. Prefer. 39, 147–155. https://doi.org/10.1016/j.foodqual.2014.07.008.

Videbæk, P.N., Grunert, K.G., 2020. Disgusting or delicious? Examining attitudinal ambivalence towards entomophagy among Danish consumers. Food Qual. Prefer. 83, 103913 https://doi.org/10.1016/j.foodqual.2020.103913.

Wan, J., Wang, X., Yang, T., Wei, Z., Banerjee, S., Friman, V.-P., Mei, X., Xu, Y., Shen, Q., 2021. Livestock manure type affects microbial community composition and assembly during composting. Front. Microbiol. 12.

Weinrich, R., Busch, G., 2021. Consumer knowledge about protein sources and consumers' openness to feeding micro-algae and insects to pigs and poultry. Future Foods 4, 100100. https://doi.org/10.1016/j.fufo.2021.100100.

Wendin, K.M., Nyberg, M.E., 2021. Factors influencing consumer perception and acceptability of insect-based foods. Curr. Opin. Food Sci. 40, 67–71. https://doi.org/10.1016/j.cofs.2021.01.007.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A., Vries, W.D., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L., 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 393, 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4.

Wongprawmas, R., Sogari, G., Gai, F., Parisi, G., Menozzi, D., Mora, C., 2022. How information influences consumers' perception and purchasing intention for farmed and wild fish. Aquaculture 547, 737504. https://doi.org/10.1016/j.aquaculture.2021.737504.

Zamparo, G., Cunico, P., Vianelli, D., Moretti, A., 2022. It is unnatural!–the role of food neophobia and food technology neophobia in shaping consumers' attitudes: a multimethod approach. Br. Food J. 125, 2275–2293. https://doi.org/10.1108/BFJ-02-2022-0099.

Zou, P., Liu, J., 2019. How nutrition information influences online food sales. J. Acad. Mark. Sci. 47, 1132–1150. https://doi.org/10.1007/s11747-019-00668-4.