Agriculture and Food

AIMS Agriculture and Food, 10(2): 266–292.
DOI:10.3934/agrfood.2025014
Received: 12 September 2024
Revised: 28 March 2025
Accepted: 11 April 2025
Published: 12 May 2025

https://www.aimspress.com/journal/agriculture

Research article

Indirect entomophagy: Consumer willingness to pay toward fish fed with insect-based feed

Emanuele Dolfi, Margherita Masi, Ernesto Simone Marrocco*, Gizem Yeter, Martina Magnani, Yari Vecchio, Alessio Bonaldo and Felice Adinolfi

Department of Veterinary Medical Science, Alma Mater Studiorum, University of Bologna, Italy

* **Correspondence:** Email: ernesto.marrocco@unibo.it.

Abstract: The European Green Deal and the Farm to Fork Strategy outline the European Union's strategy to sustainably address growing global food demand. The European Commission's guidelines for sustainable aquaculture by 2030 emphasize the sector's crucial role in this goal, particularly by promoting the use of alternative raw materials in aquafeeds to reduce reliance on fishmeal and help preserve wild fish stocks. Insects and their ability to recover nutrients from human and animal waste represent a circular alternative nutrient source that could be integrated into aquafeeds. Several obstacles still exist for adopting insect-based feeds in aquaculture, and one is represented by the consumer's acceptance, especially in Western societies. Since data regarding consumer acceptance of indirect entomophagy is still lacking, the idea of this study stems from the intention to contribute knowledge on this issue. A multivariate analysis method was used on a sample of 2426 consumers, and it allowed the identification of three groups of consumers. In general, consumers lack interest in the sustainability aspects of aquaculture production, and thus in the consumption of aquaculture productions fed with insect meal emerged, highlighting the lack of understanding of the relevance of shifting from the linear models to a circular economy approach in the aquaculture sector. The effect of information on the potential improvement of sustainability in the sector, and thus on the benefits of introducing insect meal, promoted an average 15% increase in each group to purchase these products. These results confirm the need to promote knowledge and information systems in Italy to build the so-called blue economy.

Keywords: sustainability; circular economy; indirect entomophagy; insect meal; novel protein source; aquaculture

Abbreviations: AFI: after the information; BFI: before the information; BH: balanced habitual consumers; CA: cluster analysis; F2F: Farm to Fork Strategy; IBF: insect-based feed; IM: insect meal; OS: occasional and saving consumers; QC: quality-seekers frequent consumer; WTP: willingness to pay

1. Introduction

Since the world population is constantly increasing, which is expected to reach 10 billion people by 2060 [1], there is an urgent need to sustainably increase food production to meet the future global nutrient demand. In this regard, the European Farm to Fork Strategy (F2F) is meant to develop a zero-impact agri-food system that considers the externalities affecting the environment and population [2]. For this purpose, aquaculture has been identified as one pathway to reach this ambitious goal [3,4] due to farmed fish's excellent feed conversion and nutritional value. On the other hand, aquafeeds still represent an obstacle to the sustainable development of this sector, primarily because of their price [5] and their current formulation, which includes fish meal obtained from wild fish stocks and vegetable meals [6–8]. The inclusion of plant-derived ingredients, such as soybean meal, has not only demonstrated adverse effects on growth performance and fish health in many species—mainly due to antinutritional factors and nutritional imbalances—but also poses significant challenges by intensifying direct competition for resources intended for human consumption, as well as for land use and freshwater resources [9–11]. For this reason, the scientific community is constantly researching new sources of nutrients for aquafeed formulation. Insects are considered one of the best options, thanks to their ability to recover food and feed waste into new valuable raw materials, pursuing a circular model strategy for the supply of nutrients to fish diets [12–14].

On the contrary, the adoption of this practice is still limited for different reasons. Since cost-effective and large-scale insect rearing methods still need to be developed for competitive and robust production [15], the first limitation is represented by the higher costs of this raw material compared to traditional sources [6,8,16]. To date, the inclusion of insect raw materials in aquafeed would force farmers to increase feeding costs [17], which already represent between 40–70% of the total cost of production [18], reflecting with an increased final product price to the consumers. Furthermore, European regulations still constrain the breeding of insects for feed use to limited species and substrates [19].

Another barrier may be the final consumer acceptance, particularly for Western societies unfamiliar with direct or indirect entomophagy (i.e., insects as part of the feed formulation) in their daily diets or as part of culinary traditions [20]. The scientific literature focuses mainly on consumers' acceptance of insects as food [21,22], and most of them report disgust, neophobia, and perceived health risks toward these products [23–25], while studies regarding the acceptance of insects as feed, especially for aquafeed formulation, are still lacking [26] and need further investigation [27].

In this regard, this study aims to contribute to the debate on this topic by analyzing a sample of 2426 consumers residing in Italy to investigate the consumers' willingness to pay (WTP) towards fish fed with insect-based feed (IBF) and a possible existence of a pattern between socio-demographic variables and consumption habits of farmed fish products in relation to their WTP. In addition, the effect of informing consumers about the sustainability of insect farming directly influenced their WTP was evaluated.

2. Background

Consumer choices at the point of sale are influenced by information-seeking and habitual behaviors. The ultimate product choice "on the shelf" represents a critical juncture since all the efforts invested in the production chain above are distilled into a single moment. As reported in the F2F strategy [2], comprehending and predicting consumer choices and needs is crucial for developing a sustainable agri-food system because it can assist stakeholders and policymakers in crafting more effective offerings aligned with the UN's Sustainable Development Goals (SDGs).

Entomophagy (i.e., the direct consumption of insects) and indirect entomophagy (i.e., consuming animals fed by IBFs) (see Figure 1) are routine practices in the eastern side of the globe [28,29].

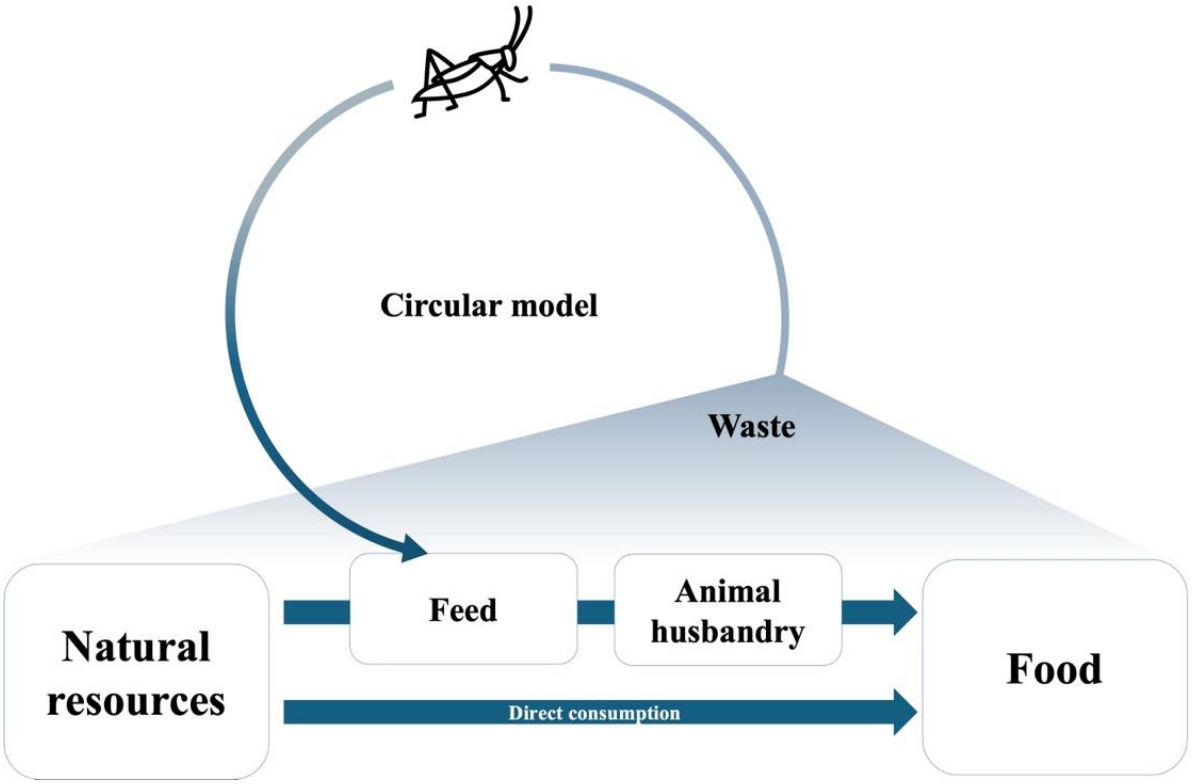

Figure 1. Indirect entomophagy in food consumption.

Understanding the consumers' and producers' acceptance is pivotal to evaluating the possibility of implementing insects as food and feed in the market of Western societies. The existing literature on insect consumption focuses mainly on the direct consumption of insects [30], particularly studies from Western countries [31] since these products are considered novel food. The main reason for the rejection of novel foods, especially those of animal origin, can be traced to the sense of disgust, which is a fundamental human reaction probably developed as a form of protection from possible hidden dangers from unfamiliar foods, reflecting on human risk perception and assessment mechanisms [32–34]. On the other hand, Baldi et al. [35] highlight how younger consumers, regardless of gender, occupation, or education, but with slightly higher income, trust innovation in food production. They actively seek new food sources, representing a more concrete possibility of future generations adopting these products for everyday consumption.

In contrast, studies on the perception and acceptance of indirect entomophagy by consumers are still few, and to date, the literature is discordant and still needs efforts to reach consistent results [26,27,36]. Most consumers generally do not have strong opinions on feed formulation or its environmental impact, primarily due to limited knowledge [37,38]; still, consumers generally prefer indirect entomophagy over the direct consumption of insects [21,39].

One of the first comprehensive analyses to gauge consumer acceptance perception toward indirect entomophagy is the PROteINSECT [40], funded by the European Union in 2016 [26]. This research involved a survey among 1300 consumers across 71 countries among Europe, East Asia, the Russian Far East, and Southeast Asia to measure the willingness to consume fish, chicken, and pork fed with insect protein. The results indicated that almost 73% of respondents were open to consuming this foodstuff.

The available information on consumer acceptance and perception of insects as part of feed formulation in aquaculture for the European population is scarce; this is likely because European legislation permitted the utilization of insect processed animal proteins (PAPs) only in 2017 through the Commission Regulation (EU) 2017/893 [41]. As a result, this research field is still in its early stages.

A study conducted on a sample of 277 Northern Italian consumers by Mancuso et al. [42] reported that nearly 76% of consumers are willing to buy and consume fish fed with insect meal (IM) if proper hygiene requirements are met. It is also emphasized that the willingness to purchase fish fed with IBF strictly correlates to the importance of price.

Laureati et al. [43] surveyed 341 students and employees from the Agriculture and Food Sciences Department of the University of Milan and other consumers outside the university. The required two socio-demographic variables were to be older than 18 years old and be Italian. The study focused on the willingness to adopt insects as food and feed; a positive trend to indirect entomophagy emerged, where 53% agreed to consume livestock, including fish, fed with IBF. Males and people with higher levels of education were significantly more willing to accept insects as feed than other consumers.

Kostecka et al. [44] investigated the acceptance of insect-based food to 210 randomly selected consumers from the Podkarpackie region, Poland. Unlike other livestock animals, poultry and fish had the highest acceptance (i.e., 58.1% and 56.7%, respectively). The consumer category that most approved IBF for fish were males older than 55 years old, probably associated with angling practices, says Kostecka and colleagues.

Ankamah-Yeboah et al. [45], in an online survey involving 610 German consumers, emphasized that approximately 23% of respondents had a negative perception of consuming fish fed with IBF compared to those fed with standard feed. Moreover, this group was not influenced by eco-labels such as organic and Aquaculture Stewardship Council (ASC).

Bazoche and Poret [46] surveyed 327 French consumers to assess the acceptability of consuming trout fed with insects. The study aimed to understand how information about the benefits of IM for fishery resources could influence consumers' perspectives. The results indicated that males appeared more receptive, possibly due to having lower-than-average food neophobia scores. Additionally, providing information to consumers about the environmental benefits of IM seemed to help overcome disgust barriers.

In the study conducted by Baldi et al. [35], they analyzed the attitude and acceptance toward fish fed with IBF in a sample of 482 Italian consumers aged under 40 years old. They reported how individuals between 18 and 25 years old exhibit a high level of openness to innovative products;

however, they are also the most concerned regarding using insects as feed in aquaculture. The significance of information is further underscored, as evidenced by the fact that informed consumers exhibited higher levels of acceptance compared to their less informed counterparts.

Giotis and Drichoutis [47] conducted an online questionnaire involving 451 consumers in Greece to investigate their acceptance and WTP for direct and indirect entomophagy. They found that approximately 55% of the respondents would be willing to pay a premium for gilt-head sea bream (*Sparus aurata*) fed with IBF, while the remaining 45% would require a discount. The results indicate that young adults, actively seeking new food sources, placing importance on certifications, and already trusting innovation in food products exhibited a higher WTP for gilt-head sea bream reared with IBF.

In the study conducted by Arru et al. [48] on an Italian population sample of 318 candidates, the price sensitivity of European sea bass (*Dicentrarchus labrax*) cost fed with IM was analyzed. Consumers have demonstrated a high price sensitivity, limiting the potential adoption of this practice. However, the results showed that consumers with limited information about the sustainability and benefits of insects as feed demonstrated higher price sensitivity, reducing willingness to spend more on insect-fed fish. Conversely, consumers with higher subjective knowledge positively correlated with their WTP.

In a similar study, Ferrer Llagostera et al. [49] examined, among a panel of 215 Spanish consumers, the WTP and perception toward utilization of IBF in the diet of farmed gilt-head sea bream. The results reported a higher WTP for sea bream fed with insects than fish fed with fish meal. In addition, IM-fed fish were perceived as more environmentally friendly than other feeds. Despite the higher cost, this type of fish was associated with the lowest expected taste perception compared to fish fed with conventional diets.

Ranga et al. [50] surveyed 233 Irish consumers (73 of them were farmers) on IBF acceptance in general animal husbandry, not only for aquaculture. 64.4% of the consumers favored consuming fish fed with IBF, while 11.6% were uncertain, and 24% were unwilling to consume it. Most participants would be prone to eat animals fed with IBF if insects were part of their natural diet and if this diet could positively impact the environment. They also report that price, food safety, and label information related to environmental and nutritional benefits positively influenced their willingness to consume. In the end, men were more willing to consume fish, while women were more concerned about the safety of these food products.

Baldi et al. [51] investigated and nudged the acceptance of using IM in farmed fish among 437 Italian consumers aged 55 and above through an online survey. The first finding is the consumers' perception of potential disgust and concerns over taste. At the same time, it is reported how nudging through images and information on sustainability changes consumers' intentions by changing the beliefs over the use of the consumers and the crucial role of the information for possible informational campaigns.

Roccatello et al. [52] interviewed 303 Italian consumers through an online questionnaire. What emerged is that variable such as age, and sustainability knowledge influence the respondents' willingness to consume. In this case, food neophobia directly influenced the perception of feed quality. They also highlighted that respondents with higher general knowledge of the aquaculture sector agreed more with the assumption that IBF may help the sector be more sustainable, and the central role of providing information to the consumer may affect their acceptance of this practice.

Several considerations emerged from the available literature review. Consumers seem generally ready to eat insect-fed farmed fish if hygiene and hedonistic requirements are respected and if they are

part of the natural diet of the reared animals. In fact, sensory liking plays a crucial role in determining the commercial success of products containing insects, whether unprocessed or processed, because people's perceptions of taste, texture, smell, and appearance heavily influence their willingness to try and continue consuming such products. Incorporating insects, directly or indirectly, into food products requires careful consideration of factors such as flavor profile, texture, and visual appeal to make them more palatable to consumers [53].

On the other hand, consumers' acceptance and WTP differ between countries and socio-cultural contexts. Still, increasing the awareness and environmental benefits of IM as a substitute raw material for fish meal in aquafeed formulation seems to positively affect the consumers' acceptance and perception.

3. Materials and methods

3.1. Data collection

To evaluate the consumer acceptance toward farmed fish fed with IBF, a questionnaire in the Italian language was administered using the computer-assisted-web-interview (CAWI) method, reaching an initial sample of 3373 individuals. The population quotas of the sample were defined based on data from the Italian National Institute of Statistics (ISTAT). The survey recorded a penetration rate of 75%, indicating the percentage of participants who responded to the questionnaire compared to the overall national selected population. The average time to complete the questionnaire was approximately 4 minutes and was organized into two sections (see Table 1).

The first part was developed to determine the socio-demographic variables characterizing the individual consumer, such as region of residence, age, gender, level of education, family composition, family movements in the last ten years, annual gross income, and dietary style.

The second section aimed to analyze the habits of the interviewee toward the consumption of farmed fish and their WTP a premium for fish raised with IBF. First, the frequency of consumption was analyzed through a single-answer closed-ended question. Then, to assess the "drivers of farmed fish purchase" and "key information on the package label," they were asked to order from the most to the least important the provided variables (see Table 1). The "purchase preference location" and "sources of information on benefits and consumption" were asked through closed-ended multiple-choice questions. Finally, the WTP was determined using the same closed-ended question and answers, both before (BFI) and after (AFI), providing the following information about insect farming sustainability: "In comparison to many other protein sources, insect farming requires less water and land, produces fewer waste products, and generates fewer greenhouse gases". These final questions were structured in terms of percentage increases relative to the current price of farmed fish. This methodological choice was made to ensure comparability among participants and to assess their WTP a premium for the product. Using percentage increments helped reduce the risk of anchoring to a specific price point, which could have influenced participants' responses. As the literature highlights, anchoring can distort price evaluation, leading consumers to overestimate or underestimate their WTP based on the initially suggested price [54].

Table 1. Questionnaire structure.

Question	Variable	Options/Responses
Purposive question		
Do you consume farmed fish?	Farmed fish consumption	Yes No
Section I: Socio-demographic		
	Gender	Male Female Other
	Age	18–24 years old 25–34 years old 35–44 years old 45–54 years old 55–64 years old Over 64 years old
	Education	Middle school license High school degree Bachelor's degree Master's degree Post university degree
	Annual gross income	0–15,000 € 16,000–20,000 € 21,000–35,000 € 36,000–75,000 € Over 75,000 €
	Geographical area of residence	Chosen from a list of 20
	Family members	Living with other people (friends, colleagues, etc.) Living with relatives (no partner, children or parents) Living alone Living with partner Living with a partner and children Living alone with children Living with parents and children Living with parents Other
	In the last ten years	My family has lived in the same territory for generations 1–2 times 3–5 times More than 5 times

Continued on the next page

Question	Variable	Options/Responses
	Dietary style	Omnivorous
		Vegetarian
		Other
Section II: Habits and WTP		
What is your frequency of consumption of farmed fish?	Frequency of consumption	Everyday
		2–3 times per week
		Once per week
		2–3 times per month
		Once a month
		Different times per year
		Rarely
Which of these factors influence your decision to purchase farmed fish? (order from the most important to the least)	Drivers of farmed fish purchase	Sensorial aspects
		Country of origin
		Quality-price ratio
		Fish health and welfare
		Sustainability of products
		Nutritional value
Which of these is your favorite place to buy farmed fish? (multiple answers)	Purchase preference location	Supermarkets
		Local markets
		Fishmongers
		Directly from the producers
		Online
Which of these are your favorite sources of information to learn about the benefits and consumption of farmed fish? (multiple answers)	Sources of information on benefits and consumption	TV programs, radio, newspapers
		Web
		Point of sale staff
		Relatives and friends
		Medical doctors
		Personal experience and habits
		Institutions (e.g., consortiums, cooperatives, etc.)
Which of these are the principal information on the package label of farmed fish products? (order from the most important to the least)	Key information on the package label	Best before/Day of harvest
		Environmental information/Certification label
		Ingredients and nutritional facts
		Information on fisherman/Farm/Product origin
		Brand
		Name of the product and species
How much would you pay for fish products raised with insect meal?	WTP before information (WTP-BFI)	Not willing to pay more
		Willing to pay up to 10% more
		Willing to pay between 10 to 25% more
		Willing to pay between 25 to 50% more
		Willing to pay more than 50%

Continued on the next page

Question	Variable	Options/Responses
"In comparison to many other protein sources, insect farming requires less water and land, produces fewer waste products, and generates fewer greenhouse gases" How much would you be willing to pay for fish products raised with insect meal?	WTP after information (WTP-AFI)	Still not willing to pay more Willing to pay up to 10% more Willing to pay between 10 to 25% more Willing to pay between 25 to 50% more Willing to pay more than 50%

3.2. Data analysis

Only the candidates who consumed farmed fish were included in subsequent analysis, and they were screened based on a first purposive question: "Do you consume farmed fish?". Thereby, 873 candidates were excluded from the initial sample. The final step before data analysis was a manual quality check to ensure all candidates had answered all the questionnaire questions, thereby excluding 74 interviewees. The final analyzed sample consisted of 2,426 candidates at the end of this process.

Furthermore, for a better representation, the twenty regions of residence have been grouped into four geographical areas, based on the Nomenclature of territorial units for statistics for the major socio-economic regions division (NUTS:1) made by EUROSTAT [55], named Northeast (Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige, Veneto), Northwest (Liguria, Lombardy, Piedmont, Aosta Valley), Central (Lazio, Marche, Tuscany, Umbria), Southern and Islands (Abruzzo, Basilicata, Calabria, Campania, Molise, Apulia, Sardinia, Sicily).

3.2.1. Descriptive and cluster analyses

The analysis began with a detailed descriptive analysis of the sample, focusing on key variables such as gender, age, education level, income, family composition, dietary habits, and geographical location. This step was essential for identifying socio-demographic and behavioral patterns within the dataset, ensuring a clearer understanding of the sample composition. These insights provided a necessary foundation for the subsequent cluster analysis (CA), allowing for a more structured segmentation of consumer groups. Subsequently, the data were analyzed using CA, which consists of a statistical method for processing data by grouping the elements of a set based on their characteristics into classes not assigned a priori, and it allows the reduction of the statistical units under study into internally homogeneous and externally heterogeneous groups. The criterion used to minimize the logical distance within the groups while simultaneously maximizing the difference between them varies depending on the type of variables utilized. The method is widely used in the social sciences [56], especially for consumer analyses [57,58]. This study used a two-step CA to identify groups with internally homogeneous and externally heterogeneous characteristics, which automatically determined the ideal number of clusters by means of the two-step cluster method. In this method, we used the log-likelihood as a distance measure, and the automatic clustering criterion is the Akaike information criterion (AIC). This information criterion calculates how far the probability distribution f, representing the model, deviates from the actual distribution g. It has the following definition:

$$AIC = 2k - 2\ln(L) \quad (1)$$

In this formula, L is the greatest value of the likelihood function of the estimated model, and k is the number of parameters in the statistical model.

The active variables utilized for the creation of the clusters were gender, age, education level, annual gross income, family composition, dietary style, geographical area of residence, frequency of consumption, drivers of farmed fish purchase, purchase preference location, sources of information on benefits and consumption, key information on the package label, WTP-BFI, and WTP-AFI. The software used for the analysis was SPSS-28.

4. Results

4.1. Consumers' socio-demographic profile

The sample was characterized by a predominance of the female gender, and about 63% of the interviewees were older than forty-five years old. Regarding the level of education, more than half graduated from high school, almost 40% graduated from college or higher degree levels, while a smaller share acquired a middle school license. Around 53% of the respondents declared a gross income between 16,000–35,000 €. Almost all of them followed an omnivorous diet; vegetarians, who usually don't eat animals, also consumed farmed fish.

The consumers have been asked to provide general information about their family composition and movements over the last ten years to make some considerations related to their family status. More than 40% of the respondents had children, and most lived with their respective partners; another significant percentage of those without children lived with their partners (52%). Many interviewed consumers stated that their families have lived in the same area for generations. Approximately three-quarters of the interviewed consumers declared that their families lived in the same location for generations. The analysis of consumers by geographical area highlighted a higher proportion of the population coming from the "Southern and Islands" area (34.5%). Considering the single regions, Lombardy represented the one with the highest number of respondents (see Table 2).

Table 2. Socio-demographic profile.

Socio-demographic variables	Total (n = 2426)	Percentage (%)
Gender		
Male	1178	48.6
Female	1248	51.4
Other	0	0
Age class		
18–24	187	7.7
25–34	317	13.1
35–44	398	16.4
45–54	469	19.3
55–64	390	16.1
Over 64	665	27.4

Continued on the next page

Socio-demographic variables	Total (n = 2426)	Percentage (%)
Education level		
Middle school license	238	9.8
High school degree	1265	52.1
Bachelor's degree	268	11.0
Master's degree/Complete degree	498	20.5
Post University degree	157	6.5
Annual gross income		
0–15,000 €	503	20.7
16,000–20,000€	413	17.0
21,000–35,000€	872	35.9
36,000–75,000 €	559	23.0
Over 75,000 €	79	3.3
Dietary style		
Omnivorous	2331	96.1
Vegetarian	56	2.3
Other	39	1.6
Family composition		
Living with other people (friends, colleagues, etc.)	17	0.7
Living with relatives (no partner, children, or parents)	24	1.0
Living alone	273	11.3
Living with partner	729	30.0
Living with a partner and children	903	37.2
Living alone with children	111	4.6
Living with parents and children	17	0.7
Living with parents	343	14.1
Other	9	0.4
In the last ten years		
My family has lived in the same territory for generations	1791	73.8
1–2 times	541	22.3
3–5 times	77	3.2
Over 5 times	17	0.7
Geographical area of residence		
Northeast	464	19.1
Northwest	637	26.3
Central	487	20.1
Southern & Islands	838	34.5

4.2. Consumers' habits and willingness to pay

In the second part of the survey, consumer information was gathered to understand consumers' habits regarding the consumption of farmed fish. Specifically, different variables were analyzed, including the frequency of consumption, factors influencing the purchase, purchase preference location, sources of information on benefits and consumption, and key information on the package label. Furthermore, the WTP a premium price for fish fed with IM, was evaluated, both before (BFI) and after (AFI) providing information on the sustainability of insect farming (see Table 3).

The analysis of the frequency of consumption of farmed fish products showed that a large part of the sample consumed these products weekly (65%). Most consumers indicated the quality-price ratio as the most important factor influencing the purchase of farmed fish products (31.9%), while sustainability of products took the last position (8.6%) (see Figure 2).

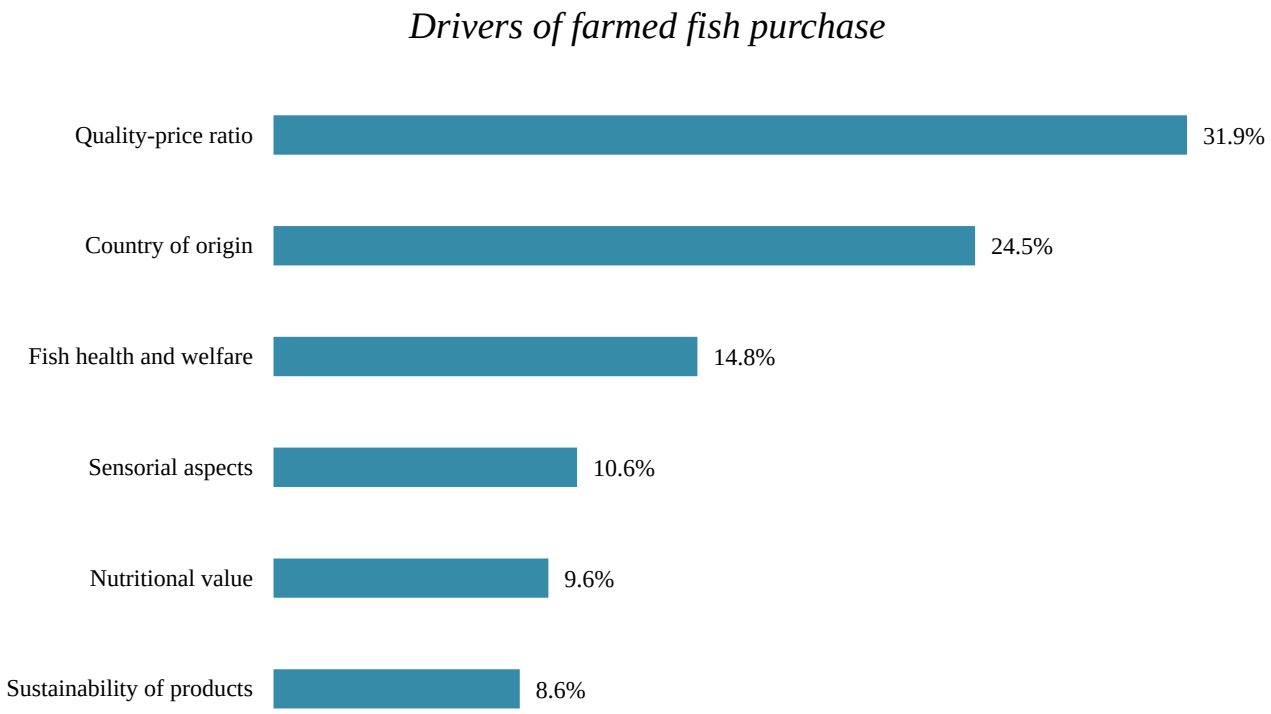

Figure 2. Drivers of farmed fish purchase among the analyzed sample.

Regarding purchase preference location, more than half of consumers said they usually buy farmed fish products from supermarkets and fishmongers (67.2% and 50.2%, respectively). The primary source of information is provided by the staff from the point of sale (44.6%), while 31% rely on their personal experience and habits. From the analysis of key information on the package label, the preferred choice of the interviewee was best before date/day of harvest (25.6%); environmental information/certification label, and brand were the last choices, 11.1% and 7.3%, respectively (see Figure 3).

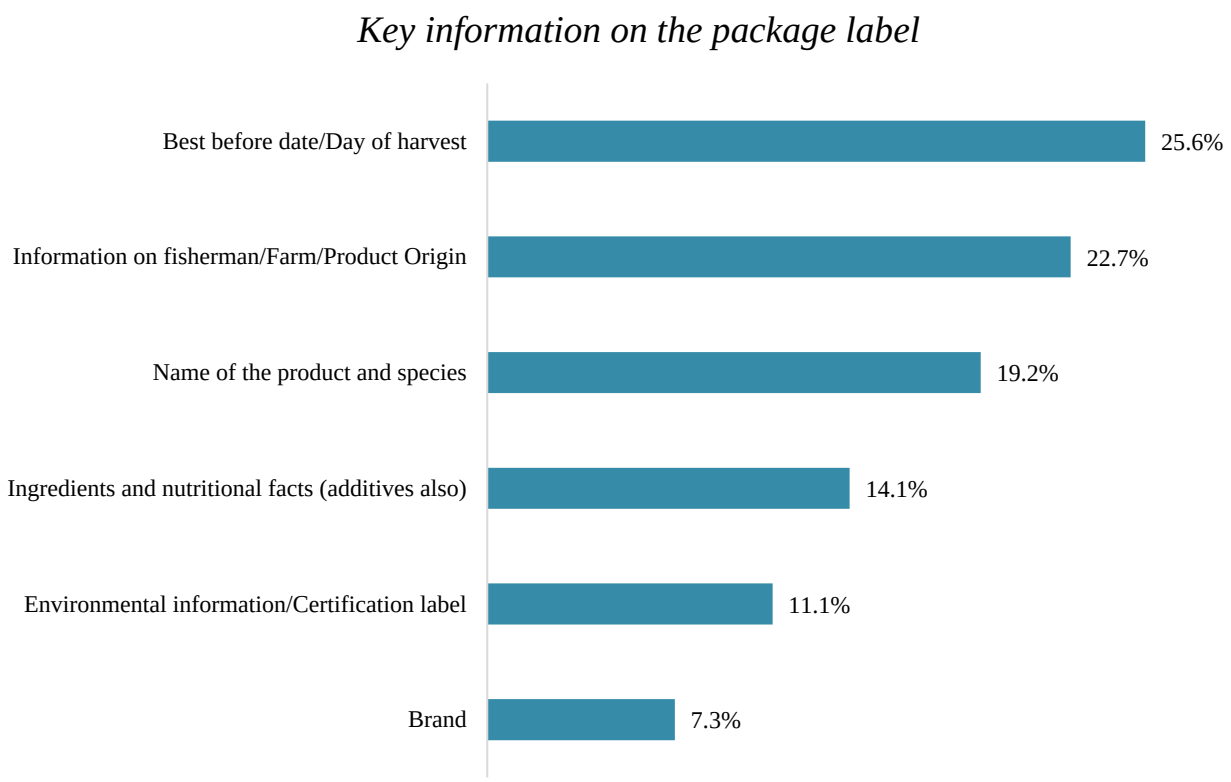

Figure 3. Preference for key information on the package label among the analyzed sample.

The results of the consumers' WTP a premium to buy fish fed with aquafeeds that enclosed IM in their formulation, showed that most respondents were not willing to spend more than the usual price (70.3%). In contrast, after the information was provided to the candidates, the share of "still not willing to pay more" (54.9%) decreased by around 15% (see Figure 4).

Table 3. Consumers' habits and WTP.

Consumers' habits in the consumption of farmed fish variables	Total (n = 2426)	Percentage (%)
Frequency of consumption		
Everyday	58	2.4
2–3 times per week	643	26.5
Once per week	887	36.6
2–3 times per month	533	22.0
Once a month	183	7.5
Different times per year	104	4.3
Rarely	18	0.7
Drivers of farmed fish purchase		
Sensorial aspects	257	10.6
Country of origin	595	24.5
Quality-price ratio	774	31.9

Continued on the next page

Consumers' habits in the consumption of farmed fish variables	Total (n = 2426)	Percentage (%)
Fish health and welfare	358	14.8
Sustainability of products	208	8.6
Nutritional value	234	9.6
Purchase preference location		
Supermarkets	1630	67.2
Local markets	535	22.1
Fishmongers	1219	50.2
Directly from the producers	246	10.1
Online	33	1.4
Sources of information on benefits and consumption		
TV programs, radio, newspapers	577	23.8
Web	893	36.8
Point of sale staff	1083	44.6
Relatives and friends	429	17.7
Medical Doctors	369	15.2
Personal experience and habits	752	31.0
Institutions	315	13.0
Key information on the package label		
Name of the product and species	466	19.2
Brand	176	7.3
Information on fisherman/Farm/Product origin	551	22.7
Best before date/Day of harvest	622	25.6
Ingredients and nutritional facts (additives also)	343	14.1
Environmental information/Certification label	268	11.1
Willingness to pay before information (WTP-BFI)		
Not willing to pay more	1706	70.3
Willing to pay up to 10% more	376	15.5
Willing to pay between 10 to 25% more	260	10.7
Willing to pay between 25 to 50% more	75	3.1
Willing to pay over 50% more	9	0.4
Willingness to pay after information (WTP-AFI)		
Still not willing to pay more	1331	54.9
Willing to pay 10% more	631	26.0
Willing to pay between 10% to 25% more	361	14.9
Willing to pay between 25% to 50% more	92	3.8
Willing to pay more than 50%	11	0.4

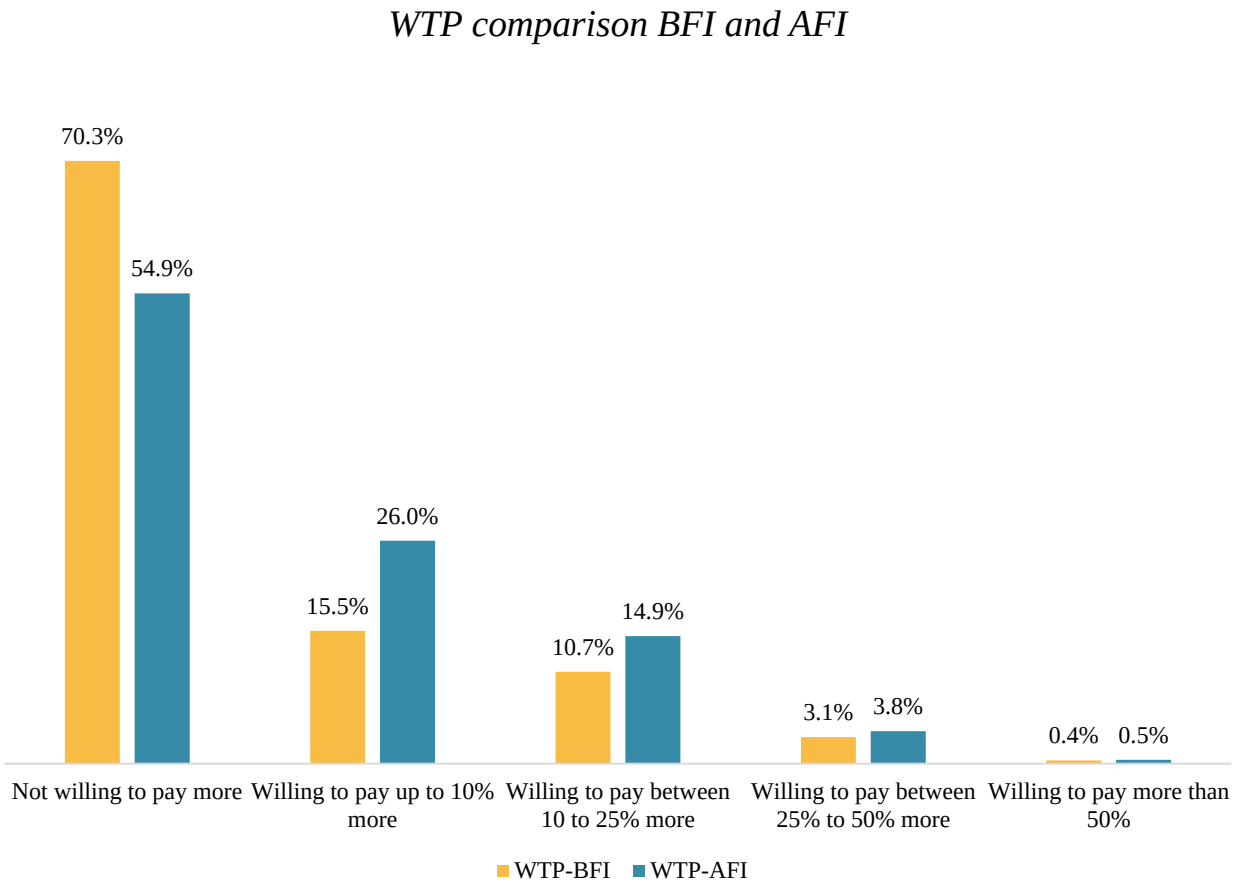

Figure 4. Consumer's willingness to pay toward fish fed with insect-based feed before and after the information was held.

4.3. Cluster analysis (CA) output

Three groups were obtained from the CA of the sample of 2426 consumers, and the division obtained was mainly based on the frequency of consumption and drivers of purchase.

The first group, occasional and saving consumers (OS), is differentiated from the other two based on the lowest frequency of consumption and the high consideration given to the quality-price ratio for the purchase decision. The second group exhibited an intermediate tendency towards the consumption of farmed fish products, compared to the other two consumption groups, basing their purchasing choice in a balanced manner on three main characteristics: the product's origin, the welfare of farmed fish, and the quality-price ratio. Therefore, they were called the balanced habitual consumers (BH). The remaining group, classified as the quality-seekers frequent consumers (QC), stood out due to more frequent consumption of farmed fish products, who considered the origin and the welfare of fish to be more critical at the time of purchase, without considering the quality-price ratio at all (see Table 4).

Table 4. CA results.

Variable	Options/Responses	OS (n = 700)	BH (n = 1095)	QC (n = 631)
Gender	Male	32%	71%	28%
	Female	68%	29%	72%
Age class	18–24	16%	3%	6%
	25–34	27%	6%	10%
	35–44	8%	28%	6%
	45–54	9%	32%	9%
	55–64	7%	26%	9%
	Over 64	33%	5%	60%
Education level	Middle school	9%	9%	12%
	High school	49%	52%	56%
	University degree	42%	39%	32%
Annual gross income	0–15,000 €	20%	19%	24%
	16,000–20,000 €	17%	18%	16%
	21,000–35,000 €	36%	37%	35%
	36,000–75,000 €	23%	23%	23%
	Over 75,000 €	4%	3%	3%
Kids in the family composition	Yes	30%	55%	35%
	No	70%	45%	65%
Dietary style	Omnivorous	97%	98%	92%
	Vegetarian	1%	2%	5%
	Other	2%	0%	3%
Geographical area	Northeast	17%	17%	25%
	Northwest	29%	23%	29%
	Center	20%	21%	19%
	Southern & Islands	34%	39%	28%
Frequency of consumption	Daily & 2–3 per week	25%	31%	30%
	Once per week	34%	36%	40%
	Monthly & yearly	41%	33%	30%
Drivers of farmed fish purchase	Sensorial aspects	11%	11%	11%
	Country of origin	4%	31%	35%
	Quality-price ratio	73%	19%	10%
	Fish health and welfare	2%	19%	21%
	Sustainability of products	2%	11%	11%
	Nutritional value	8%	9%	12%
Purchase preference location	Supermarkets	87%	75%	31%
	Local markets	24%	26%	13%
	Fishmongers	28%	45%	83%
	Directly from the producers	5%	9%	17%
	Online	1%	1%	2%

Continued on the next page

Variable	Options/Responses	OS (n = 700)	BH (n = 1095)	QC (n = 631)
Sources of information on benefits and consumption*	TV programs, radio, newspapers	23%	25%	23%
	Web	42%	37%	31%
	Point of sale staff	40%	46%	47%
	Relatives and friends	18%	16%	19%
	Medical doctors	13%	17%	15%
	Personal experience and habits	32%	32%	29%
	Institutions	12%	13%	15%
Key information on the package label*	Best before date/Day of harvest	31%	24%	22%
	Environmental information/Certification label	9%	12%	12%
	Ingredients and nutritional facts	13%	15%	15%
	Information on fisherman/Farm/Product origin	20%	23%	25%
	Brand	7%	8%	7%
	Name of the product and species	21%	19%	18%
WTP before information (BFI)	Not willing to pay more	72%	71%	68%
	Willing to pay up to 10% more	17%	15%	14%
	Willing to pay between 10 to 25% more	9%	11%	13%
	Willing to pay 25% more and above	2%	3%	5%
WTP after information (AFI)	Still not willing to pay more	57%	55%	53%
	Willing to pay 10% more	28%	25%	24%
	Willing to pay between 10% to 25% more	13%	15%	18%
	Willing to pay 25% more and above	2%	5%	5%

*Multiple answer.

4.3.1. Occasional and saving consumers (OS)

OS comprised 700 of the total sample. They were predominantly young (under 34) and over 64-year-old females residing in Italy's Central Southern regions. Most of them did not have children in

their families (70%). The prevailing level of education was high school (49%), although many were university graduates (42%). The annual gross income of this group was less than €35,000 (73%). The main factor influencing the purchase of farmed fish was the quality-price ratio (73%), giving the lowest consideration to fish health and welfare (2%) and the sustainability of the products (2%). The consumption of farmed fish products of this group was on a monthly/annual basis, mainly bought in supermarkets (87%). The main focuses on package label information were freshness (best before date/day of harvest), origin, and product/species name. This group prefers to be informed mainly through the web and by the staff at the sales points. Regarding WTP for fish fed with IM, most consumers were not prone to pay more (72%).

4.3.2. Balanced habitual consumers (BH)

BH represented the most numerous cluster, with 1,095 respondents, for most males aged 35–64 (86%) residing in Italy's Central/Southern regions. Just over half of this group had children in their family composition (55%). The prevailing level of education was the high school diploma (52%), although more than a third hold one or more university degrees (39%). The gross annual income was predominantly below €35,000 (74%). The frequency of consumption of farmed fish products was equally distributed among the three categories, with a higher frequency for once-a-week consumption. These consumers considered the product's origin (31%), the health and welfare of fish, and the quality-price ratio as principal purchase drivers. Freshness and details on the origin were considered the key label information by almost half of the candidates (47%). The preferred places of purchase were supermarkets and fishmongers. Point-of-sale personnel represented the primary sources of information. Most consumers were unwilling to pay more for fish raised with IM (71%).

4.3.3. Quality-seekers frequent consumers (QC)

QC were the smallest group, composed of 631 respondents. They were predominantly women over 64-years old without children from the northern regions of Italy. The primary educational level was a high school degree (56%). The income level of this group was mainly below €35,000 per year. The highest frequency of consumption was once a week. The primary purchasing factors were the product's origin and fish health and welfare. In this group, the quality-price ratio is the least considered driver (10%). Most preferred to make purchases at fishmongers (83%), while their information sources were staff at the points of sale. Key label information was freshness and the origins of the food product (47%). QCs were unwilling to pay a premium for products reared on IM feed; most were not prone to consuming this product (68%).

5. Discussion

Fish is generally perceived as a healthy and expensive source of nutrients [57,59,60], and many variables influence consumers' perception of this food product. Several considerations emerged from the results of our study regarding the consumption of farmed seafood products, the propensity of consumers to pay for fish fed with insect meal, and most importantly, consumer interest in sustainability aspects of the sector. The three groups differed primarily in gender, age class, kids in their family, consumption frequency, drivers, and places of purchase.

Regarding gender differences, the OS and QC groups are predominantly female. According to some studies, women tend to consume more fish than men [61]. In contrast, our results did not reveal a direct link between gender and consumption frequency, similar to the findings of Samoggia and Castellini [62].

Concerning age differences, our results confirm the findings of previous studies [61,63,64], which reported a generally higher frequency consumption of fish from older people compared to younger consumers, since the consumption frequency gradually increased from OSs to BHs and reached the highest frequency with the QCs, which is the group characterized by the oldest consumers.

The fact that the OS group is characterized by infrequent consumption driven primarily by value for money suggests that these consumers base their diets on other animal nutrient sources than fish, probably because of the higher cost compared to different foods. Furthermore, the relentless pursuit of savings may justify the limited interest in product characteristics such as origin, environmental sustainability, animal welfare, and especially the lowest WTP before and after the information was held. Since supermarkets represent this group's principal place of purchase, this characteristic suggests a low interest in seeking specific products compared to consumers who mainly purchase at fishmongers, which could provide a wider choice. On the contrary, the QC group, characterized by more frequent consumption, favors purchasing the product in specialized stores or even directly from the producer, suggesting specific research for farmed fish purchases. Furthermore, the fact that the quality-price ratio is given very little consideration indicates that this consumer group prefers to seek a product that meets criteria beyond the mere need for nourishment, such as the product's origin and the respect for the health and welfare of the fish. Finally, we find the BH group, which is positioned between the previously described consumer groups, as it is more balanced in terms of habits related to the purchase of farmed fish products, probably also mitigated by the higher presence of kids (compared to QCs) in the household leading to a lower consumption frequency, as reported by Verbeke and Vackier [61] and Jabs et al. [65].

On the other hand, similarities among the groups were characterized according to information sources, label information, and WTP variables.

Among the three consumer groups, the most relevant information on packages and labels, also reported by Masi et al. [58], were freshness and information about fisherman/farm/product origin. In addition, the brand took the last place of importance; in fact, it seems that Italians are more interested in promotional prices on the package than a firm, say Saidi et al. [60].

Regarding informational sources, every group predominantly relied on retailers at the points of sale and web-related sources for informational purposes, but with slight differences. It was interesting to observe how the share of importance of these two variables gradually shifted from one cluster to another based on their differences. For example, BH and QC, who presumably more frequently purchased fish directly from the counter, had direct contact with the retail sellers, so they relied more on their opinions and knowledge. There were no significant differences between the three groups described for the other informational sources. It was noteworthy that official sources, such as institutions and medical doctors, were of secondary importance compared to unofficial sources. This general view of the sample under study toward information sources is confirmed by Masi et al. [58] earlier research.

The limited attention to sensorial aspects observed in this study could be attributed to the fact that farmed fish is generally perceived as being of lower quality than wild-caught fish, particularly regarding taste-related characteristics [66,67]. In this regard, the findings may indirectly confirm this perception, as organoleptic quality did not play a key role in purchasing decisions across the three analyzed clusters. This suggests that the choice to purchase and/or consume farmed fish may be

influenced by other factors, such as its generally lower price compared to wild-caught fish, socio-demographic factors, beliefs, and objective knowledge [67,68], rather than the organoleptic characteristics of the product itself.

This aspect could also explain why the QC group does not assign greater importance to taste-related traits than the other groups. For these consumers, the perception of quality may extend beyond purely sensory characteristics to include ethical considerations such as animal welfare and product origin. In this sense, hedonism in food consumption is not necessarily limited to taste but can also encompass the satisfaction derived from making choices aligned with personal values. Previous studies [69,70] suggest that consumers who prioritize ethical and sustainability aspects may experience a sense of pleasure or fulfillment from consuming products that reflect their beliefs. This aligns with findings that ethical consumption can enhance perceived product quality and overall satisfaction [71].

From the present study's findings didn't emerge a defined socio-demographic profile more likely to pay a premium price for fish fed with insect meal, giving additional confirmation of the need to investigate these aspects further, which are poorly covered in the literature dealing with the consumer's point of view of indirect entomophagy. However, the CA results regarding WTP indicate that the QC group, primarily composed of women over 64 with the lowest education level among the three groups, is the most willing to pay more than 10% extra compared to the other two, while according to our knowledge, the socio-demographic profile of individuals inclined toward direct insect consumption, often identifying them as young [21,43,72], male [24,73,74], and higher-educated consumers [43].

The fact that the study does not show marked socio-demographic differences in understanding the acceptance of such products suggests that, generally, there is a low propensity to consume fish fed with IBF in Italy. There may be many causes, from disgust [21,75], neophobia [24,76,77], and potential health risks [20,22,23] to poor information and knowledge [35,46,48]. The consequence of this low propensity to spend a premium price not only represents a marked barrier to the emergence of these products on the market but also may limit the adoption of this practice from the producers [50], which are called upon to introduce it nowadays.

Confirming this low propensity toward paying a premium price, it is the negative criticism emerged regarding consumers' interest in the sustainability of fish products among the described groups. If, on the one hand, we find the OSs very price-sensitive and not very interested in the sustainable aspects of the product, it is interesting to observe how the opposite, the QCs, who are attentive to animal welfare and the origin of the product are not very interested in the sustainability of the product. This output demonstrates that the Italian consumer's attention to the sustainability of aquaculture products takes a back seat compared to other variables such as freshness and origin. This result was also confirmed by Bimbo et al. [59], who evaluated that only 10% of customers considered sustainability in purchasing fish products in their analyzed sample.

Although consumers do not see sustainability as a priority for fish production, encouraging results were obtained by asking whether they would be inclined to consume more sustainable products by introducing insect protein into their fish diet. Indeed, concerning information effect on insect farming sustainability, in the general view, every group positively increased their WTP, giving an additional confirmation to the previous studies conducted by Bazoche and Poret [46], Baldi et al. [35], Arru et al. [48], Baldi et al. [51], Dagevos and Taufik [79], Ranga et al. [50], and Roccatello et al. [52]. QC was initially more inclined to pay a premium for fish fed with IM before receiving information than the other two clusters. After the information, OS, BH and QC increased by 15%, 16% and 16%, respectively, the WTP. The 47% of QCs were prone to pay a premium, resulting in the group with the highest acceptance

for IBF-farmed fish. From a general perspective, less than half were prone to spend a premium for IBF fish, which is contrary to what was reported by Ferrer Llagostera et al. [49] and Giotis and Drichoutis [47]. Still, it should be considered that these studies have been done in countries other than Italy, where different socio-cultural variables influenced the final outputs. Still, the critical result was to assess the lack of interest in sustainability in farmed fish products among Italian consumers.

6. Conclusions

The study aimed to investigate Italian consumers' WTP a premium price for fish products reared using IM. It also investigated the drivers that might incentivize the practice of indirect entomophagy, with a particular focus on the environmental dimension and the role of information in determining the WTP for these products.

This research represents the first study among Italian consumers on the acceptance of fish raised with IBFs involving a substantial number of participants, although it is not without limitations.

First, results show how the hedonistic aspects and nutritional value did not take the expected importance as purchase drivers, differently than other research on drivers of fish consumption [59]. The reduced emphasis on sensory attributes does not necessarily indicate a lack of hedonic motivation, which instead calls for a broader, value-oriented interpretation of pleasure in food consumption, suggesting that future studies should focus on the multiple characteristics of the perceived quality of farmed fish. Moreover, as indicated by Saidi et al. [60], further research should assess the distance to the sea/lakes of the respondents rather than on a regional basis, which could provide additional insights into the consumption habits of farmed fish. Additionally, the decision to express WTP solely in terms of percentage increases presents certain limitations. As explained in the methodology section, this choice was made to reduce the risk of anchoring to a specific price point, which could have influenced participants' responses. However, consumers tend to reason in absolute terms, and their perception of a percentage increase may vary depending on factors such as income or individual characteristics [78]. Finally, a more in-depth analysis of possible negative WTP, as previously conducted by Giotis and Drichoutis [47], together with broader surveys on product acceptance [42,52], could provide valuable insights into consumer segmentation. Incorporating additional questions on the willingness to pay for such products, especially by including negative WTP, which is not widely studied by the literature, would allow for a clearer distinction between price-sensitive consumers and those with neophobic tendencies [80]. This approach could improve the understanding of consumer behavior by capturing those unwilling to pay a premium and those who might actively devalue the product due to lower acceptance, thus refining the interpretation of WTP responses. Future research should incorporate these aspects to develop a more comprehensive framework for assessing consumer acceptance and WTP for alternative and sustainable food sources.

Despite these limitations, the research results are consistent with the literature studied [46,48,49] and original in their interpretation.

A low propensity among the consumers to accept IBF fish emerged since less than half are not willing to spend more than usual. Regardless, the information positively affected the consumers' acceptance, even if it wasn't enough to drag the share above 50%. What needs to be highlighted is the poor interest from consumers regarding the sustainability aspects of aquaculture production, since from the results on consumers' habits in the consumption of farmed fish, this category always took the last places of interest. This study could anticipate future research on the adoption of indirect entomophagy

in aquaculture and the theme of the citizen-consumer gap [81], where on the one hand, European citizens demand more sustainable food production, while on the contrary, they are not willing to pay more as consumers. Regarding fish production, this gap is likely particularly pronounced among Italian consumers, underscoring the scarce concern of switching from the current linear models to a circular economy approach, as suggested by the blue economy model.

Concerning policy implications, the study's findings indicate a limited willingness among Italian consumers to pay a premium for fish fed with IBF, although an increase in acceptance is observed when sustainability-related information is provided. In a context where the Green Deal and the F2F strategy represent key EU initiatives aimed at establishing agriculturally produced food as the pathway for sustainability, policymakers could leverage these findings—specifically, that consumers are more inclined to pay when properly informed—by implementing awareness campaigns targeting a broader audience. Autonomous, industry-led initiatives could also complement public policies by providing precise and accessible information on the European Union's legal certifications, labelling systems, and production standards. These combined efforts may enhance consumer confidence in fish reared with novel feed sources and help mitigate psychological barriers such as neophobia and feelings of disgust. Mobilizing new information about the future of fish supply chains could help increase sustainable consciousness within the production sector and, on the other, promote new principles capable of shaping emerging patterns of circular consumption in line with the sustainability goals [82].

From a general perspective, insects may represent a new sustainable source of raw materials for the aquafeed formulation. However, from a practical point of view, IBF still needs time and a multidisciplinary approach from the stakeholders and policymakers to be implemented in aquafeeds.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Data availability

The data supporting this study's findings are available in aggregated form from the corresponding author upon request.

Conflict of interest

Yari Vecchio is an editorial board member for AIMS Agriculture and Food and was not involved in the editorial review or the decision to publish this article. All authors declare that there are no competing interests.

Author contributions

Conceptualization: M. Masi, E.S.M., Y.V.; Investigation: E.D., M. Masi, E.S.M.; Methodology: E.D., M. Masi, E.S.M., Y.V.; Writing original draft: E.D., E.S.M.; Writing - review & editing: E.D., M. Masi, E.S.M., G.Y., M. Magnani, Y.V., A.B., F.A.; Supervision: A.B.; F.A.; Validation: A.B., F.A. All authors have read and agreed to the published version of the manuscript.

References

1. Roser M, Ritchie H (2023) How has world population growth changed over time?. Our World in Data. Available from: https://ourworldindata.org/population-growth-over-time#article-citation.
2. European Commission (2020) Farm to Fork Strategy. Available from: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en#:~:text=Further%20information-.
3. FAO (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. FAO, Rome. https://doi.org/10.4060/ca9229en
4. FAO (2022) The State of World Fisheries and Aquaculture 2022. FAO, Rome. https://doi.org/10.4060/cc0461en
5. Adwan OMA (2017) Analyzing fish farming system in the Jordan valley comparative study. *J Soc Sci (COES&RJ-JSS)* 64: 827–832. https://doi.org/10.25255/jss.2017.6.4.827.832
6. Tschirner M, Kloas W (2017) Increasing the sustainability of aquaculture systems: Insects as alternative protein source for fish diets. *GAIA-Ecological Perspectives Sci Soc* 26: 332–340. https://doi.org/10.14512/gaia.26.4.10
7. Han DS, Shan X, Zhang W, et al. (2018) A revisit to fishmeal usage and associated consequences in Chinese aquaculture. *Rev Aquacult* 10: 493–507. https://doi.org/10.1111/raq.12183
8. Hua K, Cobcroft JM, Cole A, et al. (2019) The future of aquatic protein: Implications for protein sources in aquaculture diets. *One Earth* 1: 316–329. https://doi.org/10.1016/j.oneear.2019.10.018
9. Hedén I, Targhi BF, Baardsen G, et al. (2023) Dietary replacement of fishmeal with marine proteins recovered from shrimp and herring process waters promising in Atlantic salmon aquaculture. *Aquaculture* 574: 739735. https://doi.org/10.1016/j.aquaculture.2023.739735
10. Gasco L, Gai F, Maricchiolo G, et al. (2018) Fishmeal alternative protein sources for aquaculture feeds. In: Gasco L, Gai F, Maricchiolo G, et al., *Feeds for the Aquaculture Sector: Current Situation and Alternative Sources*, Cham: Springer, 1–28. https://doi.org/10.1007/978-3-319-77941-6_1
11. van Riel A, Nederlof MAJ, Chary K, et al. (2023) Feed-food competition in global aquaculture: Current trends and prospects. *Rev Aquacult* 15: 1142–1158. https://doi.org/10.1111/raq.12804
12. Jensen H, Elleby C, Domínguez IP, et al. (2021) Insect-based protein feed: From fork to farm. *J Insects Food Feed* 7: 1219-1233. https://doi.org/10.3920/jiff2021.0007
13. Belperio S, Cattaneo A, Nannoni E, et al. (2024) Assessing substrate utilization and bioconversion efficiency of black soldier Fly (*Hermetia illucens*) larvae: Effect of diet composition on growth and development temperature. *Animals* 14: 1340. https://doi.org/10.3390/ani14091340
14. Masi M, Adinolfi F, Marrocco ES, et al. (2025) A circular transition model for the European aquaculture sector. *Aquaculture* 596: 741819. https://doi.org/10.1016/j.aquaculture.2024.741819
15. Cadinu LA, Barra P, Torre F, et al. (2020) Insect rearing: Potential, challenges, and circularity. *Sustainability* 12: 4567. https://doi.org/10.3390/su12114567
16. Tran HQ, Nguyen TT, Prokešová M, et al. (2022) Systematic review and meta-analysis of production performance of aquaculture species fed dietary insect meals. *Rev Aquacult* 14: 1637–1655. https://doi.org/10.1111/raq.12666
17. Pulina P, Arru B, Madau FA, et al. (2018) Insect meal in the fish diet and feeding cost: First economic simulations on European sea bass farming by a case study in Italy. 2018 Conference (July 28-August), Vancouver, British Columbia. https://doi.org/10.22004/ag.econ.275929
18. Henry M, Gasco L, Piccolo G, et al. (2015) Review on the use of insects in the diet of farmed fish: Past and future. *Anim Feed Sci Technol* 203: 1–22. https://doi.org/10.1016/j.anifeedsci.2015.03.001

19. International Platform of Insects for Food and Feed (IPIFF) (2021) An overview of the European market of insects as feed. Available from: https://ipiff.org/wp-content/uploads/2021/04/Apr-27-2021-IPIFF_The-European-market-of-insects-as-feed.pdf.
20. Hartmann C, Shi J, Giusto A, et al. (2015) The psychology of eating insects: A cross-cultural comparison between Germany and China. *Food Qual Preference* 44: 148–156. https://doi.org/10.1016/j.foodqual.2015.04.013
21. Verbeke W (2015) Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. *Food Qual Preference* 39: 147–155. https://doi.org/10.1016/j.foodqual.2014.07.008
22. Hartmann C, Siegrist M (2016) Becoming an insectivore: Results of an experiment. *Food Qual Preference* 51: 118–122. https://doi.org/10.1016/j.foodqual.2016.03.003
23. Kouřimská L, Adámková A (2016) Nutritional and sensory quality of edible insects. *NFS J* 4: 22–26. https://doi.org/10.1016/j.nfs.2016.07.001
24. Imathiu S (2020) Benefits and food safety concerns associated with consumption of edible insects. *NFS J* 18: 1–11. https://doi.org/10.1016/j.nfs.2019.11.002
25. Tunca S, Budhathoki M, Brunsø K (2024) European consumers' intention to buy sustainable aquaculture products: An exploratory study. *Sustainable Prod Consumption* 50: 20–34. https://doi.org/10.1016/j.spc.2024.07.021
26. Gasco L, Biasato I, Dabbou S, et al. (2019) Quality and consumer acceptance of products from insect-fed animals. In: Sogari G, Mora C, Menozziet D, et al. (Eds.), *Edible Insects in the Food Sector: Methods, Current Applications and Perspectives*, Cham: Springer Nature, 73–86. https://doi.org/10.1007/978-3-030-22522-3_6
27. Mancini S, Sogari G, Espinosa Diaz S, et al. (2022) Exploring the future of edible insects in Europe. *Foods* 11: 455. https://doi.org/10.3390/foods11030455
28. Sogari G, Liu A, Li J (2019) Understanding edible insects as food in Western and Eastern societies. In: Bogueva D, Marinova D, Raphaely T, et al. (Eds.), *Environmental, Health, and Business Opportunities in the New Meat Alternatives Market*, Hershey (PA): IGI Global Scientific Publishing, 166–181. https://doi.org/10.4018/978-1-5225-7350-0.ch009
29. Feng Y, Zhao M, Ding WF, et al. (2020) Overview of edible insect resources and common species utilisation in China. *J Insects Food Feed* 6: 13–26. https://doi.org/10.3920/jiff2019.0022
30. Sogari G, Riccioli F, Moruzzo R, et al. (2023) Engaging in entomophagy: The role of food neophobia and disgust between insect and non-insect eaters. *Food Qual Preference* 104: 104764. https://doi.org/10.1016/j.foodqual.2022.104764
31. Stone H, FitzGibbon L, Millan E, et al. (2022) Curious to eat insects? Curiosity as a key predictor of willingness to try novel food. *Appetite* 168: 105790. https://doi.org/10.1016/j.appet.2021.105790
32. Rozin P, Fallon AE (1987) A perspective on disgust. *Psychol Rev* 94: 23–41. https://doi.org/10.1037/0033-295x.94.1.23
33. Curtis V (2011) Why disgust matters. *Philos Trans R Soc, B* 366: 3478–3490. https://doi.org/10.1098/rstb.2011.0165
34. Szendrő K, Nagy MZ, Tóth K (2020) Consumer acceptance of meat from animals reared on insect meal as feed. *Animals* 10: 1312. https://doi.org/10.3390/ani10081312
35. Baldi L, Mancuso T, Peri M, et al. (2021) Consumer attitude and acceptance toward fish fed with insects: A focus on the new generations. *J Insects Food Feed* 8: 1249–1263. https://doi.org/10.3920/jiff2021.0109

36. Magnani M, Claret A, Gisbert E, et al. (2023) Consumer expectation and perception of farmed rainbow trout (*Oncorhynchus mykiss*) fed with insect meal (*Tenebrio molitor*). *Foods* 12: 4356. https://doi.org/10.3390/foods12234356
37. Popoff M, MacLeod M, Leschen W (2017) Attitudes towards the use of insect-derived materials in Scottish salmon feeds. *J Insects Food Feed* 3: 131–138. https://doi.org/10.3920/jiff2016.0032
38. Profeta A, Hamm U (2018) Consumers' expectations and willingness-to-pay for local animal products produced with local feed. *Int J Food Sci Technol* 54: 651–659. https://doi.org/10.1111/ijfs.13933
39. Pakseresht A, Vidaković A, Frewer LJ (2023) Factors affecting consumers' evaluation of food derived from animals fed insect meal: A systematic review. *Trends Food Sci Technol* 138: 310–322. https://doi.org/10.1016/j.tifs.2023.05.018
40. PROteINSECT white paper (2016) Available from: https://www.proteinsect.eu/fileadmin/user_upload/press/proteinsect-whitepaper-2016.pdf.
41. Commission regulation (EU) 2017/893 (2017) Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0893.
42. Mancuso T, Baldi L, Gasco L (2016) An empirical study on consumer acceptance of farmed fish fed on insect meals: The Italian case. *Aquacult Int* 24: 1489–1507. https://doi.org/10.1007/s10499-016-0007-z
43. Laureati M, Proserpio C, Jucker C, et al. (2016) New sustainable protein sources: Consumers' willingness to adopt insects as feed and food. *Ital J Food Sci* 28: 652–668. https://doi.org/10.14674/1120-1770/ijfs.v476
44. Kostecka J, Konieczna K, Cunha L (2017) Evaluation of insect-based food acceptance by representatives of polish consumers in the context of natural resources processing retardation. *J Ecol Eng* 18: 166–174. https://doi.org/10.12911/22998993/68301
45. Ankamah-Yeboah I, Jacobsen JB, Olsen SB (2018) Innovating out of the fishmeal trap. *Br Food J* 120: 2395-2410. https://doi.org/10.1108/bfj-11-2017-0604
46. Bazoche P, Poret S (2020) Acceptability of insects in animal feed: A survey of French consumers. *J Consum Behav* 20: 251–270. https://doi.org/10.1002/cb.1845
47. Giotis T, Drichoutis AC (2021) Consumer acceptance and willingness to pay for direct and indirect entomophagy. *Q Open* 1: qoab015. https://doi.org/10.1093/qopen/qoab015
48. Arru B, Furesi R, Pulina P, et al. (2022) Price sensitivity of fish fed with insect meal: An analysis on Italian consumers. *Sustainability* 14: 6657. https://doi.org/10.3390/su14116657
49. Ferrer Llagostera P, Kallas Z, Reig L, et al. (2019) The use of insect meal as a sustainable feeding alternative in aquaculture: Current situation, Spanish consumers' perceptions and willingness to pay. *J Cleaner Prod* 229: 10–21. https://doi.org/10.1016/j.jclepro.2019.05.012
50. Ranga L, Noci F, Vale AP, et al. (2023) Insect-based feed acceptance amongst consumers and farmers in Ireland: A pilot study. *Sustainability* 15: 11006. https://doi.org/10.3390/su151411006
51. Baldi L, Trentinaglia MT, Peri M, et al. (2023) Nudging the acceptance of insects-fed farmed fish among mature consumers. *Aquacult Econ Manage* 28: 308–339. https://doi.org/10.1080/13657305.2023.2265875
52. Roccatello R, Endrizzi I, Aprea E, et al. (2024) Insect-based feed in aquaculture: A consumer attitudes study. *Aquaculture* 582: 740512. https://doi.org/10.1016/j.aquaculture.2023.740512

53. La Barbera F, Verneau F, Videbæk PN, et al. (2020) A self-report measure of attitudes toward the eating of insects: Construction and validation of the Entomophagy Attitude Questionnaire. *Food Qual Preference* 79: 103757. https://doi.org/10.1016/j.foodqual.2019.103757
54. Hofstetter R, Miller KM, Krohmer H, et al. (2020) A de-biased direct question approach to measuring consumers' willingness to pay. *Int J of Res Mark* 38: 70–84. https://doi.org/10.1016/j.ijresmar.2020.04.006
55. European Commission (2023) Eurostat regional yearbook. https://data.europa.eu/doi/10.2785/606702
56. Maravelakis P (2019) The use of statistics in social sciences. *J Humanit Appl Soc Sci* 1: 87–97. https://doi.org/10.1108/jhass-08-2019-0038
57. Sacchettini G, Castellini G, Graffigna G, et al. (2021) Assessing consumers' attitudes, expectations and intentions towards health and sustainability regarding seafood consumption in Italy. *Sci Total Environ* 789: 148049. https://doi.org/10.1016/j.scitotenv.2021.148049
58. Masi M, Di Pasquale J, Vecchio Y, et al. (2022) A cross-sectional study in Mediterranean European countries to support stakeholders in addressing future market demands: Consumption of farmed fish products. *Aquacult Rep* 24: 101133. https://doi.org/10.1016/j.aqrep.2022.101133
59. Bimbo F, Viscecchia R, De Devitiis B, et al. (2022) How do Italian consumers value sustainable certifications on fish?—An explorative analysis. *Sustainability* 14: 3654. https://doi.org/10.3390/su14063654
60. Saidi A, Sacchi G, Cavallo C, et al. (2022) Drivers of fish choice: An exploratory analysis in Mediterranean countries. *Agric Food Econ* 10: 29. https://doi.org/10.1186/s40100-022-00237-4
61. Verbeke W, Vackier I (2005) Individual determinants of fish consumption: Application of the theory of planned behaviour. *Appetite* 44: 67–82. https://doi.org/10.1016/j.appet.2004.08.006
62. Samoggia A, Castellini A (2017) Health-orientation and socio-demographic characteristics as determinants of fish consumption. *J Int Food Agribusiness Mark* 30: 211–226. https://doi.org/10.1080/08974438.2017.1403986
63. Birch D, Lawley M (2012) Buying seafood: Understanding barriers to purchase across consumption segments. *Food Qual Preference* 26: 12–21. https://doi.org/10.1016/j.foodqual.2012.03.004
64. Neale EP, Nolan-Clark D, Probst YC, et al. (2012) Comparing attitudes to fish consumption between clinical trial participants and non-trial individuals. *Nutr Diet* 69: 124–129. https://doi.org/10.1111/j.1747-0080.2012.01585.x
65. Jabs J, Devine CM, Bisogni CA, et al. (2007) Trying to find the quickest way: Employed mothers' constructions of time for food. *J Nutr Educ Behav* 39: 18–25. https://doi.org/10.1016/j.jneb.2006.08.011
66. Reig L, Escobar C, Carrassón M, et al. (2019) Aquaculture perceptions in the Barcelona metropolitan area from fish and seafood wholesalers, fishmongers, and consumers. *Aquaculture* 510: 256–266. https://doi.org/10.1016/j.aquaculture.2019.05.066
67. López-Mas L, Claret A, Reinders MJ, et al. (2021) Farmed or wild fish? Segmenting European consumers based on their beliefs. *Aquaculture* 532: 735992. https://doi.org/10.1016/j.aquaculture.2020.735992
68. Claret A, Guerrero L, Ginés R, et al. (2014) Consumer beliefs regarding farmed versus wild fish. *Appetite* 79: 25–31. https://doi.org/10.1016/j.appet.2014.03.031
69. Hwang K, Kim H (2016) Are ethical consumers happy? Effects of ethical consumers' motivations based on empathy versus self-orientation on their happiness. *J Bus Ethics* 151: 579–598. https://doi.org/10.1007/s10551-016-3236-1

70. Ganglmair-Wooliscroft A, Wooliscroft B (2017) Well-being and everyday ethical consumption. *J Happiness Stud* 20: 141–163. https://doi.org/10.1007/s10902-017-9944-0
71. Desai K, Tapas P, Paliwal M (2024) Evaluating the effect of values influencing the choice of organic foods. *Environ Dev Sustain* 17: 1–20. https://doi.org/10.1007/s10668-024-04836-7
72. Tan HSG, House J (2018) Consumer acceptance of insects as food: Integrating psychological and socio-cultural perspectives. In: Halloran A, Flore R, Vantomme P, et al. (Eds.), *Edible Insects in Sustainable Food Systems*, Cham: Springer, 375–386. https://doi.org/10.1007/978-3-319-74011-9_23
73. Hamerman EJ (2016) Cooking and disgust sensitivity influence preference for attending insect-based food events. *Appetite* 96: 319–326. https://doi.org/10.1016/j.appet.2015.09.029
74. Orsi L, Voege LL, Stranieri S (2019) Eating edible insects as sustainable food? Exploring the determinants of consumer acceptance in Germany. *Food Res Int* 125: 108573. https://doi.org/10.1016/j.foodres.2019.108573
75. Caparros-Megido R, Gierts C, Blecker C, et al. (2016) Consumer acceptance of insect-based alternative meat products in Western countries. *Food Qual Preference* 52: 237–243. https://doi.org/10.1016/j.foodqual.2016.05.004
76. Roma R, Ottomano Palmisano G, De Boni A (2020) Insects as novel food: A consumer attitude analysis through the dominance-based rough set approach. *Foods* 9: 387. https://doi.org/10.3390/foods9040387
77. Tunca S, Budhathoki M, Brunsø K (2024) European consumers' intention to buy sustainable aquaculture products: An exploratory study. *Sustain Prod Consum* 50: 20–34. https://doi.org/10.1016/j.spc.2024.07.021
78. Klingemann W, Kim J, Füller KD (2022) Willingness to pay. In: Homburg C, Klarmann M, Vomberg A (Eds.), *Handbook of Market Research*: Springer, 969–999. https://doi.org/10.1007/978-3-319-57413-4_35
79. Dagevos H, Taufik D (2023) Eating full circle: Exploring consumers' sympathy for circularity in entomophagy acceptance. *Food Qual Preference* 105: 104760. https://doi.org/10.1016/j.foodqual.2022.104760
80. Bass DA, McFadden BR, Messer KD (2021) A case for measuring negative willingness to pay for consumer goods. *Food Policy* 104: 102126. https://doi.org/10.1016/j.foodpol.2021.102126
81. Kollmuss A, Agyeman J (2002) Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ Educ Res* 8: 239–260. https://doi.org/10.1080/13504620220145401
82. Yeter G, Vecchio Y, Masi M (2025) Circular consumption in agrifood to become sustainable: A semisystematic review. *Circ Econ Sustain* 2025: 1–26. https://doi.org/10.1007/s43615-024-00464-5

AIMS Press