

## Back to the future: Are consumers ready to eat insect-fed poultry food products from a circular farming system? An assessment for Italy

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### ABSTRACT

The exploitation of natural resources from livestock farming would decrease if conventional protein sources in animal diets were partially replaced with insects through a circular economy approach. However, consumers' acceptance of novel insect-fed (IF) animal products is key to the final success of such products. This study analyses consumers' willingness to buy IF poultry meat and eggs using the results from an online survey of 780 Italian consumers. Overall, our results show a positive attitude of Italian consumers surveyed towards IF animal products. Moreover, we find that food neophobia and entomophobia negatively affect Italian consumers' attitude towards those products, while the trust in the role of public authorities in ensuring food safety positively impacts on it. Also, consumers' propensity towards sustainable food increases the likelihood of buying IF animal products.

### Introduction

Population growth and environmental sustainability are two of the major worldwide challenges that need to be addressed in the next decades. By 2050, the world population is predicted to exceed 9 billions, yet agricultural land can be increased only by a small amount (FAO 2017). 60 % of ecosystem services are currently degraded or not exploited sustainably, and agriculture is the second largest source of greenhouse gas (GHG) emissions, primarily from animal production and synthetic fertilisers (*ibid.*)

Agricultural systems must then undergo a revolutionary process where new ideas and their technological translation enable an increase in the long-term sustainability of food production. This transformative process will help European Union (EU) countries to meet the ambitious challenges of zero net GHG emissions by 2050 posed by the EU Green Deal (EC 2019) and to address the challenges posed by the "From Farm to Fork Strategy" (F2F) of reducing the environmental and climate footprint of EU food, while also acknowledging the interconnectedness of healthy individuals, societies, and the environment (EC 2020). Along this line, environmental and climate objectives have become very important also in the actual (2023–2027) policy framework of the

Common Agricultural Policy (CAP) and they are projected to become among the most important policy goals for the European agricultural sector (Coderoni, 2023; Coderoni et al., 2021).

In this regard, increasing the level of circularity in agricultural systems can play a crucial role, as it refers to optimizing the use of materials, maintaining the value of resources, and minimizing the generation of waste (EC 2015). A more circular agricultural system can help ensuring food production and economic viability, while adopting strategies for coping with climate change, preserving biodiversity, minimising the use of external inputs, ensuring soil fertility, and supplying better management of carbon, nutrients, and water. The new Circular Economy Action Plan (CEAP) is in fact one of the main building blocks of the European Green Deal. This action plan includes initiatives along the entire life cycle of products, from design to manufacturing and consumption, to promote circular economy (CE) processes by ensuring that products, materials, and resources are kept in the economy for as long as possible and wastes are minimized (EU 2020). By encouraging the EU's transition to a regenerative growth model, the CEAP will reduce the pressure on natural resources and on the environment and will also significantly contribute to the achievement of the EU's 2050 climate neutrality target and the zero-pollution ambition (EU 2020).

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In the agri-food sector, the issue of circularity is very relevant as agriculture could be, in principle, a highly circular system (EC 2020). However, in practice the search for higher productivity has made agricultural system less integrated over the years and, thus, less circular (Velasco-Muñoz et al., 2021). In fact, residues deriving from many agricultural productions negatively affect the sustainability of the agri-food industry given the environmental and economic impacts of their disposal (Hamam et al., 2021).

The reuse of these agricultural residues as inputs in other (not only) agri-food processes can significantly reduce waste and improve the sustainability through a CE approach (Coderoni and Perito, 2020; Hamam et al., 2021; Nattassha et al., 2020). One interesting avenue of research is represented by the use of crop residues to grow insects which in turn can be employed as a source of protein in feeding livestock, while the residual biomass can be used as a soil-conditioner thanks to the high content of organic compounds (Lippi et al., 2021). The use of insects as an alternative source of proteins in livestock feeding can improve the sustainability of animal farming through a CE approach in many ways. Firstly, it reuses material that otherwise would be wasted, as insects can be grown on low-value substrates (e.g., organic wastes or crop residues) (Barragan-Fonseca et al., 2018; Liu and Wronski, 2018; Mustapa and Kallas, 2023). The residual biomass can be also decontaminated (e.g., micotoxins) and can be reused in the agri-food sector (Camenzuli et al., 2018). Secondly, it contributes to the current search for alternative protein sources for feeding the animal sector thus reducing the environmental impact of livestock production (Lippi et al., 2021; Menozzi et al., 2021), particularly for monogastrics (Gasco et al., 2019). Thirdly, it can positively affect animal health and welfare (Gasco et al., 2020). Finally, such an approach can reduce the EU dependence on imports, therefore favouring the sustainability and long-term competitiveness of the agri-food sector, which is a highly relevant policy objective nowadays (EC 2022).

Despite the advantages provided by foods obtained from insect-fed (IF) animals in a CE system, consumers' attitude and acceptance towards such novel food products can significantly hinder their market success (Lippi et al., 2021; Menozzi et al., 2021).

In particular, the literature has shown that consumers' acceptance towards such novel foods could be influenced by two aspects not directly linked to the production processes involved, which are food neophobia, namely the fear to try unfamiliar food, and the level of insects' disgust (Lombardi et al., 2019; Spartano and Grasso, 2021). To this respect, several studies have already analyzed consumers' acceptance of edible insects meant as food (Barbera et al., 2018; Onwezen et al., 2019; Palmieri et al., 2019; Roma et al., 2020; Verbeke, 2015), while, only more recently, studies have focused also on consumers' attitude towards products from livestock with an insect-based diet (Barbera et al., 2021; Lippi et al., 2021; Menozzi et al., 2021; Naranjo-Guevara et al., 2021; Sogari et al., 2019; Weinrich and Busch, 2021).

One aspect that is disregarded in the literature is the role of trust in the public authorities in ensuring food safety on the level of acceptance of novel foods. Consumers are, in fact, mostly unable to decide whether novel foods produced by new technologies are associated with possible risks, as they have very limited knowledge of these technologies (Vega-Zamora et al., 2019). To cope with this lack of knowledge, they have to rely on the members of the food supply chain and on public authorities which establish the rules to ensure food safety and perform the controls (Earle and Cvetkovich, 1995; Hobbs and Goddard, 2015). The role of consumers' trust in the food system is even more relevant when foods with credence characteristics like sustainability, are involved, as in the case of IF foods (Macready et al., 2020). Thus, when investigating the acceptance of IF animal products, it could be relevant

to also investigate the role of consumers' trust in public authorities in ensuring food safety, also considering that food neophobia may simply result from the absence of consumers' trust in the food system (Cavaliere and Ventura, 2018).

Against this background, the objective of this study is to analyze the economic viability of a CE system by evaluating Italian consumers' acceptance and intention to purchase IF poultry products (i.e., meat and eggs). The consumer's acceptance is investigated by means of a survey and in relation to economic, socio-demographic, and psychological characteristics as well as the degree of trust in public authorities in ensuring food safety, food neophobia and food purchase behaviour and preferences. In the survey, the respondents are presented with a description of a CE food system that produces the IF animal products consumers are asked about their intention to buy. The analysis sheds light on the consumers' characteristics and attitudes that affect the willingness to buy (WTB) IF poultry products and thus it can potentially inform policy decisions to support a shift in food consumption patterns towards more sustainable solutions.

The rest of the paper proceeds as follows: Section 2 presents the review of the pertinent literature; Section 3 describes the dataset analysed, and the estimation approach; Section 4 shows the results and discussion, and Section 5 concludes.

## Literature review

The use of insects as feedstuff to partially replace protein-related ingredients in the animal diet (e.g., soymeal) has been receiving growing attention. This novel feedstuff can help to foster food productivity while decreasing the negative impact on the environment. However, a crucial point for a novel feedstuff to be effective is the acceptance by the consumer of the final animal product. Literature shows that while Western consumers often reject to try or to buy food containing visible insects, mainly due to disgust (Barbera et al., 2018; Onwezen et al., 2019; Verbeke, 2015), they seem more willing to try IF animal products (Ankamah-Yeboah et al., 2018; Barbera et al., 2021; Naranjo-Guevara et al., 2021; Sogari et al., 2019). Conversely, when the insects are not visible in insect-enriched food, the consumer acceptance is higher (Laureati et al., 2016; Roma et al., 2020; Schösler et al., 2012); this can partially explain the reason why the acceptance towards IF animal products is higher compared to food containing directly insects. Among different IF animal products, fish and chicken seem to have a higher acceptance rate, because insects can be already part of fishes' and birds' diets (Kostecka et al., 2017; Barbera et al., 2021; Sogari et al., 2019). Sogari et al. (Sogari et al., 2023) review the studies concerning the use of insects in feeding fishes, poultry and pigs. Their study focuses on consumer acceptance, on the main barriers and the implications for production as well as on the quality of the final animal products. Another recent systematic review on IF animal products was carried out by Pakseresht et al. (Pakseresht et al., 2023) that underline how risk perception, food neophobia and uncertainty about the safety of the products are the main barriers of consumers' acceptance of those products, while ethical and environmental concerns of the consumers are less relevant. Research also shows that affective factors, such as emotions and feelings, play a role in explaining consumer's intention to buy insect-based products and their role becomes bigger the more the products are perceived as innovative (Onwezen et al., 2019).

As regards the tools to increase consumer acceptance, studies show that providing information on the environmental and nutritional benefits (Bazoche and Poret, 2021; Laureati et al., 2016; Lombardi et al., 2019; Menozzi et al., 2021; Roma et al., 2020), and on the improvement in animal welfare (Szendrő et al., 2020) of using insects as food or feed

are effective.

Among the existing studies on consumer intention to try or buy IF poultry products, Altman et al. (Altmann et al., 2022) investigate consumers' preferences towards chicken breasts from animals fed either with insect meal or with spirulina algae. The study highlights that providing information to the consumers reduces their reluctance towards those products in a more pronounced way for the chicken breasts and for the consumers with higher environmental consciousness. Sogari et al. (Sogari et al., 2022) investigate the intention to buy and the willingness to pay of a group of Italian consumers for farmed ducks fed either with insect-based meal or with live insects. The intention to buy insects-fed duck meat is mainly explained by the attitude towards eating such kind of meat supporting the importance of using psychometric scales to explain consumer behaviour. Other key drivers are identified in consumers' sensitiveness towards environmental issues and towards animal welfare as well as previous experience with entomophagy. The drivers are independent of the product being considered: either ducks fed with live insects or with insects-based meal. The provision of information related to the sustainability and nutritional benefits of a duck diet based on insects reinforces the effect of the previous experience with entomophagy on the intention to buy.

Spartano and Grasso (Spartano and Grasso, 2021) analyse the willingness to try and to pay for eggs from IF hens. They collected data from a sample of UK consumers and found that disgust and food neophobia are the main barriers to trying IF hen eggs. Mustapa and Kallas (Mustapa and Kallas, 2023) investigate Spanish consumers' willingness to consume pork, chicken, eggs, and fish fed with insect proteins as a sustainable feed alternative, especially focusing on the effect of socio-demographic and psychometric characteristics. Their results show that significant differences in willingness to consume IF foods exist across respondents with different sociodemographic characteristics: for instance, people with higher levels of education show higher levels of food neophilia and higher willingness to buy IF foods. Weinrich and Busch (Weinrich and Busch, 2021) assess the consumer knowledge about the protein source in feeding pigs and poultry and the consumer intention to buy pigs and poultry meat from animal fed with insects or with micro-algae. Between 30 % and 41 % of the respondents declared to be willing to buy either IF poultry meat or IF pork or both, while approximately 35 % of the respondents they do not know about their willingness. The intention to buy IF animal products is higher the higher is the positive attitude of the consumer towards the introduction of those products and the higher are the social norms.

Studies on the readiness of Italian consumers to incorporate insects into human or into animal diet reveal that more than half of the consumers are ready to eat IF animal products and approximately one fifth of the respondents declared their willingness to eat food containing insects (Laureati et al., 2016). Roma et al. (Roma et al., 2020) find that 23 % of the respondents are not willing to try insects either as food or as feed for animals. The results of the studies on Italian consumers are in line with the results from other countries confirming that consumers' acceptance is higher in the case of insects used to feed animals or used as not visible food supplements rather than used as visible ingredient in the food. Amato et al. (Amato et al., 2023) found that the type of feed used is not the most important driver of consumer choice towards poultry meat. Lippi et al. (Lippi et al., 2021) investigate the readiness of Italian consumers to eat eggs from IF hens. They identify four classes of consumers and find that two third of the consumers are ready to buy that kind of product. The acceptance increases if the eggs are produced locally. The cluster of consumers not willing to buy IF hen eggs is the one with the highest level of food neophobia. The role of socio-demographic variables in affecting Italian consumer preferences towards insect-based food or feed is sample-dependent. In some studies, it was found that males (Cicatiello et al., 2016; Laureati et al., 2016) young people (Laureati et al., 2016; Lombardi et al., 2019; Mustapa and Kallas, 2023; Roma et al., 2020) and people holding a university degree (Cicatiello et al., 2016; Roma et al., 2020) are more likely to express a positive intention

towards trying insect-based food or animal products.

Some studies carry out non-hypothetical experiments to assess the consumer's intention to try insects as food or IF animal products. Padulo et al. (Padulo et al., 2022) check that a testing experience decreases the aversion towards trying insect-based products, while an informative session without the tasting experience does not generate any effect.

None of the studies investigate the role of the trust in the public authorities in ensuring food safety on the WTB foods containing insects or IF animal products. Thus, this work contributes to the already existing literature on entomophagy in three ways: i) it investigates the role of trust in authorities responsible to ensure food safety; ii) it investigates the WTB in the case of IF animal products coming from a CE approach with the advantages mentioned in section 1; iii) it outlines whether the consumer's characteristics and attitude impact in the same way on the choice of different IF animal products coming from the same type of animal (poultry), i.e., meat and eggs.

## Materials and methods

### Data collection and measures

Data for this analysis are collected from an internet-based survey which was administered to Italian consumers in the period January-March 2022 and distributed online through different social media networks and instant messaging applications. As in previous studies investigating consumer preferences using online survey data (Coderoni and Perito, 2021; Perito et al., 2020; Staffolani et al., 2022), the questionnaire link was distributed through groups and pages with a general target audience to minimize potential sampling biases which may arise in convenience samples.

The questionnaire includes an introductory section informing participants about the focus of the research project that motivates the survey, that is, a CE approach to improve the sustainability of the poultry supply chain using insects grown on agri-food wastes as feed. After being ensured about the anonymity and confidentiality of the collected data according to the EU regulations, all participants to the study had to electronically sign a privacy consent form before starting the survey. Subjects younger than 18 years old are excluded from the survey through a screening question, together with individuals who declare not to consume/buy neither poultry meat nor eggs, leading to a final sample of 780 respondents.<sup>1</sup>

The questionnaire is structured with closed ended questions to collect information on the respondent's socio-demographic characteristics, food purchase behavior, level of trust in the safety of the food system and in its controls, attention to sustainability issues in the food consumption, attitude towards new foods, as well as towards insects. In particular, following previous studies on novel foods (i.e., Coderoni and Perito, 2021; Coderoni and Perito, 2020; Lippi et al., 2021; Menozzi

**Table 1**  
Statements of the food neophobia scale.

S1	<i>I eat almost everything</i>
S2	<i>I am afraid to eat things I have never had before</i>
S3	<i>At dinner parties, I always try new foods</i>
S4	<i>I do not know what is contained in a food, I will not try it</i>
S5	<i>I do not trust new foods</i>
S6	<i>I am constantly sampling new and different foods</i>

<sup>1</sup> We believe this is a very interesting sample size as, in the literature on entomophagy, median sample size is much smaller with 184 observations in general and 200 observations for studies based on Italian data, according to (Palmieri et al., 2019). Even looking at papers published after the study by (Palmieri et al., 2019), to the best of our knowledge, our sample is the largest to date for Italy.

et al., 2021), the potential food neophobic behavior of participants is measured using the six-item FNS selected by Ritchey et al. (Ritchey

*j* (i.e., poultry meat or eggs) is affected by a set of variables as follows:

$$WTB_{ij} = f(FNS_i, ENTHO_i, TRUST_i, PURCH\_PREF_i, SUST\_BELIEF_i, CONS_{ij}, SEC_i | \beta_j) + e_{ij} \quad (1)$$

et al., 2003) from the FNS originally developed by Pliner and Hobden (Pliner and Hobden, 1992) and validated in Italian by Laureati et al. (Laureati et al., 2018). Respondents are asked to indicate their level of agreement/disagreement with three neophilic statements (S1, S3 and S6 of Table 1), and three neophobic statements (S2, S4, S5 of Table 1) about new foods or eating situations using a 5-point Likert scale. All queries were specified as a 5-point Likert scale ranging from “I totally disagree” to “I totally agree”. Following Verbeke (Verbeke, 2015) and Coderoni and Perito (Coderoni and Perito, 2021), all variables included in the empirical analysis other than the FNS are dichotomized to facilitate the interpretation of the empirical results, by giving value one to the response categories “agree” and “totally agree” and zero otherwise.

We also collect information on consumers’ attitude towards insects in general, not referring to an eating context, by asking them to choose among “fear”, “disgust”, “indifference”, “curiosity”, “charm”. We refrain from using the Entomophagy Attitude Questionnaire scale (Barbera et al., 2021) for this purpose because the scale is specifically framed in an eating context, while we wanted to catch a no context-specific inclination.

As the lack of consumers’ trust in the food chain is recognized as a key barrier to the shift towards more sustainable diets, especially when foods with credence characteristics like IF-foods are involved (Macready et al., 2020), we also investigate the level of respondents’ trust in the food system by asking them to rate their level of trust in public authorities in ensuring food safety on a 5-point Likert scale.

Finally, to investigate potential differences in respondents’ beliefs about sustainability issues in the agri-food system, participants were also asked to indicate their level of agreement on a 5-point Likert scale with the following statement: “I believe that changes in current dietary habits may improve environmental conditions and social welfare”.

After receiving some information about the potential environmental advantages of using insects in livestock feed through the aforementioned CE approach,<sup>2</sup> participants are asked about their intention to purchase IF poultry meat and eggs and to motivate their answers. Respondents who declare to be willing to purchase products from the CE system under analysis are also asked to state their willingness to pay for meat and/or eggs from IF animals compared to those raised with traditional feed.

### Data analysis

To investigate consumers’ attitude towards IF poultry products, we posit a simple empirical relation where the *i*th consumer’s WTB product

<sup>2</sup> In details, respondents were provided with the following statement about the advantages of using insects in livestock feed through a CE approach: “Various studies suggest the use of alternative protein sources in animals farming to make such production more sustainable. One of these sources consists in the use of insects. Many species of insects are in fact very nutritious, and their production is more sustainable in terms of water and land consumption compared to protein sources traditionally used in animal feed (e.g., soya). Furthermore, some insects can grow on plant residues that would otherwise be wasted, thus supporting a circular economy in the agri-food sector. Moreover, it is important to note that insects are normally consumed in nature by many animals, such as poultry and chickens, and therefore can be considered as a natural feed. The replacement of part of traditional protein sources with insects in animal feed would guarantee the possibility of producing animal products limiting the exploitation of natural resources.”

Where  $FNS_i$  and  $ENTHO_i$  measure consumer *i* food neophobic and entomophobic behavior (i.e., respondent declares they fear or feel disgust by insects) respectively,  $TRUST_i$  represents individual *i* level of trust in public authorities in ensuring food safety,  $PURCH\_PREF_i$  is a vector of variables related to food purchase preferences of respondent *i* (i.e., attention to price, to labels and certifications, to reduced packaging, to sustainable foods),  $SUST\_BELIEF_i$  includes beliefs related to the influence of a change in dietary habits on supporting a shift towards more sustainable food production,  $CONS_{ij}$  indicates the consumption frequency of product *j*,  $SEC_i$  is a vector of demographic variables for each respondent *i* (i.e., sex, age, income class, education level and geographic area of residence),  $e_{ij}$  is an idiosyncratic error term, while  $\beta$  is a vector of coefficients qualifying the relationship between  $WTB_{ij}$  and the explanatory variables which can be estimated using a logit estimator. According to the logit model formulation, the probability of each respondent *i* making a certain choice ( $y_i \neq 0$ ) given the explanatory variables  $X_i$ ’s can be expressed as follows (Pyndick and Rubinfeld, 1998):

$$P(y_i \neq 0 / X_i) = \frac{\exp(X_i \beta)}{1 + \exp(X_i \beta)} \quad (2)$$

### Results and discussion

The summary statistics and description of the relevant variables included in the analysis are reported in Table 2. A more detailed description of the variables included in the analysis is provided in the Appendix (Table A1).

Focusing on the socio-demographic characteristics of respondents, even though our sample is not representative of the Italian population from a geographical standpoint, given the prevalence of individuals from the North of Italy (76 %), the sex and age distribution of interviewed people overlap in many ways with the official statistics for the Italian population (ISTAT<sup>3</sup>). Moreover, the average respondents’ frequency of consumption of poultry products is in line with the average consumption level for Italian consumers in 2021 (UNINDUSTRIA 2022). However, it is also important to acknowledge that our sample is also characterized by a high proportion of graduate respondents (65 %) compared to the one for the Italian population (21 %) (ISTAT<sup>4</sup>), and a low proportion of individuals who declare to live on a tight budget (7 %). As regards the higher proportion of young and graduated respondents, it is worth mentioning here that the nature of the data source might have affected these results. In fact, the use of web instruments to administer the questionnaire has facilitated reaching a high number of respondents, but it usually generates a biased sample, in which younger people with a higher level of education or web literacy are over-represented (Canavari et al., 2005). Although the sample cannot be regarded as representative of Italian consumers, it still provides some interesting insights into the relationships between the variables under analysis.

<sup>3</sup> Italian Resident population on 1 January: By age group Available at: <http://dati.istat.it/Index.aspx?QueryId=42869> (last accessed: 03/03/23).

<sup>4</sup> Education Levels and Employment Returns - Year 2021 Available at: <https://www.istat.it/it/files/2022/10/Livelli-di-istruzione-e-ritorni-occupazionali-anno-2021.pdf> (last accessed: 03/03/23).



**Table 2**  
Description and summary statistics of selected variables ( $n = 780$ ).

Variable name	Description	Mean	Std. dev.
WTB_meat	1=respondent would be willing to buy IF poultry meat, 0 otherwise.	0.83	0.37
WTB_eggs	1=respondent would be willing to buy IF eggs, 0 otherwise.	0.84	0.37
FNS	food neophobia scale ranging from $-12$ to $+12$	$-2.58$	3.82
Entomophobia	1=respondent declares to fear or feel disgusted by insects, 0 otherwise.	0.39	0.49
Trust	1=respondent trusts the role of public authorities in ensuring food safety, 0 otherwise.	0.65	0.48
Price	1=respondent pays attention to price in food purchase decisions	0.23	0.42
Certifications	1=respondent pays attention to certifications (e.g., organic, sustainable packaging) in food purchase decisions, 0 otherwise.	0.54	0.50
Packaging	1=respondent pays attention to reduced and recyclable packaging in food purchase decisions, 0 otherwise.	0.49	0.50
Sust_belief	1=respondent believes that changes in current dietary habits may improve environmental conditions and social welfare, 0 otherwise.	0.83	0.38
Low_sust	1=respondent buys rarely sustainable foods (e.g., organic, and local foods), 0 otherwise.	0.10	0.30
Meat_often	1=respondent eats poultry meat more than once a week, 0 otherwise.	0.38	0.49
Eggs_often	1=respondent eats eggs more than once a week, 0 otherwise.	0.41	0.49
Male	1=male respondent, 0 otherwise.	0.46	0.50
College_edu	1=college degree or higher, 0 otherwise.	0.65	0.48
Low_income	1=respondent declare to have a low income <sup>a</sup> .	0.07	0.25
Boomer	1=respondent was born between 1946 and 1964, 0 otherwise.	0.23	0.42
Gen X	1=respondent was born between 1965 and 1980, 0 otherwise.	0.29	0.46
Millennials	1=respondent was born between 1981 and 1996, 0 otherwise.	0.31	0.46
Gen Z	1=respondent was born between 1997 and 2004, 0 otherwise.	0.14	0.35
North_West	1=respondent is from Northwest Italy, 0 otherwise.	0.31	0.46
North_East	1=respondent if from Northeast Italy, 0 otherwise.	0.45	0.50
Centre	1=respondent is from Central Italy, 0 otherwise.	0.12	0.33
South_Isles	1=respondent is from South or from the Isles, 0 otherwise.	0.12	0.32

Notes: <sup>a</sup>Three income classes were identified based on the reported level of income adequacy compared to necessary needs and purchases.

As regards the variables of interest here, 83 % and 84 % of respondents declared to be willing to buy IF poultry meat and eggs respectively. This is in line with other studies which show that IF fish and chicken are more accepted compared to other types of animal products (Kostecka et al., 2017; Barbera et al., 2021; Sogari et al., 2019) and that a large share of Italian consumers is ready to buy IF animal products (Laureati et al., 2016; Lippi et al., 2021). The sustainability motivation seems to be the most relevant driver of the WTB. Indeed, around 77% of the respondents who are willing to buy IF poultry meat and eggs would do that as they believe these products are more sustainable than those obtained from animals raised with conventional diets.

About the respondents that would not buy IF foods, more than 70 % of them declared they would not do so as they have never tried these products before, and they would need more information about them. Moreover, about half of them (i.e., 16 % of the total sample) declares to be against the use of insects in food production and they fear IF poultry meat and eggs would taste differently than those obtained from animals raised with conventional diets. Thus, overall, the share of respondents that have a strong sentiment of rejection against these novel foods seems to be quite low, within the sample analysed.

This conclusion is reinforced by the analysis of the FNS values in the sample, which the literature shows to be one of the main obstacles to trying novel food. The total FNS score is computed as the sum of the individual item scores, reversing the scoring of neophilic statements, so that the total FNS score for each respondent ranges from  $-12$  (neophilic behavior) to  $12$  (neophobic behavior). In the sample, the average FNS score is negative ( $-2.58$ ) indicating that the interviewed people are quite open to novel foods. In line with previous studies investigating Italian consumers' attitude towards novel foods from upcycled ingredients (e.g., Coderoni and Perito, 2021; Coderoni and Perito, 2020), the original values of the FNS items scores reported in Fig. 1 confirm on the one hand a high propensity of Italian consumers surveyed to sample new foods (3.34), and on the other hand, a strong attention to food composition (3.12). 54 % of the respondents declare to pay attention to product certifications in their food purchase decisions, while only 23 % of them declare that price plays a crucial role in food choices. An interesting group of "sustainable consumers" seem to emerge as most respondents (83 %) believes that changes in current dietary habits may improve environmental conditions and community welfare, and almost half of respondents (49 %) pays attention to aspects related to

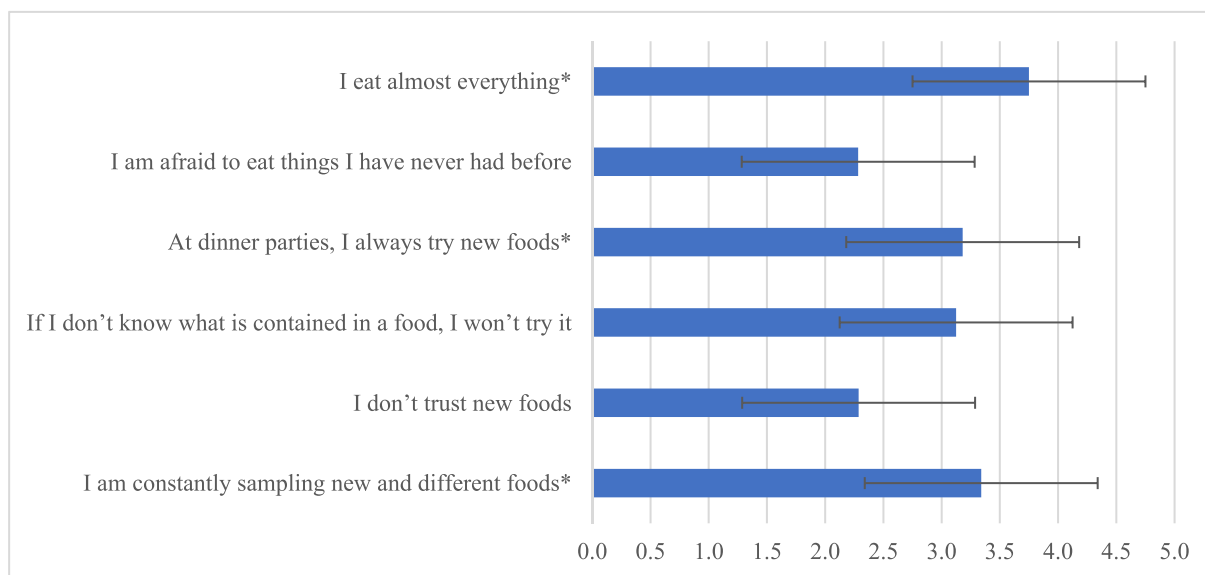
sustainability in their food choices, such as reduced and recyclable packaging of food products.

Table 3 reports the estimated marginal effects from the two separate logistic regression investigating consumers' WTB poultry meat (*WTB\_meat*) and eggs (*WTB\_eggs*) from IF animals, while the estimated coefficients for the two logistic regressions are reported in Appendix 1 (Table A2).

Focusing on the socio-demographic characteristics of respondents, our results show that being graduate increases the likelihood of being willing to purchase IF foods (0.044 for poultry meat, 0.046 for eggs), in line with previous studies on the intention to buy foods containing insects or IF animal products (Cicatiello et al., 2016; Mustapa and Kallas, 2023; Roma et al., 2020). This result may be explained by the fact that people with higher educational level may also have a higher level of knowledge and concern about food sustainability (Sánchez-Bravo et al., 2020). On the other hand, people declaring to live on a tighter budget are approximately 10 % more likely to be willing to purchase IF poultry meat and eggs that relatively more affluent consumers. Indeed, studies have shown that income level is not fully indicative of consumer awareness of sustainability of food production (Sánchez-Bravo et al., 2020). As mentioned by Coderoni and Perito (Coderoni and Perito, 2021) this positive purchase intention of low-income respondents may derive from the questionnaire formulation, where the price of IF poultry meats and eggs is not mentioned nor it is made clear that a CE approach of this type may imply higher costs for poultry farmers. Therefore, one can think that these products may be as expensive or even cheaper than the ones obtained using conventional feed, as they use wastes deriving from other production processes. This argument is also confirmed in the last section of the questionnaire, where we investigate consumers' willingness to pay for IF poultry products, as only 15 % of respondents willing to buy IF poultry meat or eggs would pay a higher price for these foods compared to conventional ones.

While age does not seem to play a significant role in determining the likelihood of purchasing IF poultry products, being male seems to positively affect consumers' attitude towards these foods, especially for poultry meat (0.042). The role of sex is also found in other studies on the intention to purchase insect-based foods or IF animal products by Italian consumers (Cicatiello et al., 2016; Palmieri et al., 2019; Roma et al., 2020).

As regards consumers' attitudes towards food consumption, in line with previous studies investigating consumers' willingness to try insect-



**Fig. 1.** Food Neophobia Scale: items, means and standard deviation ( $n = 780$ ). Note: Asterisk indicates food neophilic statements entering the FNS score calculation with a negative sign.

**Table 3**

Estimated average marginal effects from logistic regression for poultry meat and eggs ( $n = 780$ ).

	WTB_meat		WTB_eggs	
	Coefficient	Standard. error	Coefficient	Standard. error
FNS	-0.007***	0.003	-0.008***	0.003
Entomophobia	-0.161***	0.022	-0.156***	0.022
Trust	0.045**	0.022	0.052**	0.022
Price	-0.019	0.026	-0.030	0.026
Certifications	0.027	0.025	0.018	0.025
Packaging	0.054**	0.025	0.054**	0.025
Sust_belief	0.047*	0.026	0.046*	0.027
Low_sust	-0.050	0.032	-0.017	0.033
Meat_often/ Eggs_often	0.019	0.022	0.020	0.021
Male	0.042*	0.023	0.023	0.023
College_edu	0.044**	0.022	0.043**	0.022
Low_income	0.080*	0.045	0.103**	0.047
Boomer	0.021	0.036	0.037	0.036
Gen X	0.004	0.033	0.004	0.033
Millennials	-0.021	0.031	-0.034	0.031
North_West	0.064**	0.032	0.065**	0.033
North_East	0.041	0.031	0.043	0.031
Centre	0.075*	0.041	0.055	0.040
Pseudo R <sup>2</sup>	0.215		0.204	

Notes: Asterisks \*, \*\*, \*\*\* represent 10 %, 5 % and 1 % significance levels, respectively.

based foods (Barbera et al., 2021; Lombardi et al., 2019; Spartano and Grasso, 2021), our results show that food neophobia, and even to a higher extent, entomophobia significantly decrease the likelihood of consumers to try IF poultry meat ( $-0.007$  and  $-0.161$  respectively) and eggs ( $-0.008$  and  $-0.156$  respectively).

On the other hand, as expected, the trust in the role of public authorities in ensuring food safety increases consumers WTB IF poultry products by approximately 5 %. This finding, coupled with the strong interest on the product composition, which emerged from the analysis of the FNS components, might suggest an important attention to food safety and quality of Italian consumers surveyed. A similar result is found by Coderoni and Perito (Coderoni and Perito, 2020), who however mainly focused on the role of generalized trust on purchase decisions of foods made with upcycled ingredients, rather than on the level of trust in the food system. This finding highlights the importance of

public authorities in providing food safety controls, thus guaranteeing consumers that the food which has been authorized is safe and that controls are made also after the food is approved.

Attention to aspects related to the sustainability of food products is positively associated with the likelihood of purchasing IF foods, as found also by Palmieri et al. (Palmieri et al., 2019). For instance, people who pay attention to reduced and recyclable packaging in their food purchase decisions and who believe that changes in current dietary habits can significantly improve environmental conditions and community well-being are also more likely to be willing to buy IF poultry meat (+5.4 % and +4.7 % respectively) and eggs (+5.4 % and +4.6 % respectively).

On the other hand, attention to price and certifications do not seem to significantly affect the probability of trying IF products, even though the estimated coefficients for these two variables show the expected signs.

We do not find statistically significant relationship between the willingness to try IF foods and the frequency of poultry and eggs consumption as well as the frequency of consumption of sustainable foods (i.e., organic and local).

Interestingly, the impact of consumer's characteristics and attitudes is almost the same for both IF poultry meat and eggs. This means that, at least in the sample analysed, within the same category of animal, different animal products do not lead to changes in consumer's behaviour.

## Conclusions

Replacing part of traditional protein sources with insects in animal diet would reduce the exploitation of natural resources from animal farming. Many insect species are very nutritious, can be grown on crop residues that would otherwise be wasted, and their production is less input-demanding (e.g., in terms of water and land use) compared to other protein sources. Moreover, insects can be considered a natural feed for poultry.

This study has evaluated Italian consumers acceptance of poultry meat and eggs derived from IF chickens bred in a CE system.

Results show a positive attitude of Italian consumers surveyed towards foods from IF chickens as they believe that these products are more sustainable than those obtained from animals raised with conventional diets. Fear of insects and food neophobia may act as a barrier

to consumers' purchases of these products, but interestingly, the role of trust in the capability of public authorities in ensuring food safety seem to be important to improve the likelihood of buying. Also, the sustainable attitude of consumers increases the likelihood to buy IF animal products. Results suggest interesting insights to support policy intervention like properly informing consumers about sustainability issues and ensuring a safe and controlled food system to increase trust.

Interestingly, surveyed consumers' attitudes towards the two products analysed, i.e., IF poultry meat and eggs, are almost the same. This suggests that different animal products from the same animal category do not imply different consumer's behaviour.

Some limitations of the approach are worth mentioning here to suggest further research directions. First, the sample analysed is not representative of the whole country's consumers, thus results should be considered valid within the sample analysed, while nation-wide and representative surveys should be conducted to avoid problems linked to self-selected and biased samples.

Besides, as for such novel food, which might have a high component of disgust, sensory acceptability could be very relevant, the willingness to buy should be evaluated in more real contexts also allowing for

products tastes to catch potential variation in consumer's behaviour after a tasting experience.

### CRediT authorship contribution statement

**Giulia Tiboldo:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Linda Arata:** Conceptualization, Data curation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Silvia Coderoni:** Conceptualization, Data curation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

### Declaration of competing interest

There is no conflict of interest to report.

### Data availability

Data will be made available on request.

## Appendix A

**Table A1**

Variables definition.

Variable name	Original question	Scale
WTB_meat	Would you be willing to buy IF poultry meat?	Yes/No
WTB_eggs	Would you be willing to buy IF eggs?	Yes/No
FNS	Please indicate your level of agreement with the following statements: <i>I eat almost everything</i> <i>I am afraid of things I have never had before</i> <i>At dinner parties, I always try new foods</i> <i>If I do not know what is contained in food, I do not try it</i> <i>I do not trust new foods</i> <i>I am constantly sampling new and different foods</i>	5-point Likert scale
Entomophobia	What is your relationship with insects?	Ad-hoc scale fear, disgust, indifference, curiosity, charm
Trust	I trust the controls carried out by the public authorities in ensuring food safety <i>When choosing food products, how much are these factors relevant to you:</i>	5-point Likert scale
Price	Price	5-point Likert scale
Certifications	The presence of certifications of specific production methods (e.g., organic, free range animal farming, packaging obtained from sustainable forest management, and so on).	5-point Likert scale
Packaging	Reduced and recyclable packaging in food products purchase decisions, 0 otherwise.	5-point Likert scale
Sust_belief	Please indicate your level of agreement with the following statement: <i>"I believe that changes in current dietary habits may improve environmental conditions and social welfare".</i>	5-point Likert scale
Low_sust	How often do you buy sustainable foods/foods with lower environmental impacts?	Ad-hoc scale never, sometimes, often, always
Meat_often	How often do you eat poultry meat?	Ad-hoc scale never, once a week, a few times a week, everyday
Eggs_often	How often do you eat eggs?	Ad-hoc scale never, once a week, a few times a week, everyday

**Table A2**

Logistic regression estimation results for poultry meat and eggs ( $n = 780$ ).

	WTB_meat		WTB_eggs	
	Coefficient	Std. err.	Coefficient	Std. err.
FNS	-0.075***	0.031	-0.087***	0.031
Entomophobia	-1.701***	0.242	-1.652***	0.241
Trust	0.474**	0.232	0.548**	0.232
Price	-0.201	0.274	-0.316	0.271
Certifications	0.290	0.262	0.188	0.263
Packaging	0.569**	0.264	0.565**	0.265
Sust_belief	0.495*	0.279	0.485*	0.280
Low_sust	-0.534	0.338	-0.182	0.347

(continued on next page)

Table A2 (continued)

	WTB_meat		WTB_eggs	
	Coefficient	Std. err.	Coefficient	Std. err.
Meat_often/Eggs_often	0.200	0.230	0.210	0.226
Male	0.450*	0.243	0.242	0.240
College_edu	0.466**	0.231	0.457**	0.231
Low_income	0.849*	0.481	1.086**	0.502
Boomer	0.223	0.380	0.390	0.383
Gen X	0.038	0.346	0.047	0.345
Millennials	-0.219	0.332	-0.355	0.328
North_West	0.676**	0.342	0.684**	0.344
North_East	0.434	0.326	0.458	0.329
Centre	0.797*	0.439	0.585	0.427
Constant	0.409	0.504	0.451	0.504
Pseudo R <sup>2</sup>	0.215		0.204	

Notes: Asterisks \*, \*\*, \*\*\* represent 10 %, 5 % and 1 % significance levels, respectively.

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