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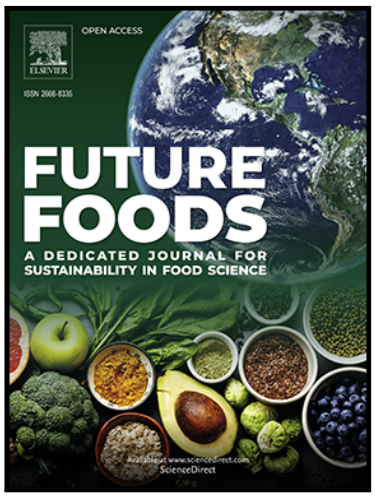

Forging a Sustainable Agricultural Future: Tradition and Innovation in Shaping Acceptance of Insect-Based Foods

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Highlights

- A cluster analysis was conducted to identify distinct profiles of Insect based foods (IBF) consumption based on environmental concerns and food system opinions
- Four clusters emerged: Earth-Balance Responsibles, Green Consumers, Indifferents, and Greens but Meat-Saving
- Preferences for IBF were investigated visually: participante preferered dishes were the insect was not visible
- We investigated the association between traditional disgusting food and IBF: a constant, albeit small association between them was found, especially in foods where the insect is visible

Forging a Sustainable Agricultural Future: Tradition and Innovation in Shaping Acceptance of Insect-Based Foods

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† These authors contributed equally to this work

Keywords

Consumer profiles, environmental concern, eating intention, disgust, socio-demographic differences, sustainable consumption.

Abstract

This study investigates the potential for a sustainable future in agriculture, examining how the interplay between tradition and innovation influences the acceptance of insect-based foods. As global demand for alternative protein sources rises, it is important to understand how individuals' attitudes toward traditional "disgusting" dishes and their sensitivity to environmental sustainability interact to shape attitudes toward new insect-derived products.

The main research aim was to identify profiles of consumers possessing different attitudes toward traditional "disgusting" dishes and new insect-derived products. A survey of 1402 Italian participants was thus conducted to detect the relationships between i) opinions toward traditional "disgusting" food and insects-containing food, and ii) orientation toward both environmental issues and traditional food. A Cluster Analysis was performed on the basis of a previous Principal Component Analysis (PCA) in order to identify distinct consumers' profiles based on their environmental concern and food system opinions. The four emerged clusters, - i.e. Earth-Balance responsibles, Green consumers, Indifferents and Selective eco-conscious consumers - differ for socio-demographic features and attitudes toward traditional "disgusting" food and insect-based alternatives, that were detected through a photo-choice task including 10 traditional Italian foods and 11 insect-based options. Correlation and Correspondence analyses verified the relationship between preferences for traditional foods and their insect-based counterparts within each cluster. Results show that environmental concern toward food systems influenced the acceptability of insect-based foods differently across the identified clusters. Additionally, socio-demographic features and ties to culinary traditions significantly influenced innovative food choices.

In sum, this study provides insights for the sustainable integration of insect-based foods into mainstream dietary choices, emphasizing the crucial role of a harmonious blend of tradition and

innovation in this evolving landscape. Furthermore, care for the visual aspects is suggested for product development within the emerging insect-based foods market.

1. Introduction

In the contemporary era, sustainable agriculture has become critical in addressing global challenges such as food security, resource efficiency, and mitigating environmental impacts. Within this context, insects have emerged as a promising tool for creating a more sustainable food system. The consumption of insects, studied extensively and recognized as an alternative protein source, responds to the increasing global demand for protein driven by population growth (Merlino et al., 2024). Insect production also offers higher environmental sustainability

compared to traditional livestock farming, requiring less water and land, demonstrating efficient feed conversion, and emitting fewer greenhouse gases and ammonia (de Sousa et al., 2023; Halloran et al., 2016; Mancuso et al., 2019; Verduna et al., 2020).

Despite these advantages, Western consumers have been slow to accept edible insects, often due to a sense of disgust (Boer & Lemke, 2023; La Barbera et al., 2020). This reluctance reflects broader patterns seen in the green market, where sustainable choices should align with consumer preferences and values. As environmental concern gains prominence, research shows that increased awareness can positively influence perceptions of insects as a sustainable food option (Jensen & Lieberoth, 2019). However, psychological barriers such as food disgust, neophobia, and cultural beliefs remain significant challenges to the widespread adoption of such an option (Merlino et al., 2024).

Culinary traditions play a critical role in shaping food preferences and the acceptance of novel foods, including insect-based products. In Mediterranean countries (Italy in particular), where food traditions are deeply embedded in culture, a successful proposal of insect-based foods should take into account both tradition and innovation features (Toti et al., 2020; La Barbera et al., 2020). In this regard, visual presentation and association with familiar traditional dishes seem to both mitigate disgust and increase acceptability toward insect-based foods (House, 2018). Moreover, it is important to consider that consumers' willingness to try unfamiliar or "disgusting" foods is often linked to perceptions of sustainability, particularly when there is an emotional connection to traditional dishes (Boer & Lemke, 2023; Merlino et al., 2022). More in general, socio-cultural factors - such as culinary tradition, food accessibility, and sociodemographic variables (including ethnicity and religion) - as well as socio-psychological factors - such as food styles, perceived ethical aspects of food production, and

environmental concern) seem to be important aspects influencing individuals' willingness to consume insect-based dishes (Anagonou et al., 2023).

The present study

The current study aims to explore the issue of consumers' preferences toward insects as food. The focus is on the interconnection between environmental concern, propensity for insect consumption, and attitudestoward those traditional dishes that may be culturallyassociated with the feeling of disgust. The main objective is to detect distinct profiles of consumers characterized by different patterns of choice regarding insect-food and traditional "disgusting" dishes as well as in terms of socio-demographic and socio-psychological features[1].

To this end, we address the following research questions, formulated before the data collection.

1) Are there distinct profiles of attitudes and beliefs toward traditional "disgusting" food and innovative insect-based dishes among consumers who prioritize environmental concern?

2) What impact do socio-demographic characteristics have on individuals' intentions to consume insect-based dishes within the different consumers' profile?

3) Is there an association between traditional "disgusting" food and preferences for insect-based dishes?

[1] This paper is based on some data that were already used from another study (Merlino et al., 2024), that aimed to test an insect consumption model by integrating biospheric values, social norms, perceptions of sustainability, animal welfare, and food neophobia/neophilia to better predict consumers' behaviour. However, in the present paper the objective is quite different, and data were analysed i) through statistical techniques that are different from the ones used in the previous study, and ii) for responding to research questions that are different from the ones addressed in the previous paper.

2. Material and method

Participants

A total of 1402 Italian residents participated in the study. The sample was equivalent to the one recruited by Merlino et al. (2024) and was composed predominantly of women (69.9 %), with ages ranging from 18 to 85 years (mean = 40.68, *s.d.* = 14.90) and a mediumhigh level of education. In comparison with the general Italian population (ISTAT, 2023), there is an overrepresentation of women (65% in the sample vs. 51% in the Italian population) and of individuals with a University degree (55% vs. 20% in the general population) .

Procedure

A web-based survey was developed using Google Forms and distributed nationally via social and electronic media platforms such as Facebook, Instagram, WhatsApp, and e-mails among Italian consumers between December 2021 and July 2022, following the snowball sampling procedure method (see Merlino et al., 2024). The Facebook and Instagram groups used for recruitment were curated to include communities focused on food sustainability, innovation, tradition, and environmental awareness, ensuring participants with a potential interest in the study's themes. For WhatsApp and email lists, word-of-mouth based respondents selection was made in order to provide a broader spectrum of opinions. These platforms were chosen to reach a diverse yet targeted audience while leveraging digital channels commonly used by Italian consumers. The survey was spread also by the European Food Safety Authority's focal points. Despite the advantages of this approach, we acknowledge that such sampling may introduce demographic biases, which are discussed in the limitations. .

The survey adhered to ethical standards defined by the Declaration of Helsinki and received approval from the Bioethics Committee of the University of Turin (Prot. n. 0676006/2021).

Participants expressed their informed consent before filling in the questionnaire. The completion time was about 15-20 minutes. Answers were set as mandatory for every question for scientific purposes of completeness of information. Before questionnaire completion, participants were advised of this option, and in the informed consent it was declared that they could have abandoned the survey at any moment. In this way, only complete questionnaires were included in the analyses.

Measures

The following measures, included in an online questionnaire, were considered for the study[2].

- The first section included the socio-demographic characteristics of the respondents (including gender, age, family size, educational level, food style, and religion). The second section includes the socio-psychological measures related to environmental and food issues, as reported in Table 1.

Table 1. Socio-psychological measures: characteristics and items.

Measures	Characteristics	Items
Biospheric Values, 4 items, $\alpha = 0.92$	Associated with individuals' values related to the emphasis on the environment and biosphere preservation (de Groot & Steg, 2008; Stern, 2008):	Protecting the environment: preserving nature; Unity with nature: feeling part of the natural environment Preventing pollution: protecting natural resources; Respecting the earth: harmony with other species
Attitude Toward Food Sustainability Scale, 8 items, $\alpha = 0.93$	Related to food sustainability concerning supply-chain management and sustainable practices (see Sottile et al., 2023; Merlino et al., 2024). This scale was obtained by combining the indexes of the environmental impact of the	Organic production method; Use of alternative energies; Biodegradable or recyclable packaging; Carbon footprint certification; Water footprint certification; Short supply chain; Local origin;

[2] The original questionnaire included also other measures not addressed in this study.

	food chain introduced by Roib´as et al. (2015), and the social and economic sustainability indicators included in Merlino et al. (2022).	Reduced use of chemical compounds (e.g., pesticides).
New Human Interdependence Paradigm Scale (NHIP), 5 items, α = 0.94	Related to the interdependence between human progress and nature conservation, viewed as a dynamic process of integrating human needs into natural processes (Corral-Verdugo et al., 2008).	True human progress can only be achieved by maintaining ecological balance; Safeguarding nature today means securing the future of mankind; We must reduce our consumption levels to ensure the wellbeing of present and future generations; Humanity can only progress by safeguarding natural resources; People can only enjoy nature if they make wise use of its resources.
Beliefs about daily meat consumption, 3 items, α = 0.87	Concerning the consequences of meat consumption in daily life with items created ad hoc for the present study (Castle & Goodman, 2014; Ornes, 2016; Randers et al., 2021)Goodman, 2014; Ornes, 2016; Randers et al., 2021).	Eating meat or cold cuts every day (or almost every day) poses a health risk to people; Eating meat or cold cuts every day (or nearly every day) poses a risk to the environment; The negative environmental consequences of eating meat or cured meats affect only those places where production is industrial (e.g. from intensive livestock farms).

Note: Each item was assessed using a 7 -point Likert-type scale (from 0 = not all important or completely disagree to 6 = very important or completely agree).

- The third section includes a 3-item scale, *ad hoc* created, that verified participants' knowledge of insect-based foods production through the following questions: "Did you know that this drink (photo of a fruit juice), like other foods (e.g., gummy candies, canned red fruits, alcoholic bitters, etc.), contain the additive E 120, cochineal, a dye made from the insect of the same name?"(yes/no); "Now that you know" (choice between I no longer buy it, I continue to buy it); "Do you know that some foods we bring to our table, such as flours and by-products, may coincidentally contain insect fragments?" (yes/no); "Did you know that EFSA (European Food Safety Authority) has issued a positive opinion regarding the use of some insects on consumer tables (e.g., larvae of the yellow meal (Tenebrio

molitor), meal of the domestic cricket (Acheta domestica)?" (yes/no). Through this last question, it was possible to understand if consumers were informed that there was a specific Novel Food Regulation and a regulatory body to support the safety of insect-based foods. Therefore, the objective was to collect information about public awareness of the food control system with particular reference to the EU Food Safety Regulation and the European Food Safety Authority and to verify the effect of this particular knowledge on consumer choices.

- The fourth section includes the intention to eat insect-based food with respondents' eating habits regarding 10 selected traditional foods linked withtypical Italian food preparations. Theeating experience for the traditional food and the intention to eat insect-based foods were assessed using a visual approach integrated with the questionnaire-based method. First, respondents were asked to choose which of 10 different foods, representative of the Italian culinary tradition, they had previously consumed through the question, "Which of these foods have you already eaten?". Subsequently, the same procedure was repeated, presenting 11 insect-based dishes for evaluation using the question: "Which of these foods would you eat?" Thus, this comparison provided valuable insights into participants' attitudes toward both traditional and innovative culinary offerings.

- The fifth section covers the attitude towards disgusting traditional foods. The assessment of disgusting traditional foods involved the use of a textual variable and a check-all-that-apply (CATA) question, structured with 10 images depicting various Italian traditional food items (see Table 2) that can even carry significant cultural meaning for the intercepted individuals. Among these foods, there were a few examples of foods that are biologically similar to insects and have comparable nutritional benefits, such as shrimps, sea cicadas, or

fried fish, which are part of the diet of many Western peoples but are not typically associated with disgust (Boer & Lemke, 2023). On the other hand, other dishes, such as *Casu Martzu*, spleen-filled focaccia, snails, or tripe, while considered delicious by many Italian consumers due to their association with tradition, may be perceived as disgusting by those less familiar with Italian traditional cuisine. For these latter foods, consumption often elicits a mix of enthusiasm and disgust (Barone & Pellerito, 2020; Bell & Moran, 2022). Similar to insects, familiarity, cultural background, and socio-demographic variables are the main barriers to the acceptability of such traditional "disgusting" national dishes, overriding personal taste preferences (Bearth et al., 2021).

Table 2. Photographs of the 10 Italian traditional dishes presented in the survey. Each image was sourced online and accompanied by the corresponding conventional name of the dish.

Land snails[1]	Casu martzu[2]	Tripe[3]
		
Spleen-filled focaccia[4]	Raw fish5	Spaghetti with shrimps[6]
		
Fried frog legs[7]	Fried fish[8]	Percebes[9]
		
Sea cicadas[10]	No choice	
		

[1] https://www.flymeto.com/blog/en/what-a-little-snack-snail/
[2] http://www.ricetteecooking.com/view.php/id_1124/lingua_0/whoisit_1
[3] https://www.sfizioso.it/la-ricetta-originale-della-trippa-alla-piacentina/
[4] https://cottoecrudo.it/i-5-migliori-panini-con-la-milza-di-palermo/
[5] https://bluaragosta.it/ricetta/crudites-di-pesce-con-gazpacho-di-melone-e-insalata-di-farro
[6] https://blog.giallozafferano.it/loti64/spaghetti-con-gamberi-e-pomodorini/
[7] https://it.dreamstime.com/
[8] https://www.cucchiaio.it/ricetta/frittura-di-pesce-mista/
[9] https://www.finedininglovers.it/articolo/percebes-crostacei-cosa-sono
[10] https://www.parcodeltapo.org/prodotti_dettaglio.php?id=3926

- Finally, the sixth section includes the intention to eat insects-based foods (utilising visual acceptance, as detailed in Merlino et al., 2024). The assessment of this intention entailed the use of a textual variable and a check-all-that-apply (CATA) question, structured with eleven images depicting various insect-based food items (see Table 3).

Table 3. Photographs of insects-based foods presented in the survey. These images were sourced online and represent existing insect-based products available on the international market.

Insects burger[1]	Insects sandwich[2]	Chocolate with grasshoppers[3]
		
Tartlets with grubs[4]	**Spaghetti with crickets[5]**	**Fried grasshoppers[6]**
		

Muffins with cricket flour[7]	Fried insects[8]	Crackers with cricket flour[9]
		
Insect protein bars[10]	**Pasta with insect flour[11]**	**None**
		

[1] https://www.rte.ie/brainstorm/2021/0524/1223553-insect-based-food-bug-burger-insect-energy-bar/;
[2] https://stock.adobe.com/ch_it/images/close-up-on-a-fried-mealworm-insect-burger/271559936;
[3] van Huis et al, 2013. *Edible insects. Future prospects for food and feed security*;
[4] van Huis et al, 2013. *Edible insects. Future prospects for food and feed security*;
[5] https://www.dezeen.com/2014/02/14/entomo-website-design-promotes-insects-as-food/;
[6] https://www.healthline.com/health-news/why-edible-insects-are-the-next-superfood-trend;
[7] https://www.insetticongusto.com/ricette-a-base-di-insetti/muffin-dolci-con-farina-di-grilli-ricetta/;
[8] https://it.123rf.com/photo_67488230.html;
[9] https://www.nicepng.com/ourpic/u2w7u2u2r5o0t4q8_crick-cricket-crackers-box-olive-gourmet-cracker-chips/;
[10] https://solobici.es/barritas-proteicas-de-insectos/;
[11] https://aliainsectfarm.it/tagliatelle-con-farina-di-grillo-alia-insect-farm/

In the latter case, respondents were prompted to evaluate their willingness to consume these items through the question "*Which of the following foods would you eat?*". The questionnaire incorporated images without accompanying descriptions, aiming to gauge how simple visual judgment influenced the frequency of choosing different dishes. The objective was to evaluate the acceptability of insect-based foods by presenting a diverse array of alternatives. Participants could choose between commercially available ready-made products and items to be prepared, creating a spectrum of choices for potential consumption. The primary goal was to assess the actual acceptability of various product forms, including sweet and savoury dishes, with insects either visible or in flour form. Additionally, options involved whole insects combined with conventional

dishes like pasta or insects in flour form for use in baked preparations (e.g., muffins) or commercially available ready-made products (e.g., bars or crackers). The set of alternatives deliberately featured both visible and invisible forms of insects. Rather than seeking a balance between these types, the aim was to maximise variation in the shapes and visual presentations of the insects. From the initial set of 11 dishes, the analysis focused on measuring the frequency with which each image was chosen and then the specific type of dish selected by individuals. Participants also had the option to choose "no choice". In this case, they were prompted to evaluate their consumption habits of disgusting traditional items through the question "*Which of the following foods did you eat in the past?*". For this latter selection, the author chose the images of 10 typical dishes linked with different Italian regions. In particular, the selected traditional foods are unconventional and often considered disgusting by unfamiliar consumers. Again, participants had the option to choose "no choice".

We chose not to describe the dish paired with the picture to understand how simple visual evaluation or familiarity (in the case of traditional foods) might influence the frequency of choice of different dishes. The objective of the study was to evaluate the acceptability of both insect-based and traditional foods by utilizing a broader range of potential dish alternatives. For insect-based options, commercially available products were included to create a diverse selection from which consumers could choose for potential consumption. The focus was to assess the actual acceptability of various product forms: for instance, whole insects incorporated into conventional dishes (such as pasta) or insect-based ingredients already processed into commercial products (e.g., bars or crackers).

Similarly, for traditional foods, dishes were selected that might elicit a sense of disgust. The study did not aim to balance the number or type of dishes between traditional and insect-based options. Instead, the emphasis was on maximizing diversity in presentation, offering both sweet

and savoury dishes, with insect-based ingredients either visible or processed into flour. These dishes included whole insects paired with conventional foods, insect flour incorporated into baked goods, or products already available on the market. Additionally, traditional dishes of varying origins and forms were offered.

Given the range of choices, the intention to consume was measured by assessing the frequency of dish selection rather than focusing on the specific types of dishes chosen.

Data Analysis

After preliminary descriptive analyses, a Principal Component Analysis (PCA) was run on on the administered scales. . Kaiser–Meyer–Olkin (KMO) measures of sampling adequacy and Bartlett's test were performed before the PCA (Broen et al., 2015). The reliability analysis for internal consistency was conducted for each factor, using Cronbach's Alpha, with a threshold value of 0.7 (Yin et al., 2023). Only components with factor loadings higher than 0.5 were considered. The loadings of the PCA factors were used as dependent variables in the Cluster Analysis to define distinct groups of individuals based on their attitudes, beliefs, and values concerning the relationship between food production and the environment. Initially, the two-step Cluster Analysis suggested a 4-group solution as the best sample segmentation. The k-means technique, based on Hierarchical Cluster Analysis and Euclidean distances, was employed to cluster consumers according to their attitude patterns. Then, an ANOVA analysis was carried out for running comparisons among clusters in terms of socio-demographic characteristics and intention to consume insect-based and traditional foods. Additionally, two Correspondence Analyses (CAs) were performed to assess the attitude towards disgusting traditional foods and the intention-to-eat insect-based foods, measuring the association between the obtained clusters and the selected insect-based and traditional foods. The clusters' propensity to traditional and insect-based foods was

evaluated in the first CA, analysing the relationship between clusters and the number of selections comparing the two sets of photos (traditional vs. novel). A second CA was then conducted to analyse the association between clusters and each traditional and insect-based dish. This statistical approach was designed to uncover patterns and relationships within clusters (categorical variables) and the array of both new and traditional foods presented in the survey (nominal variables). Simultaneously, it visually organises them within the same dimensional space (Lana et al., 2017; Merlino et al., 2022). Drawing on a contingency table, CA leverages the frequencies of rows and columns (encompassing categorical and nominal variables) to position them in a geometric space, relying on Chi-square distances. Increased proximity between points on the map indicates a more robust association between variables in the rows and columns (Harcar & Spillan, 2006; Kaynak & Kucukemiroglu, 2001). The dimensions identified in the CA can be understood by identifying the primary contributors to the explained variance along each axis. The proportion of variance explained by each dimension is referred to as singular values (Beldona et al., 2005). In this study, each dimension was considered valid only if its singular value exceeded 0.20 (Hair et al., 1998). Finally, a correlation analysis (i.e., point biserial correlations) between traditional and novel food choices was computed for each cluster separately. All the statistical analyses were performed using the SPSS for Windows version 27.0. The analytic plan was pre-specified, and any analyses were clearly identified before data collection and discussed appropriately in the following results section.

3. Results

Consumption patterns and consumers' profiles

The Principal Component Analysis (PCA), [3]resulted in 3 principal components, explaining 69% of the variance (Table 4).

Table 4 . Principal Component Analysis on environmental sustainability and the food-supply chain

Items	Principal components		
	Sustainable supply-chain	Balance with the environment	Responsible meat consumption
Organic production method	0.708		
Use of alternative energy	0.837		
Biodegradable or recyclable packaging	0.771		
Carbon footprint certification (for low CO2 emissions)	0.876		
Water footprint certification (for limited water use)	0.866		
Short supply chain	0.826		
Local origin	0.696		
Reduced use of chemical compounds (e.g., pesticides)	0.692		
Preventing pollution: protecting natural resources		0.851	
Respect the earth: harmony with other species		0.850	
True human progress can only be achieved by maintaining ecological balance		0.751	
Eating meat or cold cuts every day (or almost every day) poses a health risk to people.			0.839
Eating meat or cold cuts every day (or nearly every day) poses a risk to the environment			0.849
The negative environmental consequences of eating meat or cured meats affect only those places where production is industrial (e.g. from intensive livestock farms)			0.484
Cronbach's Alpha	0.93	0.85	0.60

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation. Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.885; Bartlett's Test of Sphericity - Approx. Chi-Square= 13485.548; Sig.= 0.000

The first component (47.3% of the total variance) was named "Sustainable supply-chain" as it concerns a consumption model based on attention towards the sustainability approach of the food production system, the principles of circular economy, and the low-impact supply chain. The second component (12.7% of the total variance), named "Balance with the Environment" is characterised by holding values and beliefs oriented at maintaining a balance with the environment and ecosystems. The last component, named "Responsible meat consumption", accounted for 9% of the total variance and regards a consumption model based on the belief about the negative impact of the meat production system on both human health and the environment.

The cluster analysis allowed the definition of 4 different consumer groups. Data referring to the definition of the clusters are the coordinates of the cluster centres for the three distinct principal components (Table 5).

Table 5. Characteristics of the four extracted clusters of consumers.

	Clusters				F	χ^2	*Sig.*
Principal component	Earth-Balance responsibles	Green consumers	Indifferents	Selective eco-conscious consumers			
Sustainable supply-chain	-0.4908	0.2741	-0.0577	0.1559			
Balance with the environment	0.1477	0.1943	-0.4942	0.2393			
Responsible meat consumption	0.1106	1.0062	-0.3081	-0.8817			
			Socio-demographic variables				
Age (mean)	41.57	40.59	39.15	41.29	1.24		0.29
Age ranges (%)							
18-25	20.1	23.6	24.4	18.9	20.69		0.29

26-35	18.9	21.9	24.4	21.0		
36-45	17.4	13.9	12.7	20.3		
46-55	21.6	18.8	22.1	16.1		
56-65	19.2	17.4	15.5	19.6		
>65	2.7	4.3	0.9	4.2		
Sex (%)						
Men	28.8	25.0	40.6	37.3	23.5	***
Women	71.2	75.0	59.4	62.7		
Average annual income of the family						
I prefer not to answer	20.7	14.4	21.1	16.1	22.1	0.104
< 25.000 €	24.0	29.3	27.7	30.1		
from 25.000 to 40.000 €	30.9	32.8	27.2	33.6		
from 40.000 to 60.000 €	17.4	12.9	14.6	13.3		
> 60.000 €	6.9	10.5	9.4	7.0		
I am agnostic	10.2	15.3	8.9	10.5		
I am an atheist	16.8	25.1	16.9	11.2		
Educational level						
Primary school	0.0	0.0	0.0	1.4	21.3	*
Lower Secondary school	3.0	2.8	4.2	4.2		
Upper secondary school	34.8	34.1	35.2	28.0		
Master's degree	62.2	63.1	60.6	66.4		
Family size (m. of members)						
1	10.8	9.9	7.5	7.0	29.4	0.207
2	25.2	23.8	22.1	25.2		
3	20.4	22.7	16.0	23.8		
4	33.9	30.9	39.4	30.1		
5	7.2	11.1	11.	13.3		
>5	0.9	1.1	1.9	0.0		
Food style						
Omnivore	80.2	77.7	87.3	87.4	125.8	*
Vegan	0.3	1.1	0.9	0.0		
Vegetarian	5.4	9.5	0.9	0.4		

Other	13.1	8.7	10.8	12.2

Significance level: ***p-value < 0.001; *p -value< 0.05

The first cluster was named *Earth-Balance responsibles* and represented 51% of the whole sample. In this group the "Balance with the Environment" and "Responsible meat consumption" components simultaneously weighed positively in defining the choice model. At the same time, the component "Sustainable supply-chain" had the greatest influence on the cluster definition, but negatively. Individuals in this cluster were not oriented towards choosing foods from sustainable, traditional supply chains, linked to land-based production systems, where the human-environment-animal balance is maintained and preserved. Despite this, for these individuals, having a balanced relationship with the environment is important, but it seems that this attention is more guided by risk prevention motives (i.e.: risk posed to human and environmental health).

The second cluster, which was named *Green consumers*, represented 24% of the sample and was composed of individuals aware of environmental issues. Indeed, all three components were weighted positively in defining the model of choice for cluster 2. The people in this cluster were mainly skeptical regarding meat consumption for environmental and health risk issues; at the same time, these consumers direct their choices to avoid production systems in alternatives to industrial ones to ensure the sustainability of food systems and are interested in having a balanced relation with the environment.

In the third cluster, all three components weighed simultaneously negatively in defining the food orientation in this group (15% of the sample). For this reason, the cluster was identified as the *Indifferents*. It was represented by individuals whose food choice orientation is not guided by pro-environmental attitudes and who do not show skepticism towards the reduction of meat consumption. The component "Balance with the Environment" had the greatest impact on the model of choice for the *Indifferents*, negatively.

The last cluster (10% of the sample), named *Selective eco-conscious consumers*, was defined positively by the components "Balance with the Environment" and "Sustainable supply-chain". At the same time, the component "Scepticism towards meat consumption" was weighted negatively in the mode ling of the food orientation. In fact, these individuals were characterised by their attention to preserving a balance with the environment and a positive attitude toward sustainable food production models, while displaying a discordant attitude towards excessive meat consumption and its related risks.

Concerning socio-demographic statistics, the four groups of consumers were different in terms of gender, education level, and food style. The only cluster not related to the environment, the group of *Indifferents*, is balanced in terms of gender composition, while the others are mainly composed of women. Regarding food styles, a higher percentage of vegetarians and vegans is found in the green consumers cluster, suggesting an association between green values and avoidance of meat consumption.

Consumer knowledge about insects as additives and insect-based foods

Table 6 . Consumer knowledge of the four clusters about insects as additives and insect-based foods.

Questions	Answers	% within Cluster Number of Case				Total	χ^2	*Sig.*
		Earth-Balance responsible	Green consumers	Indifferents	Selective eco-conscious consumers			
Did you know that this drink (photo of a fruit juice), like other foods (e.g., gummy candies, canned red fruits, alcoholic bitters, etc.), contains the additive E 120, cochineal, a dye made from the insect of the same name?"	No	60.1	58.6	63.8	71.3	61.1		
	Yes	39.9	41.4	36.2	28.7	38.9	8.9	*

Now that you know: *(only those who answered no to the previous question)*	I no longer buy it	13.8	12.8	16.0	18.9	14.1	12.1	0.206
	I continue to buy it	34.5	36.3	38.5	42.0	36.8		
Did you know that EFSA (European Food Safety Authority) has issued a positive opinion regarding the use of some insects on consumer tables (e.g., larvae of the yellow meal (*Tenebrio molitor*), meal of the domestic cricket (Acheta domestica)	Yes	68.5	67.2	64.3	60.1	66.3		
	No	31.5	32.8	35.7	39.9	33.7	3.7	0.289

Significance level: *p -value< 0.05

Concerning consumers' knowledge about insects as additives (see Table 6), the four consumer clusters differed only on knowledge about insects used as additives in common foods (i.e., E120). The *Green consumers* were the most knowledgeable about this issue, followed by the *Earth-Balance responsibles*. It is interesting to notice that the *Selective eco-conscious consumers* were the least knowledgeable about insects used as additives, while it could be logical to hypothesize that the *Indifferents* could be the ones. For this cluster, maintaining a commitment to environmental values may take precedence, even as they retain the option to consume meat. In this context, the significance of knowledge regarding insects used asadditives appears to diminish. Regarding IBF knowledge, the four clusters did not show any significant difference.

Attitude towards disgusting traditional foods and the intention-to- eat insect-based dishes within each profile

Table 7. The number of insect-based and traditional dishes selected within each cluster.

Number of chosen dishes (insect-based)	% within Cluster Number of Case				Total (%)	χ^2	Sig.
	Earth-Balance responsible	Green consumers	Indifferents	Selective eco-conscious consumers			
0 (none)	45.3	42.1	45.5	51.0	44.2	33.6	0.497
1	9.6	7.6	9.9	8.4	8.5		
2	6.3	8.0	7.0	7.0	7.3		
3	7.8	6.5	7.5	8.4	7.1		
4	7.2	7.7	4.2	5.6	6.8		
5	6.6	6.6	5.2	4.9	6.2		
6	5.7	8.3	4.2	4.2	6.6		
7	2.4	3.5	5.2	1.4	3.3		
8	0.9	3.1	3.8	2.1	2.6		
9	2.7	1.5	2.8	1.4	2.0		
10	2.4	2.7	0.9	2.8	2.4		
11	3.0	2.5	4.2	2.8	2.9		
Total chosen dishes (n.)	**823**	**1953**	**558**	**311**			
Total chosen dishes (mean)	**2.47**	**2.74**	**2.62**	**2.17**			
Number of chosen dishes (traditional)							
0 (none)	3.6	3.5	2.8	2.1	3.6	30.1	0.462
1	1.2	1.7	2.8	2.1	1.2		
2	6.9	3.5	2.3	6.3	6.9		
3	9.0	10.5	10.8	11.2	9.0		
4	10.8	12.1	12.7	15.4	10.8		
5	13.5	13.3	13.1	14.7	13.5		
6	16.8	16.4	17.8	17.5	16.8		
7	15.9	15.8	10.3	12.6	15.9		
8	12.6	14.3	14.1	10.5	12.6		
9	6.9	6.6	8.9	2.8	6.9		
10	2.7	2.2	4.2	4.9	2.7		
Total chosen dishes (n.)	**1881**	**3952**	**1177**	**817**			
Total chosen dishes (mean)	**5.65**	**5.54**	**5.53**	**5.71**			

No significant data

The clusters *Earth-balance responsibles* and *Selective eco-conscious consumers* were the least oriented towards insect consumption; in fact, among the total disagreements obtained from the question "Which of these insect foods would you eat?", 50% of the "none" responses were obtained from cluster *Earth-balance responsibles*. On the contrary, *Green Consumers* were the most inclined to consume insect-based products (Table 7). However, considering only the positive answers regarding the insect-based foods alternatives, the number of insect foods selected by

consumers in the 4 groups did not differ significantly: on average, out of 11 types of foods proposed to respondents, the 4 clusters chose 4 dishes similarly. Specifically, the main foods chosen were those in which the insect was not visible and, above all, a sweet product (muffins with 683 agreement). In contrast, among the products with the insect visible, the most chosen one was fried crickets. In addition, 542 respondents indicated that they were willing to consume pasta with insect flour, while only 172 chose *spaghetti* with visible insects.

Table 8 . Preferences (%) for each traditional dish selected by cluster.

	% of preferences within Cluster Number of Case				χ^2	Sig.
Traditional Italian dishes	Earth-Balance responsibles	Green consumers	Indifferents	Selective eco-conscious consumers		
Sea cicadas	64.0	59.2	58.2	61.5	2.7	0.436
Land snails	58.0	60.2	62.9	60.1	1.3	0.720
Casu martzu	18.3	22.0	28.6	21.0	8.2	*
Tripe	63.1	60.9	62.9	57.3	1.7	0.664
Fried fish	94.9	93.7	93.0	94.4	1.0	0.785
Spleen-filled focaccia	31.8	32.5	32.4	26.6	2.0	0.565
Spaghetti with shrimp	70.9	75.5	71.8	65.7	6.9	0.076
Raw fish	92.2	92.1	93.0	93.0	0.3	0.969
Fried frog legs	33.3	33.2	36.6	26.6	3.9	0.266
Percebes	28.8	31.4	31.5	28.0	1.5	0.743

Significance level: *p -value< 0.05

Clusters differed significantly in terms of preferences towards the *Casu martzu* (Table 8). On the contrary, no statistically significant differences emerged among the consumer groups for other Italian traditional dishes.

Table 9 . Preferences (%) for each insect-based dish chosen within each cluster.

Insect-based dishes	% of preferences within Cluster Number of Case				χ^2	Sig.
	Earth-Balance responsibles	Green consumers	Indifferents	Selective eco-conscious consumers		

Insect burger	23.4	30.2	27.2	18.9	10.5	**
Insect sandwich	23.4	27.2	24.4	16.1	8.4	*
Chocolate with grasshoppers	7.2	10.0	11.7	9.1	3.4	0.323
Tartlets with grubs	5.4	6.7	8.0	4.9	2.1	0.551
Spaghetti with crickets	12.6	11.2	14.6	13.3	1.9	0.586
Fried grasshoppers	17.7	17.7	22.5	17.5	2.8	0.414
Muffins with cricket flour	48.0	51.9	43.7	40.6	8.9	*
Fried insects	13.5	16.5	20.7	15.4	4.9	0.174
Crackers with cricket flour	30.3	32.3	25.8	26.6	4.2	0.235
Insect protein bars	29.1	32.0	27.7	26.6	2.7	0.428
Pasta with insect flour	36.3	38.3	35.7	28.7	4.8	0.184

Significance level: **p-value < 0.01; *p -value< 0.05

Concerning the preferences for visually examined insect-based foods (Table 9), we detected significant differences in the four groups of consumers, for foods where insects are not visible, such as insect burgers, insect sandwiches, and muffins with cricket flour. The *Green Consumers* are the most inclined to consume IBF, while the *Selective eco-conscious consumers* are the least inclined. We can suppose that the ambivalent attitude exhibited by this cluster is a barrier to IBF.

Propensity to traditional and novel insect-based food within each profile

To better understand the association between the extracted clusters and the propensity to traditional and novel insect-based food, four CAs were performed: their results related to the association between clusters and the frequency of choice (propensity) of the traditional Italian dishes and the insect-based foods are reported in Figure 1. In addition, the graphical association between clusters and the different proposals of traditional and insect-based foods is reported in Figure 1. The singular values, the inertia, and the proportion explained by each estimated dimension resulting from the CAs are reported in the Supplementary Materials. According to Hair et al. (1998), both bi-dimensional (see graphs *a, b, d* in Figure 1) and uni-dimensional solutions (see graph *c* in Figure 1) can be accepted for singular values (eigenvalues) greater than 0.20.

Regarding the relationship between clusters and preferences for insect-based foods, it emerged that the clusters most characterized by environmental issues, *Earth Balance Responsible*s,

and *Selective eco-conscious consumers* are inclined to consume products where the insects are not visible, like pasta with insect flour and insect protein bars. On the other hand, the *Indifferents* cluster is oriented to consume products where the insect is visible, like fried insects and tartlets with grubs.

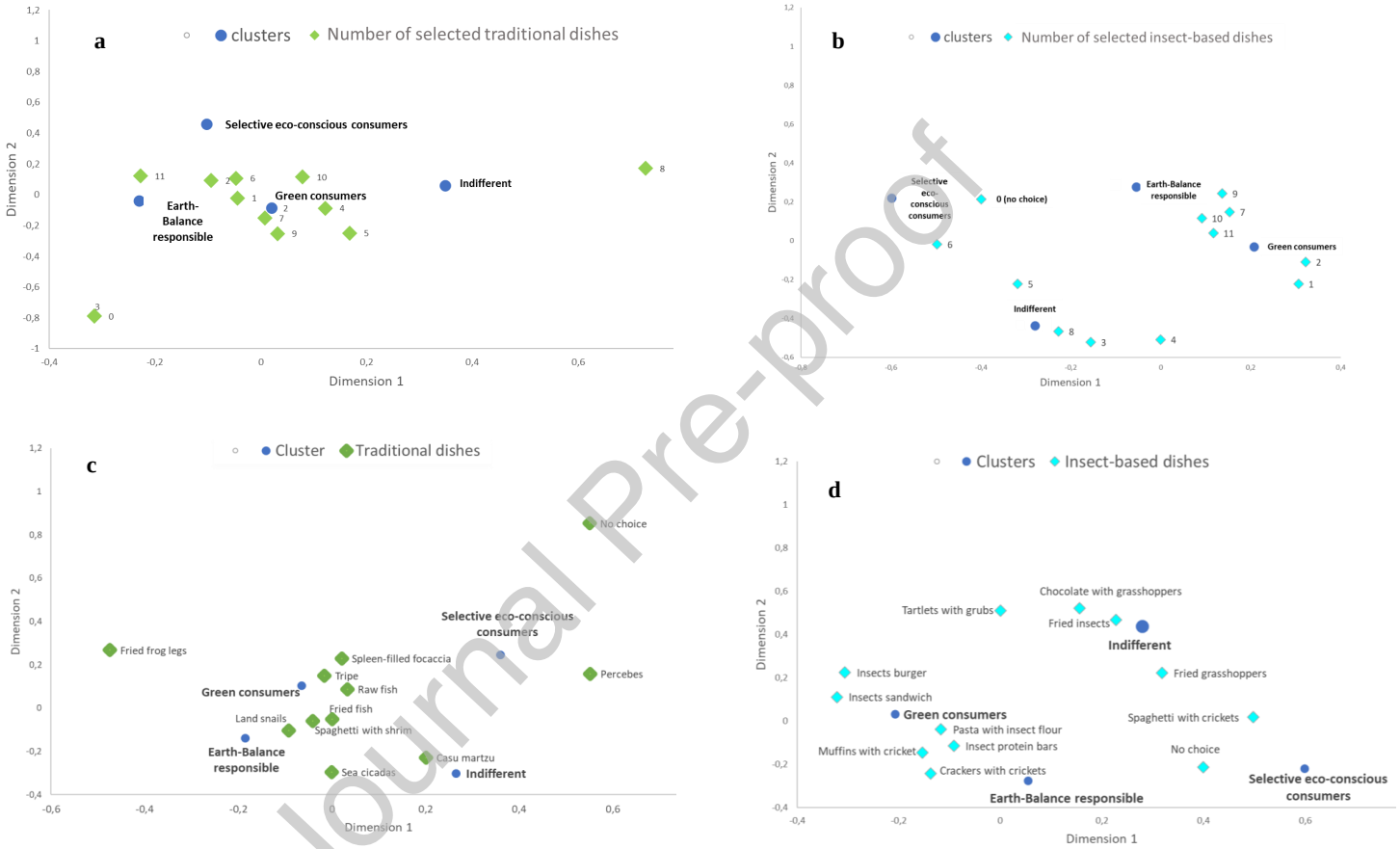

Figure 1. Correspondence Analysis (***a:*** clusters x number of selected traditional dishes; ***b:*** clusters x number of selected insect-based dishes; **c*:*** clusters x preferences of traditional dishes; ***d:*** clusters x preferences of insect-based dishes).

Results of correlation analysis (see Appendix) showed that there is a constant and modest association in terms of point biserial correlation value (*rpb* ranging from 0 to a maximum of 0.36) between traditional seafood (i.e. sea cicadas, fried fish, spaghetti with shrimps, percebes) and insect-based foods, especially in foods where the insect is visible, in all the consumer groups. This association is not found between raw fish and insect-based foods. This result can suggest a link between marine and terrestrial arthropods consumed as food based on visual similarity. In general, the *Selective eco-conscious consumers* were much more inclined towards both traditional disgusting foods and innovative insect-based foods.

In addition, a recurrent and medium positive strong association appeared in the 4 clusters between Spleen-filled focaccia and fried insects and insects' sandwiches, fried frogs, and snails with fried insects. Finally, the clusters *Indifferents*, and *Selective eco-conscious consumers* were characterized by a positive correlation between the preferences for Spaghetti with shrimp and pasta with Pasta with insect flour.

4. Discussion

Despite hesitancy among Western consumers to incorporate insects into their diet, niche markets for insect-based food are emerging (Boukid et al., 2023; van Huis et al., 2013). In Italy, both researchers and practitioners have shown interest in entomophagy with discussions centered around insect farming practices, features of firms producing insects in Italy, and the challenges of ensuring food safety and sustainability in insect-based production (Colombo, 2015).

This study sheds light on Italian consumers' perceptions of insect-based foods, highlighting the interplay between environmental awareness, culinary traditions, and attitudes toward sustainable eating. Through a robust analysis, the present study identified four distinct consumer

clusters, offering valuable insights into how socio-demographic and psychological factors influence the acceptance of insect-based foods. In particular, the segmentation into Earth-Balance Responsibles, Green Consumers, Indifferents, and Selective Eco-Conscious Consumers - based on their attitudes towards the environment - allowed to fulfil the first aim of the research. provides a nuanced view of the heterogeneity in attitudes toward insect-based foods.

The most represented cluster was the *Earth-balance responsibles* one, revealing that half of the respondents showed environmental concern to avoid risks, linked both to the environment itself and tohuman health. The overall findings of our research clearly show a medium level of acceptance of insect-based food, very low knowledge of the features of this new food, and, in particular, scarce expertise in certain subjects (e.g., health and environmental benefits) that can promote its tasting and consumption. These findings align with a study conducted by Roma et al. (2020) since these scholars suggested that providing targeted information about entomophagy may increase the consumers' acceptance of insect-based food, but we did not confirm the effect of knowledge in our results. Regarding the possible differential role of socio-demographic factors on the willingness to taste insect-based foods, our resultshighlighted that individuals' gender, education level, and food stylesimpact the attitudes of Italian consumers towards insects as a potential food source.

Regarding gender, women were more open to accepting entomophagy than men, and this is in disagreement with previous studies reporting that Italian women (Tuccillo et al., 2020, Palmieri et al., 2019, Sogari et al., 2017) and other European women in Belgium (Verbeke et al., 2015), the Netherlands (Tan, Van Den Berg, & Stieger, 2016), Germany (Hartmann et al., 2015), Hungary (Gere, Székely, Kovács, Kókai, & Sipos, 2017) and Switzerland (Schlup & Brunner, 2018), were less amenable to eating insect-based food. The only cluster not related to the environment, the group of *Indifferents*, was found to be balanced in terms of sex composition,

while the others were mainly composed of women, confirming their sensitivity towards sustainable consumption and environmental issues about the market (Merlino, Renna, et al., 2022). Age differences were not found in the clusters, thus contradicting previous research conducted in Italy (Sogari et al., 2023) and Denmark (Videbæk & Grunert, 2020), showing that intention to eat IBF decreases with the increases in age. The complexity of the presented data suggests the need to conduct further research to investigate the role of socio-demographics variables in Western societies. Significant differences in terms of the number of chosen IBF were not found but we were able to underline some interesting trends, which are partially in contrast with existing literature: on average, out of 11 types of IBF visually proposed to respondents, the four clusters chose 4 products similarly and we were not able to detect any statistical difference. Specifically, the most chosen foods were those in which the insect was not visible (e.g., 542 participants indicated that they were willing to consume pasta with insect flour, while only 172 expressed the same willingness for *spaghetti* with visible insects), confirming results obtained in real tasting experiences (Tuccillo et al., 2020) and suggesting a link between the visual presentation of IBF and actual behaviour. These results show that also food familiarity plays a role; indeed, existing studies showed that a combination of insects served with familiar products like pasta or spaghetti was identified as a further strategies which could increase acceptance of unfamiliar foods (Caparros Megido et al., 2014). However, in our sample, the most selected insect-based food was a muffin, not a typical Italian dish but very known in the Italian context, in which insects were not visible (683 agreements). This is an interesting finding in contrast with previous studies focusing on savoury products (Tan et al., 2017), thus suggesting a potential market niche for sweet foods and desserts, previously neglected. Again, considering products' visibility, significant distinctions were discovered among the four clusters when insects are not visible, such as insect burgers, insect sandwiches, and muffins made with cricket flour,

confirming results from different countries showing that consumers are more likely to eat insect-based food in which the disgust triggering optical stimuli are not visible (Hartmann and Siegrist, 2017). The *Greens* displayed the highest inclination towards insect-based food, while the *Selective eco-conscious consumers* exhibitedthe lowest inclination. This suggests that the ambivalence displayed by the latter group acts as a barrier to accepting insect-based food. Another interesting result is that the clusters more characterized by environmental issues, *Earth Balance Responsibles*, and *Selective eco-conscious consumers* are oriented to consume products where insects are not visible, like pasta with insect flour and insect protein bars. On the other hand, the *Indifferents* cluster is oriented to consume products where the insect is visible, like fried insects and tartlets with grubs. This difference is very interesting: it could be argued that the concern for environmental issues can trigger a dilemma between the willingness to eat insects for motives linked to sustainability and the contemporary concern for insects' well-being. This potential conflict is absent in the *Indifferents* and participants in this cluster may not perceive the visibility of the insect as a disturbing factor because they are not interested in environmental issues. Motives related to food dietary styles can be excluded because vegans and vegetarians were equally distributed in the clusters. Regarding our last research question, concerning a possible association between traditional and novel foods, we found interesting results through correlational analysis, answering the call made by Roma et al. (2020) for the investigation of the similarity of insects with raw seafood and crustaceans (Roma et al., 2020). The constant, albeit small association between traditional seafood (i.e. sea cicadas, fried fish, spaghetti with shrimps, percebes) and insect-based food, especially in foods where the insect is visible, could suggest an association between marine and terrestrial arthropods consumed as a food based on visual similarity. This association is not found where there is visual dissimilarity. To enhance consumer acceptance of insect-based foods, the findings suggest practical recommendations. Producers

should focus on creating products with invisible insect ingredients, such as pasta or muffins made with insect flour, as these are more widely accepted. Marketing strategies should be tailored to specific consumer clusters: highlighting sustainability for eco-conscious consumers and leveraging the visual similarity of insects to familiar foods like seafood to reduce disgust. Public education campaigns and collaborations with schools could improve knowledge of insect-based food potential benefits, while policymakers should support clear labelling and offer incentives for sustainable innovation in the food industry. These strategies can help align tradition and innovation, paving the way for greater adoption.

A more comprehensive exploration of Italian consumers' perceptions of insect consumption is necessary, including a broader investigation into the motivations of those open versus reluctant to taste IBF. Future studies could also delve into consumers' willingness to incorporate insects into their daily diets, considering that current research often treats entomophagy as a novelty. Assessing whether individuals, having tried and hopefully enjoyed insect-based foods, are genuinely open to making them a regular part of their diet is a significant aspect. This shift involves more than just a one-time taste test and is likely influenced by factors related to habits and traditions. In addition, it will also be necessary to consider the price of these products, which being new on the market, may not be affordable for everyone.

5. Conclusions

Despite the outlined constraints, this study provides valuable insights. It suggests that the acceptance of insect-based food among Italian consumers mirrors similar considerations observed in other European countries, such as exposure to foreign cuisine, local food traditions, and

educational factors (Cicatiello et al., 2016). Overcoming challenges related to the appearance of insect-based foods appears to be crucial for contemplating the integration of entomophagy into the Italian context.

This study contributed with data from a large sample of consumers in a Western country, making it possible to validate and extend previous findings in the entomophagy literature. Results have practical implications for the industry, in that insect food companies need more information on potential customers and their attitudes and intentions. In particular, the findings suggest that targeted marketing strategies could enhance the adoption of insect-based foods by focusing on environmental benefits for more eco-conscious consumers and emphasizing taste and visual appeal for more skeptical groups.

The study's limitations include reliance on self-reported preferences, the focus on Italian consumers, and the need for a broader environmental impact scale. Future research should explore insect-based food acceptance across different cultural contexts, assess the impact of education campaigns, and investigate ways to integrate insect-based ingredients into familiar foods to increase acceptance. Another limit is represented by the snowball sampling procedure which can affect the generalizability of results. Future studies should collect data that are representative of the Italian population. In addition, another limitation of this study was the absence of a question to check respondents' attention during compilation. Systems for quality control based on speed of compilation will also be included in future research to further ensure data integrity. Finally, also the composition of the sample, which was predominantly represented by women, could be considered as a limitation. This gender imbalance may affect the generalizability of the findings, as previous research has shown that men and women can differ in their food choices, particularly when it comes to novel or unconventional food sources like insect-based products. Future studies

should aim for a more balanced sample to better capture the diversity of attitudes towards insect-based foods across different demographics.

In conclusion, this research provides a contribution to the scientific literature through the definition of different consumption profiles, which provide a step forward in the knowledge of how the intersection of tradition, innovation, and sustainability concern can shape the future of the food system.

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