“Consumer acceptance of low trophic fish-farmed species”

Estudiante
Elisa Hernández Álvarez

Tutor
Rafael Ginés Ruiz

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UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA
Facultad de Veterinaria

ABSTRACT

Aquaculture is emerging as a crucial production system to address future food demands. While its environmental footprint is smaller compared to other food industries, the circular economy can further enhance aquaculture sustainability, especially for low trophic level species that can utilize by-products from agricultural production. This study aimed to assess consumer perception of farmed thicklip grey mullet (*Chelon labrosus*) within the context of a circular economy approach to aquaculture. A sensory evaluation was conducted involving three fish species: thicklip grey mullet, gilthead seabream, and European seabass. Thus, a survey was administered to understand consumer attitudes towards fish consumption, aquaculture, and the circular economy. Results indicated that while thicklip grey mullet was less familiar to consumers compared to the other two species, it was generally well-received. However, perceptions of wild-caught versus farmed fish persisted, with consumers associating wild-caught fish with higher quality and freshness. The study highlighted the importance of consumer education and effective communication strategies to address these misconceptions and promote the benefits of sustainable aquaculture. To foster consumer acceptance of farmed fish, particularly low-trophic-level species like thicklip grey mullet, it is essential to emphasize the role of sustainable aquaculture in reducing environmental impact, ensuring food security, and providing high-quality, nutritious products. By addressing consumer concerns, promoting transparency, and highlighting the benefits of sustainable aquaculture practices, the industry can contribute to a more sustainable and resilient food system.

1. INTRODUCTION

1.1. Application of circular economy in aquaculture

The circular economy aims to optimize the use of resources by prolonging their presence in the production cycle for as long as possible, minimizing waste generation and making use of those by-products whose production could not be avoided (MITECO, 2024).

Five principles to transform agro-food systems into a circular bio-economy have been defined (Muscat et al., 2021; Verreth et al., 2023):

- Safeguard the health of agro-ecosystems
- Avoid waste
- Prioritise the use of biomass streams for basic human needs
- Use and recycle by-products
- Use renewable energy

In modern aquaculture, these principles are primarily applied through initiatives such as waste management, the recycling of nutrients and by-products, the incorporation of new sustainable ingredients in aquafeeds, and innovative production systems that reuse excess nutrients. Among these systems, aquaponics and integrated multi-trophic aquaculture (IMTA) are particularly noteworthy (Chary et al., 2023). Aquaponics combines recirculating aquaculture with hydroponics in a single production system (FAO, 2020), while IMTA integrates the cultivation of species from different trophic levels within the same environment (Kamleshbhai et al., 2023). This model allows, for instance, the complementary cultivation of fish, mollusks, and algae, where the waste produced by some species serves as resources, such as feed or fertilizer, for others (Kamleshbhai et al., 2023).

1.2. Implementation of a circular system in local aquaculture

The Canary Islands offer ideal conditions for the development of aquaculture. The mild climate, with minimum water temperatures of 17-18°C, allows for year-round growth and reduces the risk of disease outbreaks. This results in shorter cultivation periods and a competitive advantage

for cultivating large sizes of various species. The islands' location also provides a barrier against diseases prevalent in other regions, supporting organic certification (GOBCAN, 2014). Moreover, there is a long-standing tradition of cultivating species such as gilthead seabream and European seabass, which reached sales of 1,502 and 5,383 tons, respectively, in 2023 (GOBCAN, 2024a).

Additionally, the archipelago is also the leading producer of bananas in Spain (MAPA, 2022), with approximately 470,000 tons produced in 2023 (ASPROCAN, 2023). Despite being the region's most significant agricultural activity, banana harvesting process generates a high amount of residues, nearly 80% of the total plant mass, which has traditionally been used as livestock feed (Ramírez-Bolaños et al., 2023).

The aquaculture sector has undergone a significant process of innovation and diversification in recent decades, particularly concerning fish feed (APROMAR, 2023b). The use of new raw material sources in feed formulations is essential for maintaining the sector's sustainability standards and ensuring its future growth (APROMAR, 2023b).

In line with this approach, previous research has explored the use of by-products such as banana pseudo-stem and banana flower as feed for low-trophic-level species, like tilapia, achieving promising results (Ramírez-Bolaños et al., 2023).

For this study, an isocaloric and isoproteic diet was designed incorporating 20% of banana pseudo-stem by-product as an alternative ingredient to cornmeal. The pseudo-stem, supplied by local producers of banana cultivars (*Musa acuminata*; Cavendish subgroup of the AAA banana cultivar group), was processed to extract external fibers for bioplastic purposes, while the ramaining residue was treated, sanitized, dried, sterilized and grind for later inclusion as raw material in fish feed. The approximate composition of the banana pseudo-stem is detailed in Table 1.

Table 1. Proximate composition in wet weight of pseudo-stem banana by-product

Lipids	1.01±0.32%
Protein	7.25±2.48%
Ash	15.97±2.67%
Carbohydrates	76.09±5.58%
Moisture	8.97±1.01

1.3. Justification of *Chelon labrosus* as a species of interest

Chelon labrosus, also known as thiklip grey mullet ("lebrancho"), is a promising option for diversifying aquaculture in the Canary Islands (García-Márquez et al., 2021) following the principles of the circular economy. Although the current trend in the European Union focuses on the cultivation of carnivorous or high-trophic-level species (Guillen et al., 2025), this approach faces significant challenges due to the high production costs associated with the need for large quantities of fishmeal and fish oil (Pujante-Rodríguez, 2019) and the environmental impact generated by their production compared to herbivorous or omnivorous species, whose cultivation is considered more sustainable (Guillen et al., 2025).

Within the framework of European Union sustainability policies, the future of the aquaculture sector depends on promoting sustainable practices that integrate environmental, economic, and social objectives (Guillen et al., 2025). In this context, farming low-trophic-level species, such as *Chelon labrosus*, takes on particular significance. Its potential as an aquaculture species is partly determined by its adaptability to different environmental conditions and its omnivorous feeding habits (Pujante-Rodríguez, 2019), which facilitate the incorporation of diets based on by-products from local banana cultivation, as has been demonstrated with other low-trophic-level species such us tilapia (Ramírez-Bolaños et al., 2023). Additionally, it is a native species that is naturally found in our environment (Figure 1) (Pujante-Rodríguez, 2019).

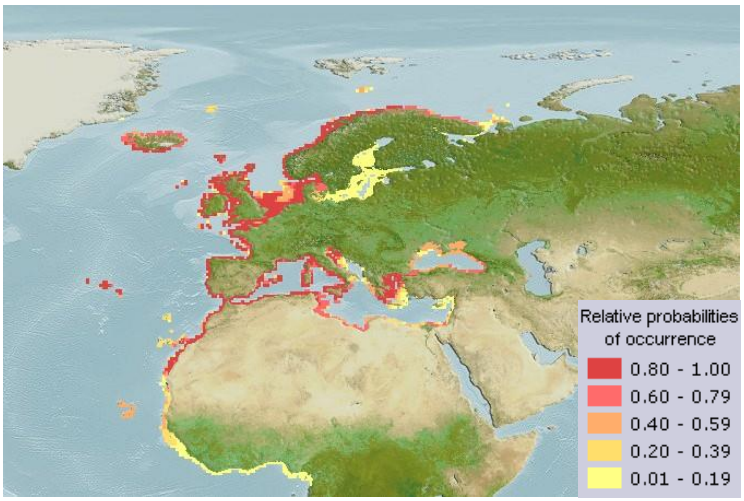

Figure 1. Geographical distribution of *Chelon labrosus*. (AquaMaps, 2019)

Therefore, the circular economy offers an opportunity to implement innovative practices in the aquaculture of this species, which would help reduce production costs, optimize the use of local resources, and minimize waste generation, aligning with the sustainability goals promoted by the European Union.

1.4. Promoting trust in aquaculture as a strategy for growth

Global consumption of aquatic foods has significantly increased in recent years (FAO, 2024) due to the growth of aquaculture, which plays an increasingly important role in the future food supply (APROMAR, 2023b). However, as aquaculture production expands to meet the rising demand for seafood (FAO, 2024), its environmental impact also increases. Although this impact varies considerably depending on the species farmed and the production method used, it is generally lower than that of other animal protein production (Guillen et al., 2025), such as beef or pork (APROMAR, 2023b). This makes aquaculture the livestock activity with the smallest carbon footprint (APROMAR, 2023a), highlighting its potential to provide sustainable and highly nutritious food (FAO, 2024).

Nevertheless, consumers tend to perceive farmed fish less favorably compared to wild-caught fish due to various factors related to preconceived beliefs and sensory perceptions.

One of the main reasons for this negative perception of farmed fish is the belief that wild-caught products are fresher, more natural, and of higher quality, while aquaculture products are often associated with a more artificial and manipulated process (Claret et al., 2014). Additionally, the use of antibiotics and artificial feeds in aquaculture systems reinforces the idea that wild-caught fish is healthier (Claret et al., 2014). Cultural factors also play a role, as extractive fishing is traditionally associated with a higher standard of quality, leading to a greater preference for these products (Mitra et al., 2021). However, previous studies have shown that blind taste tests reveal no differences in taste or quality between wild-caught and farmed fish, suggesting that many of these beliefs are unfounded and can be reshaped through appropriate information (Claret et al., 2016), highlighting the need to implement communication strategies aimed at informing and educating consumers about the benefits of aquaculture, especially when sustainable practices such as the use of agricultural by-products in feeds are adopted.

2. OBJECTIVES

Building on the premises outlined above, this study aims to delve into consumer perceptions of farmed thicklip grey mullet (*Chelon labrosus*) through a sensory tasting involving different aquaculture species familiar to consumers, followed by a post-tasting survey assessment. The specific objectives of this research are as follows:

a. To determine the local consumer acceptance of a low-trophic-level aquaculture species (*Chelon labrosus*) through a sensory evaluation.

b. To compare the organoleptic quality of three aquaculture species (gilthead seabream, European seabass, and thicklip grey mullet) based on consumer perceptions.

c. To identify and analyze the socioeconomic factors that influence consumer perception.

d. To evaluate how different levels of information (no information/information about the fish species, but not the production method/information of both the fish species and the production method) impact consumer perception and acceptance.

3. MATERIAL AND METHODOLOGY

3.1. Consumer selection

A total of 189 consumers were recruited using quota-based probabilistic sampling, considering gender (at least 45% male) and age (18 to 75 years). Recruitment was carried out through a marketing agency hired for this purpose.

3.2. Instrument

A specific questionnaire was designed, consisting of 98 questions divided into 10 sections as follows: demographic data (6 questions); knowledge of sustainable aquaculture practices (11 questions); degree of participation in food purchasing and preparation (4 questions); fish consumption frequency (10 questions); general knowledge of aquaculture and fishing (26 questions); main criteria for choosing fish to consume (6 questions); evaluation of the information received about the project (9 questions); trusted sources of information on aquaculture (8 questions); main reasons conditioning paying more or less for fish; and sensory analysis (9 questions). Questions regarding the sensory analysis of each species included taste, texture, and overall evaluation.

3.3. Sample presentation

Consumers were invited in groups of 24 and received varying levels of prior information before tasting and evaluating the fish samples. One group of consumers had no information about what they were consuming (NO INFORMATION). In a second group, the species to be consumed was identified but without additional information (SPECIES INFORMATION). In the third group, in addition to identifying the species, consumers were informed about the project's objectives and the relevance of farming low-trophic-level fish species within the context of the circular economy. This included highlighting the work with a native species and its potential implications for the local economy (PROJECT INFORMATION).

Each consumer received three successive samples of fish cooked in individual aluminum food trays in an oven at 115°C for 10 minutes. For the NO INFORMATION group, the order of the

samples was randomized for each consumer to prevent order effects from influencing their evaluations. For the other two groups, this step was unnecessary, as the species to be sampled were identified beforehand.

The species evaluated included thiklip grey mullet (*Chelon labrosus*), the target species for development within the project, as well as gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*), two commercially common species well-known to consumers and serving as references to gauge the acceptance of the target species.

The gilthead seabream and European seabass used in this study were sourced from local fish farming companies. The thiklip grey mullet was farmed at the Aquaculture Facilities of the Science and Technology Park Foundation of the University of Las Palmas de Gran Canaria until it reached a size comparable to that of commercially farmed specimens. In all cases, the fish were descaled and filleted into portions of 25 grams prepared for cooking.

3.4. Sensory evaluation

Each consumer was provided with a template for evaluating each fish sample. They rated the texture, taste, and overall acceptance of the product on a continuous, ungraded scale anchored at 0 (minimum value) and 10 (maximum value).

3.5. Statistical análisis

Descriptive analyses were conducted for all variables. Means, standard deviation (SD), medians, and ranges were calculated for continuous variables. Proportions were calculated for categorical variables. The normality of the data was tested using the Kolmogorov-Smirnov test. Comparisons between groups were performed using parametric (student t-test or ANOVA test) or non-parametric test (Kruskal-Wallis). To assess significant differences among the means of the different groups, a post hoc Tukey test was performed. Differences in the categorical variables were tested by the chi-squared test. The data were analyzed using SPSS v22 statistical software (Armonk, NY, USA). Probability levels of <0.05 (two tailed) were considered statistically significant.

4. RESULTS

4.1. Demographic analysis

A total of 189 people participated in the survey. The percentage of women and men was 50.3% and 49.7%, respectively. The mean age of the series was 39.1 ± 14.6 years (median = 37, range 16 – 80 years). Most of the participants had a university education (62.7%) and were salaried employees (58.1%). Regarding income level, 30.6% of the participants reported an income of less than 1500 euros per month, and 56.9% reported an income of 1500 to 2500 euros per month. Only 12.3% of the participants reported living alone, and 34.8% of them had three members in the household. When divided into groups, 79 (41.8%) participants were included in group A (unaware of the type of fish and its production method), 45 (23.8%) in group B (aware of the type of fish but not the production method), and 65 (34.4%) in group C (aware of both the type of fish and the production method prior to tasting).

The demographic analysis of the three study groups showed no significant differences in gender, educational level, profession, income, or household size, ensuring proper comparison across groups (Table 2). The only significant difference was in age ($P = 0.005$), with Group C being younger on mean (34.5 years). Group A had a mean age of 41.4 years and Group B had 41.7 years. Gender distribution was balanced across groups. Most participants had university-level education, and the majority were salaried employees. Income distribution and household size were similar, with no significant differences noted among the groups.

4.2. Analysis of prior knowledge of production models

The term blue economy was known by 38.6% of respondents (n = 71), while 32.1% of the respondents were unfamiliar with it. The majority of those who claimed to know the meaning of the term had a university education (77.5%, 55 out of 71 individuals), whereas 50% of those with primary education (6 out of 12) and 52% of respondents with bachelor education (26 out of 50) stated they were not familiar with the term ($P = 0.003$). No differences were observed regarding this in relation to group (A, B, or C), age, or gender of the respondents.

In the whole series, aquaculture and circular economy were the most recognized terms, with 74.2% and 67.7% “yes” responses, respectively (Table 3). On the contrary, hydroponics and

aquaponics were the least known terms, recording the highest percentages of unawareness (54.6 and 63.2%, respectively). Significant differences were observed in age categories regarding knowledge of aquaculture ($P < 0.001$). Participants aged ≤25 years showed less knowledge compared to those aged 26 – 64 and ≥65 years. Thus, while 48.8% of participants under 25 years old were familiar with aquaculture, this percentage increased to 82.4% and 75.0% among participants aged 26 to 64 and those over 65, respectively (Table 3). No significant gender differences were found for any term. No differences were observed among the three groups into which the participants were divided. Educationally, university-level participants exhibited greater awareness of circular economy ($P < 0.001$), while participants with primary education exhibited the highest levels of unawareness (80.3 and 38.5%, respectively). Other terms showed no significant differences across educational levels. Efforts to enhance awareness of aquaculture and circular economy should target younger participants, while initiatives for hydroponics and aquaponics should engage all age groups, especially focusing on younger individuals. Education interventions are crucial, particularly for participants with primary education, to improve understanding.

40.4% of the respondents (74 out of 189) considered the role of the circular economy to be very influential or completely influential in daily life, while 22 people (11.6%) considered it to be not at all, slightly, or somewhat influential. Most of the people who positively valued the circular economy in daily life were between 26 and 65 years old (53 out of 129 individuals in this age range, 41.1%), while 45.4% of respondents over 65 years old (5 out of 11) considered the circular economy to be not at all or slightly influential ($P < 0.001$). A statistical difference was observed regarding the level of education, with individuals holding bachelor degrees being the ones who most valued the influence of the circular economy in daily life (46% of them) followed by individuals holding university degrees (38.2%). In contrast to the 41.6% (5 out of 12) of those with primary education who considered it to have no, little, or some influence ($P = 0.002$). No other significant differences were observed.

Regarding the influence of the circular economy on job creation, 44.8% of respondents considered it very or highly influential, in contrast to the 16.4% who considered it to have no, little, or some influence. No statistically significant differences were observed based on age, gender, education level, or group.

Table 2. Descriptive analysis of the main demographic variables in the three study groups (N, (%)).

	Group A (n = 79)	Group B (n = 45)	Group C (N = 65)	*P* value[#]
Gender				0.937
Female	40 (51.3)	23 (51.1)	31 (48.4)	
Male	38 (48.7)	22 (48.9)	33 (51.6)	
Age (years)				**0.005***
Mean ± SD	41.4 ± 15.9	41.7 ± 13.0	34.5 ± 12.9	
Median (range)	42 (16 – 80)	44 (18 – 69)	30 (18 – 66)	
Educational level				0.451
Primary studies	7 (9.0)	3 (6.7)	3 (4.7)	
Secondary studies	3 (3.8)	2 (4.4)	1 (1.6)	
Bachelor studies	19 (24.4)	17 (37.8)	15 (23.4)	
University studies	78 (62.8)	23 (51.1)	45 (70.3)	
Profession				0.194
Self-employed	10 (12.8)	4 (8.9)	3 (4.8)	
Salaried employee	45 (57.7)	27 (60.0)	36 (57.1)	
Student	12 (15.4)	4 (8.9)	16 (25.4)	
Retirees, unemployed, and others[†]	11 (14.1)	10 (22.2)	8 (12.7)	
Income (€)				0.451
<1500	24 (31.2)	12 (26.7)	21 (32.8)	
1500 – 2500	42 (54.5)	30 (66.7)	34 (53.1)	
2500 – 3500	5 (6.5)	1 (2.2)	7 (10.9)	
>3500	6 (7.8)	2 (4.4)	2 (3.1)	
Household size (persons)				0.260
1	13 (16.7)	2 (4.4)	8 (12.5)	
2	15 (19.2)	11 (24.4)	18 (28.1)	
3	25 (32.1)	21 (46.7)	19 (29.7)	
4 or more	25 (32.1)	11 (24.4)	19 (29.7)	

Group A: unaware of the type of fish (European seabass, thicklip grey mullet, and gilthead seabream) or its production method.
Group B: aware of the type of fish but not the production method.
Group C: aware of both the type of fish and the production method prior to tasting.
[#]Chi-square test.
*Kruskal-Wallis test.
[†]Others includes civil servants, part-time jobs, or internship contracts.

Table 3. Descriptive analysis of the prior knowledge that the surveyed population had regarding terms related to the present study (N, (%)).

	Aquaculture			Hydroponics			Aquaponics			Circular Economy			Common Good Economy		
	No	Vaguely	Yes	No	Vaguely	Yes	No	Vaguely	Yes	No	Vaguely	Yes	No	Vaguely	Yes
Whole series	21 (11.3)	27 (14.5)	138 (74.2)	101 (54.6)	40 (21.6)	44 (23.8)	117 (63.2)	42 (22.7)	26 (14.1)	28 (15.1)	32 (17.2)	126 (67.7)	43 (23.0)	70 (37.4)	74 39.6)
Group															
A	8 (10.4)	11 (14.3)	58 (75.3)	44 (56.4)	17 (21.8)	17 (21.8)	52 (66.7)	17 (21.8)	9 (11.5)	12 (15.4)	14 (17.9)	52 (66.7)	22 (28.2)	33 (42.3)	23 (29.5)
B	3 (6.5)	6 (13.3)	36 (80.0)	21 (47.7)	11 (25.0)	12 (27.3)	24 (54.5)	14 (31.8)	6 (13.6)	7 (15.9)	8 (18.2)	29 (65.9)	7 (15.6)	18 (40.0)	20 (44.4)
C	10 (15.6)	10 (15.6)	44 (68.8)	36 (57.1)	12 (19.0)	15 (23.8)	41 (65.1)	11 (17.5)	11 (17.5)	9 (14.1)	10 (15.6)	45 (70.3)	14 (21.9)	19 (29.7)	31 (48.4)
P value	0.636			0.864			0.408			0.989			0.126		
Age (years)*															
≤25	10 (23.3)	12 (27.9)	21 (48.8)	28 (66.7)	8 (19.0)	6 (14.3)	29 (69.9)	10 (23.8)	3 (7.1)	6 (14.0)	7 (16.3)	30 (69.8)	11 (25.6)	12 (27.9)	20 (46.5)
26 – 64	8 (6.1)	15 (11.5)	108 (82.4)	67 (51.1)	29 (22.1)	35 (26.7)	81 (61.8)	30 (22.9)	20 (15.3)	19 (14.5)	20 (15.3)	92 (70.2)	28 (21.2)	55 (41.7)	49 (37.1)
≥65	3 (25.0)	0	9 (75.0)	6 (50.0)	3 (25.0)	3 (25.0)	7 (58.3)	2 (16.7)	3 (25.0)	3 (25.0)	5 (41.7)	4 (33.3)	4 (33.3)	3 (25.0)	5 (41.7)
P value	**<0.001**			0.443			0.539			0.109			0.438		
Gender															
Female	12 (12.9)	12 (12.9)	69 (74.4)	53 (57.6)	18 (19.6)	21 (22.8)	55 (59.8)	26 (28.3)	11 (12.0)	13 (14.0)	20 (21.5)	60 (64.5)	18 (19.1)	37 (39.4)	39 (41.5)
Male	9 (9.7)	15 (16.1)	69 (74.2)	48 (51.6)	22 (23.7)	23 (24.7)	62 (66.7)	16 (17.2)	15 (16.1)	15 (16.1)	12 (12.9)	66 (71.0)	25 (26.9)	33 (35.5)	35 (37.6)
P value	0.683			0.693			0.182			0.297			0.454		
Educational level															
Primary studies	3 (23.1)	3 (23.1)	7 (53.8)	10 (76.9)	2 (15.4)	1 (7.7)	10 (76.9)	2 (15.4)	1 (7.7)	5 (38.5)	6 (46.2)	2 (15.4)	4 (30.8)	7 (53.8)	2 (15.4)
Secondary studies	1 (16.7)	2 (33.3)	3 (50.0)	3 (50.0)	2 (33.3)	1 (16.7)	4 (66.7)	1 (16.7)	1 (16.7)	1 (16.7)	1 (16.7)	4 (66.7)	2 (33.3)	1 (16.7)	3 (50.0)
Bachelor studies	8 (15.7)	10 (19.6)	33 (64.7)	32 (65.3)	9 (18.4)	8 (16.3)	35 (71.4)	10 (20.4)	4 (8.2)	11 (22.0)	13 (26.0)	26 (52.0)	11 (21.6)	20 (39.2)	20 (39.2)
University studies	9 (7.8)	12 (10.3)	95 (81.9)	56 (47.9)	27 (23.1)	34 (29.1)	68 (58.1)	29 (24.8)	20 (17.1)	11 (9.4)	12 (10.3)	94 (80.3)	26 (22.2)	42 (35.9)	49 (41.9)
P value	0.086			0.221			0.606			**<0.001**			0.585		

*The age was categorized as follows: up to 25 years as the period of studies, up to 64 years as the period of active employment, and beyond that age as retirement.
P values were calculated using the Chi-square test.

4.3 Fish consumption habits

Table 4 shows that 61.3% of participants always participate in household food purchase decisions, and 54.3% always participate in actual purchases. In food preparation, 39.8% always participate, while 17.7% participate half of the time. Lower participation rates were seen in food purchases and preparation.

Table 4. Descriptive analysis of the degree of participation in the purchase and preparation of food (N, (%)), rated according to the 7-point Likert scale*.

	1	2	3	4	5	6	7
Degree of participation in household food purchase decisions	0	6 (3.2)	9 (4.8)	17 (9.1)	18 (9.7)	22 (11.8)	114 (61.3)
Degree of participation in household food purchases	2 (1.1)	7 (3.8)	14 (7.5)	17 (9.1)	16 (8.6)	29 (15.6)	101 (54.3)
Degree of participation in the preparation of food consumed in your household	3 (1.6)	14 (7.5)	17 (9.1)	33 (17.7)	15 (8.1)	30 (16.1)	74 (39.8)

*(1) Never participate, (2) participate a little, (3) participate somewhat, (4) participate half of the time, (5) participate quite a bit, (6) participate a lot, and (7) always participate.

It is worth noting that we did not observe any gender differences. That is, men and women were distributed similarly in terms of decision-making when purchasing food, doing the shopping, and preparing meals. On the contrary, significant differences were observed regarding age. Thus, respondents ≤25 years and ≥65 participated less frequently in household food purchasing decisions and food purchases, with the majority of active decision-making being done by those aged 26 – 64 ($P < 0.001$ in both comparisons). Similarly, young subjects under 25 and over 65 years were less frequently involved in food preparation, with the most significant participation coming from those aged 26 – 64, particularly in the "always participate" category ($P = 0.037$). This significant differences were also observed when age was analyzed as a continuous variable ($P = 0.008$ and $P = 0.028$, for food purchase decision and food purchases, respectively).

Other significant differences were as follows: 1) individuals with higher education levels (university) were more frequently involved in household food purchasing decisions, especially in the "always participate" category, while those with primary or secondary education levels participate less often ($P = 0.026$); and 2) salaried employees were the most actively involved in household food purchasing decisions while self-employed individuals, students, and the unemployed participate less frequently ($P = 0.021$). No other significant associations were observed.

The majority of respondents bought their fish in supermarkets (N = 134, 72.4%), while 16.2% reported purchasing fish at markets. Buying fish from fishermen's guilds was a minority.

Table 5. Descriptive analysis of fish consumption frequency (N, (%)).

Frequency	Extractive fishing	Aquaculture fish
Several times a week	16 (8.6)	3 (1.6)
1 or 2 times a week	90 (48.4)	12 (6.5)
1 or 2 times a month	59 (31.7)	21 (11.3)
Less than once a month	11 (5.9)	11 (5.9)
Almost never	9 (4.8)	32 (17.2)
Never	1 (0.5)	13 (7.0)
Not sure	0	94 (50.5)

Regular consumption of aquaculture fish was low (Table 5). Most respondents consumed fish from extractive fishing weekly (48.4%), whereas aquaculture fish was predominantly consumed almost never (17.2%) or uncertainly (50.5%). These differences in consumption frequency were statistically significant ($P < 0.001$). When the 13 respondents who did not consume aquaculture fish were asked why they didn't, 3 said they didn't like the taste, 3 cited not liking the texture, 4 mentioned it causing aversion, 1 said it didn't have good quality, and 2 did not provide a reason.

Aquaculture fish consumption frequency varied across age groups. Younger individuals (≤25) tend to consume it less frequently compared to older age groups. The 26 – 64 age group consumed with the highest frequency ($P = 0.008$). It is important to highlight that individuals with university education tend to consume aquaculture fish more frequently compared to those with lower levels of education ($P < 0.001$). Thus, the 3 participants who reported consuming fish several times a week had university education, and 10 out of the 12 participants who reported consuming fish 1 or 2 times a week had that level of education. Differences by gender were not observed.

The survey included a series of questions aimed at understanding opinions on fish consumption. Below is the frequency analysis of the responses to those questions (Table 6).

Table 6. Perceptions and consumption of fish: opinions and habits. The data represent the number of responses (N) and their percentage (%), rated according to the 7-point Likert scale*.

	1	2	3	4	5	6	7
Q1	7 (3.7)	22 (11.7)	27 (14.4)	45 (23.9)	36 (19.1)	20 (10.6)	31 (16.5)
Q2	5 (2.7)	4 (2.1)	7 (3.7)	18 (9.6)	23 (12.2)	41 (21.8)	90 (47.9)
Q3	29 (15.3)	14 (7.4)	12 (6.3)	60 (31.7)	27 (14.3)	17 (9.0)	30 (15.9)
Q4	91 (48.1)	31 (16.4)	18 (9.5)	24 (12.7)	13 (6.9)	6 (3.2)	6 (3.2)
Q5	13 (6.9)	13 (6.9)	3 (1.6)	97 (51.3)	23 (12.2)	21 (11.1)	19 (10.1)
Q6	9 (4.8)	8 (4.2)	6 (3.2)	80 (42.3)	37 (19.6)	24 (12.7)	25 (12.3)
Q7	7 (3.7)	6 (3.2)	6 (3.2)	139 (73.5)	21 (11.1)	8 (4.2)	2 (1.1)
Q8	14 (7.4)	7 (3.7)	13 (6.9)	115 (61.2)	17 (9.0)	12 (6.4)	10 (5.3)
Q9	28 (14.9)	14 (7.4)	12 (6.4)	78 (41.5)	23 (12.2)	15 (8.0)	18 (9.6)
Q10	22 (11.6)	16 (8.5)	18 (9.5)	108 (57.1)	11 (5.8)	9 (4.8)	5 (2.6)
Q11	4 (2.1)	1 (0.5)	1 (0.5)	32 (16.9)	20 (10.6)	56 (29.6)	75 (39.7)
Q12	36 (19.1)	22 (11.7)	26 (13.8)	86 (45.7)	5 (2.7)	6 (3.2)	7 (3.7)
Q13	20 (10.6)	31 (16.4)	29 (15.3)	27 (14.3)	34 (18.0)	23 (12.2)	25 (13.2)
Q14	5 (2.6)	4 (2.1)	17 (9.0)	99 (52.4)	16 (8.5)	20 (10.6)	28 (14.8)
Q15	5 (2.6)	4 (2.1)	13 (6.9)	94 (49.7)	21 (11.1)	20 (10.6)	32 (16.9)

*(1) Strongly disagree, (2) disagree, (3) somewhat disagree, (4) neither agree nor disagree, (5) somewhat agree, (6) agree, and (7) strongly agree.

Q1. I am sufficiently informed about fish.
Q2. I eat fish because I like its taste.
Q3. I don't eat more fish because it is too expensive.
Q4. I don't eat more fish because it may be harmful to health.
Q5. Wild-caught fish has higher quality than farmed fish.
Q6. Wild-caught fish has more taste than farmed fish.
Q7. Farmed fish is firmer than wild-caught fish.
Q8. Wild-caught fish is fattier than farmed fish.
Q9. Wild-caught fish is fresher than farmed fish.
Q10. Farmed fish is more expensive than wild-caught fish.
Q11. Farmed fish is more regulated than wild-caught fish.
Q12. Wild-caught fish offers more guarantees than farmed fish.
Q13. I find it difficult to assess the quality of fish.
Q14. Gilthead seabream mostly comes from aquaculture.
Q15. European seabass mostly comes from aquaculture.

Notably, 47.9% eat fish due to its taste (Q2), while 24.9% don't consume more fish because it is too expensive (Q3). Wild-caught fish was generally perceived as having higher quality (21.1%, Q5) and more taste (25.0%, Q6). Farmed fish was considered more regulated (39.7%, Q11). Many respondents found it difficult to assess fish quality (25.4%, Q13). Most believed that gilthead seabream (25.4%, Q14) and European seabass (27.5%, Q15) primarily come from aquaculture. We should note the high percentages of responses in the middle point ((4) neither agree nor disagree), indicating a general lack of knowledge on the subject matter (Q1, Q3, Q5, Q6, Q7, Q8, Q9, Q10, Q12, Q14, and Q15).

In any case, the majority of respondents considered as “very positive” that the fish is healthy (80.4%), safe (84.7%), nutritious (77.2%), tasty (83.1%), and sustainable (66.8%). On the contrary, 34.9% of the respondents considered as “very negative” that the fish was expensive, although for 23.3% of them, this circumstance was neither negative nor positive. While no significant differences were detected by gender, age, or income level, among respondents who

considered the high price of fish as "somewhat positive", 50% of them had a university education ($P = 0.003$). Overall, consuming fish is pleasant for 54.5% of the respondents, while only 4.3% found it unpleasant.

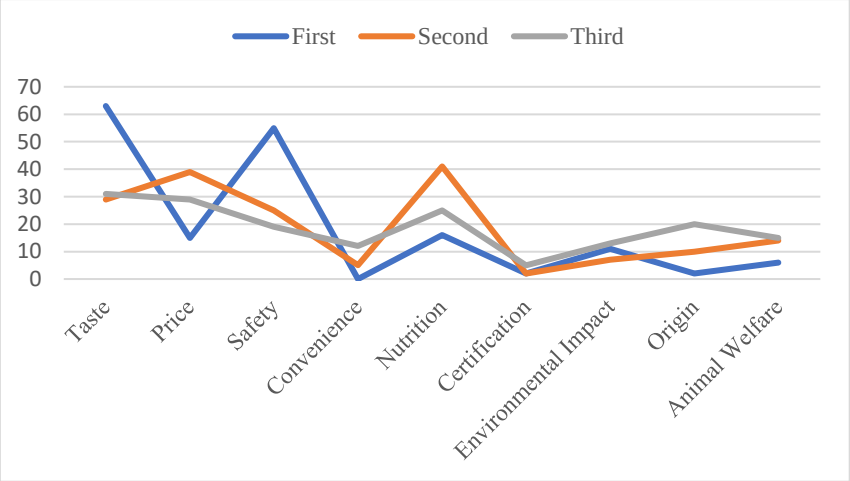

Figure 2. The three most important features when buying or consuming fish. The Y-axis represents the absolute number of respondents.

On this regard, taste was considered the most important factor when buying/consuming fish (blue line, Figure 2); price and nutritional value were the second most important factors (orange line), and once again price was considered the third most important factor (gray line). On the contrary, convenience was considered the less important factor when buying/consuming fish (blue line, Figure 3); certification was the second less important factors (orange line), and once again certification and origin were considered the third less important factors (gray line).

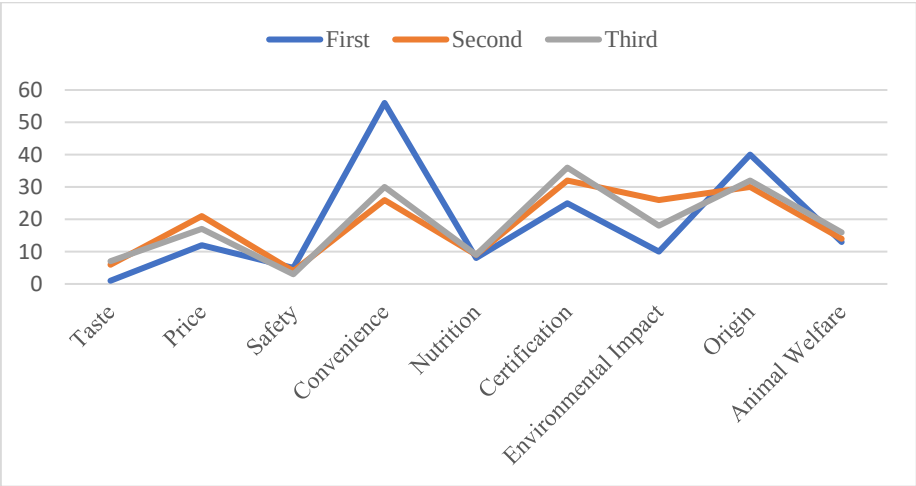

Figure 3. The three less important features when buying or consuming fish. The Y-axis represents the absolute number of respondents.

4.3.1. Consumer perception of thicklip grey mullet (*Chelun labrosus*)

A total of 115 respondents (61.2%) were familiar with the thicklip grey mullet before attending the tasting. Although no significant differences were detected regarding gender or educational level, it was observed that the proportion of respondents who knew the thicklip grey mullet was significantly lower among individuals under 25 years old (25 out of 43 (58.1%) did not know the fish), compared to those over 25 (47 out of 143 individuals (32.8%) were not familiar with this fish), with this difference being statistically significant ($P < 0.001$). Despite this, consuming fish sustainably was responded to very positively by 66.8% of the series, with no significant differences observed by age, gender, or educational level. Furthermore, the inclusion of locally sourced ingredients in the diet of farmed thicklip grey mullet was seen as positive or very positive by 72.6% of respondents. This is important, considering that 31.0% of the respondents stated that the feeding habits of the thicklip grey mullet negatively influence the product quality, and 53.4% of them considered that thicklip grey mullet caught in open waters have higher quality than those inhabiting port areas. This opinion was predominant among respondents with university degrees. Thus, 60 out of 117 participants with university education (51.3%) agreed or strongly agreed that thicklip grey mullet caught in open waters was of higher quality than that caught in port waters, a difference that was significant compared to groups with less education ($P < 0.001$).

While it is true that 61 respondents (32.3%) believed that the price of thicklip grey mullet should be lower than that of European seabass and gilthead seabream, 35.9% (n = 68) neither agreed or disagreed with this statement. This opinion was more prevalent among individuals with primary education compared to those with university education (53.8% vs. 26.5%, respectively; $P = 0.043$).

The majority of respondents had not consumed thicklip grey mullet before the tasting (N = 80 (42.6%), Table 7). This percentage was higher among respondents with university education (80.0% had not consumed the fish), compared to respondents with primary education (83.3% had previously consumed thicklip grey mullet; $P = 0.003$). By gender, we found a lower predisposition to consume farmed thicklip grey mullet among women (31.2 vs. 16.3%, respectively; $P = 0.013$). No other significant differences were observed.

Table 7. Descriptive analysis of previous consumption and intention to consume thicklip grey mullet (N (%)), in the complete series and according to gender, age, and educational level.

	Previous consumption of thicklip grey mullet*		
	Yes	No	P value#
Whole series	35 (18.5)	80 (42.3)	
Gender			0.340
Female	14 (26.9)	38 (73.1)	
Male	20 (32.3)	42 (67.7)	
Age (years)			0.972
≤25	5 (27.8)	13 (72.2)	
26 – 64	28 (30.1)	65 (69.9)	
≥ 65	1 (33.3)	2 (66.7)	
Educational level			**0.003**
Primary studies	5 (83.3)	1 (16.7)	
Secondary studies	2 (40.0)	3 (60.0)	
Bachelor studies	12 (42.9)	16 (57.1)	
University studies	15 (20.0)	60 (80.0)	
	Would you consume thicklip grey mullet?		
	Yes	No	
Whole series	102 (54.8)	84 (45.2)	
Gender			0.273
Female	48 (51.1)	45 (47.9)	
Male	52 (57.1)	39 (42.9)	
Age (years)			0.155
≤25	27 (62.8)	16 (37.2)	
26 – 64	65 (50.0)	65 (50.0)	
≥ 65	8 (72.7)	3 (27.3)	
Educational level			0.741
Primary studies	8 (66.7)	4 (33.3)	
Secondary studies	4 (66.7)	2 (33.3)	
Bachelor studies	26 (52.0)	24 (48.0)	
University studies	62 (53.4)	54 (46.6)	
	Would you consume farmed thicklip grey mullet?		
	Yes	No	
Whole series	142 (75.1)	45 (24.1)	
Gender			**0.013**
Female	64 (68.8)	29 (31.2)	
Male	77 (83.7)	15 (16.3)	
Age (years)			0.098
≤25	28 (65.1)	15 (34.9)	
26 – 64	103 (78.6)	28 (21.4)	
≥ 65	10 (90.9)	1 (9.1)	
Educational level			0.865
Primary studies	10 (83.3)	2 (16.7)	
Secondary studies	4 (66.7)	2 (33.3)	
Bachelor studies	38 (74.5)	13 (25.5)	
University studies	89 (76.7)	27 (23.3)	

*74 respondents did not answer this question. The percentages were calculated based on the total number of valid responses.
#P values were calculated with Chi-square test.

When asked about the reasons for not consuming thicklip grey mullet, the majority responded that it was because they were repulsed by the eating habits of this fish (n = 50, 62.5%). Twenty percent of the respondents said it was because of its taste, and 17.5% because of the quality of its meat. However, when asked why they would not be willing to consume farmed thicklip grey

mullet, most said it was because they did not like the taste (n = 18, 42.9%). A total of 16 individuals said it was because of the quality of the meat (38.1%), and 19% responded that they disliked aquaculture.

4.3.2. Variables influencing fish consumption and change of consumption habits

As previously discussed, the price of fish and, specifically, the dietary habits and production methods of the thicklip grey mullet appeared to be determining factors for consuming and purchasing this food. In fact, the mean price that respondents would pay per kilogram for gilthead seabream and European seabass was significantly higher than that for thicklip grey mullet (10.4 ± 5.2, 10.5 ± 4.7 and 8.1 ± 3.9 euros, respectively; $P < 0.001$ for both comparisons).

We aimed to explore the monetary variable in the context of fish purchase and consumption. We observed that 23.7% of respondents strongly agreed or totally agreed to pay more for fish species with a good image, although 22.6% strongly disagreed or totally disagreed with this statement. These percentages were 69.2% and 12.4% in relation to quality, and 30.1% and 13.0% in relation to sustainability, respectively. Asked in the reverse, we observed that 39.8% of respondents strongly agreed or totally agreed to pay less for fish species with a bad image, while 17.2% strongly disagreed or disagreed with this statement. These percentages were 61.2% and 8.6% in relation to quality, and 31.2% and 12.9% in relation to sustainability, respectively. Gender and age were demographic variables associated with these issues. While 74.1% of women strongly disagreed with paying more for fish species with a good image, 65.2% of men strongly agreed ($P = 0.042$). A similar pattern was observed regarding sustainability ($P = 0.044$). This trend was reversed concerning quality: 52.9% and 100% of men strongly disagreed or disagreed with paying more for higher quality fish, while 61.7% of women strongly agreed ($P = 0.046$). Regarding age, while 41.7% of those over 65 years old strongly disagreed with paying less for species with lower sustainability, 27.9% of those under 25 years old strongly agreed with doing so ($P = 0.009$).

Overall, receiving information about thicklip grey mullet was considered very useful (Table 8). However, 24.9% of respondents considered as “somewhat unhelpful” to have information about breeding and selection (Q3); 21.6% found as “somewhat unhelpful” to receive comparative information with other aquaculture species (Q8), and 18.9% found as “somewhat unhelpful” to receive information about the origin of the fish (Q6). The information considered most useful

by the respondents was related to the feeding of seabream (Q2) and its nutritional value (Q7), as suggested in previous analyses.

Table 8. Descriptive analysis of the perception of the usefulness of the information received about thicklip grey mullet. The numbers represent the frequency and percentage of valid responses (N, (%)).

	Very useful	Useful	Marginally useful	Not useful
Q1	112 (59.6)	73 (38.8)	3 (1.6)	0
Q2	113 (60.8)	68 (36.6)	3 (1.6)	2 (1.1)
Q3	42 (22.7)	88 (47.6)	46 (24.9)	9 (4.9)
Q4	79 (42.7)	85 (45.9)	20 (10.8)	1 (0.5)
Q5	70 (37.6)	78 (41.9)	31 (16.7)	7 (3.8)
Q6	72 (38.1)	69 (37.3)	35 (18.9)	9 (4.9)
Q7	121 (65.1)	55 (29.6)	7 (3.8)	3 (1.6)
Q8	52 (28.1)	82 (44.3)	40 (21.6)	11 (5.9)
Q9	96 (51.3)	70 (37.4)	15 (8.0)	6 (3.2)

Q1: How do you consider the information received about thicklip grey mullet farming?
Q2: How would you consider receiving information about the feeding characteristics of farmed thicklip grey mullet?
Q3: How would you consider receiving information about the breeding and selection processes of farmed thicklip grey mullet?
Q4: How would you consider receiving information about the environmental sustainability of thicklip grey mullet farming?
Q5: How would you consider receiving information about the animal welfare of farmed thicklip grey mullet?
Q6: How would you consider receiving information about the origin of farmed thicklip grey mullet?
Q7: How would you consider receiving information about the nutritional value of farmed thicklip grey mullet?
Q8: How would you consider receiving information about the differences between farmed thicklip grey mullet and other aquaculture species?
Q9: How would you consider receiving information about the degree of contribution of thicklip grey mullet farming to the economy and employment?

Finally, we asked about trust in different sources for receiving information related to aquaculture (Table 9). The most reliable source for respondents was information from research centers (76.3% fully agreed), followed by government sources of information (37.6%) and aquaculture companies themselves (32.2%). Among the least reliable were social media (32.2% of respondents strongly disagreed) and TV and press (23.0%).

Table 9. Trust of respondents in different sources of information. The data represent the number of responses (N) and their percentage (%), rated according to the 4-point Likert scale.

	Strongly disagree	Disagree	Agree	Strongly agree
Government	13 (7.2)	30 (16.6)	70 (38.7)	68 (37.6)
Research centers	2 (1.1)	1 (0.5)	41 (22.0.)	142 (76.3)
Aquaculture companies	7 (3.8)	41 (22.4)	76 (41.5)	59 (32.2)
Retail companies	7 (3.9)	53 (29.3)	89 (49.2)	32 (17.7)
TV and press	42 (23.0)	71 (38.8)	54 (29.5)	16 (8.7)
Social media	59 (32.2)	73 (39.9)	34 (18.6)	17 (9.3)
Consumer associations	8 (4.4)	41 (22.4)	81 (44.3)	53 (29.0)
NGOs*	21 (11.4)	39 (21.2)	74 (40.2)	50 (27.2)

*Non-governmental organizations (NGOs).

81.8% of individuals aged 65 and older strongly agreed or agreed that the government was a reliable source of information in this regard, compared to 77.3% of respondents aged 26 to 64, and 71.4% of those under 25 (P = 0.010). Regarding TV and press, these percentages were 54.5%, 39.5%, and 30.2%, respectively (P = 0.043). No significant differences were observed regarding social media. However, in this regard, we observed that among respondents with a university education, 21.7% strongly agreed or agreed that social media was a reliable source of information. This percentage was 33.3% among respondents with high school education and 63.6% among those with primary education (P = 0.002).

4.4. Sensory analysis

The tasting guests were divided into three groups as follows: Group A (n = 79), participants who were unaware of the fish species and their production method before tasting; Group B (n = 45), participants who knew the fish species but not their production method before tasting; and Group C (n = 65), participants who had all the information before tasting. The participants continuously evaluated three sensory parameters: taste, texture, and overall satisfaction.

As shown in Table 10, the gilthead seabream consistently received the highest overall satisfaction scores across all groups, particularly in Groups B and C. European seabass followed closely in preference, while thicklip grey mullet was rated the lowest in all sensory parameters across all groups. Notably, the highest taste and texture scores were for gilthead seabream in Groups B and C. The specific values for mean, standard deviation, median, and range are detailed in Table 10. Within Group A, gilthead seabream had the highest ratings for taste (mean 6.87), texture (mean 7.22), and overall satisfaction (mean 7.43), while thicklip grey mullet had the lowest (taste mean 6.00, texture mean 6.41, overall satisfaction mean 6.32). These

differences were statistically significant for the three sensory parameters ($P = 0.004$, $P = 0.016$, and $P = 0.001$, respectively). Specifically, we observed significant differences between the thicklip grey mullet and the European seabass in terms of taste ($P = 0.005$), texture ($P = 0.022$), and overall satisfaction ($P = 0.007$), without significant differences being observed in relation to the gilthead seabream.

In Group B, gilthead seabream also rated highest in taste (mean 7.95), texture (mean 7.94), and overall satisfaction (mean 7.78), with thicklip grey mullet scoring lowest (taste mean 6.28, texture mean 6.60, overall satisfaction mean 6.56). These differences were statistically significant for the three sensory parameters ($P < 0.001$, $P = 0.002$, and $P < 0.001$, respectively). Specifically, we observed significant differences between the thicklip grey mullet and the European seabass in terms of taste ($P < 0.001$), texture ($P = 0.010$), and overall satisfaction ($P < 0.001$), without significant differences being observed in relation to the gilthead seabream.

Table 10. Sensory analysis of fish within different groups (*).

	Group A (n = 79)			
	Gilthead seabream	European seabass	Thicklip grey mullet	P value[#]
Taste (mean ± (SD))	6.87 ± 2.15	7.10 ± 1.90	6.00 ± 2.38	0.004
Median (range)	7.40 (0 – 10)	7.29 (0.3 – 10)	6.04 (0 – 10)	0.010
Texture (mean ± (SD))	7.22 ± 1.96	7.33 ± 1.98	6.41 ± 2.43	0.016
Median (range)	6.60 (0.6 – 10)	7.60 (0.3 – 10)	6.66 (0.9 – 10)	0.036
Global (mean ± (SD)	7.43 ± 1.66	7.28 ± 1.84	6.32 ± 2.36	0.001
Median (range)	7.92 (1.9 – 10)	7.39 (0.3 – 10)	6.66 (0 – 10)	0.004
	Group B (n = 45)			
	Gilthead seabream	European seabass	Thicklip grey mullet	
Taste (mean ± (SD))	7.95 ± 1.76	7.91 ± 1.78	6.28 ± 2.27	<0.001
Median (range)	8.12 (2.1 – 10)	8.33 (1.4 – 10)	6.46 (1.3 – 10)	<0.001
Texture (mean ± (SD))	7.94 ± 1.92	7.83 ± 1.68	6.60 ± 2.29	0.002
Median (range)	8.33 (2.0 – 10)	8.12 (2.7 – 10)	6.87 (1.9 – 10)	0.006
Global (mean ± (SD)	7.78 ± 1.48	8.07 ± 1.34	6.56 ± 2.16	<0.001
Median (range)	7.92 (3.5 – 10)	8.23 (3.9 – 10)	6.66 (1.0 – 10)	0.001
	Group C (n = 65)			
	Gilthead seabream	European seabass	Thicklip grey mullet	
Taste (mean ± (SD))	8.00 ± 1.63	7.51 ± 2.15	6.98 ± 2.35	0.020
Median (range)	8.33 (2.8 – 10)	8.12 (0 – 10)	7.40 (0 – 10)	0.062
Texture (mean ± (SD))	8.00 ± 1.60	7.66 ± 2.09	7.14 ± 2.15	0.042
Median (range)	8.23 (3.4 – 10)	7.92 (0 – 10)	7.71 (0 – 10)	0.081
Global (mean ± (SD)	7.96 ± 1.40	7.53 ± 2.03	7.13 ± 2.12	0.046
Median (range)	8.33 (2.9 – 10)	8.0 (0 – 10)	7.60 (0 – 10)	0.111

Abbreviations: SD, standard deviation.
[#]Anova t test was used for mean comparisons; Kruskal Wallis was used for median comparisons.
(*) Group A: Participants who were unaware of the fish species and their production method before tasting; Group B: participants who knew the fish species but not their production method before tasting; Group C: participants who had all the information before tasting.

Finally, for Group C, gilthead seabream had again the highest scores for taste (mean 8.00), texture (mean 8.00), and overall satisfaction (mean 7.96), while thicklip grey mullet received the lowest scores in taste (mean 6.98), texture (mean 7.14), and overall satisfaction (mean 7.13). These differences were statistical significant for the three sensory parameters ($P = 0.020$, $P = 0.042$, and $P = 0.046$, respectively). However, they lost their statistical significance when parametric tests were applied. Interestingly, we did not detect statistical differences in pairwise analyses ($P > 0.05$ in all cases), suggesting that the information received before the tasting conditioned the sensory perception of the thicklip grey mullet.

To delve into sensory perception among different groups, we conducted intergroup analyses. As shown in Table 11, gilthead seabream consistently received the highest overall scores across all groups, particularly in taste and texture. Interestingly, although thicklip grey mullet scored the lowest across most parameters, a slight improvement was observed in Group C (participants who knew the fish species and their production method before tasting), reinforcing the previous finding: the information received before the tasting conditioned the sensory perception of the thicklip grey mullet. The specific values for mean, standard deviation, median, and range are detailed in Table 11. The sensory analysis of fish reveals notable differences among the groups. For gilthead seabream, Group C had the highest mean taste score (8.00 ± 1.63) and texture score (8.00 ± 1.60), with statistically significant differences compared to Group A ($P = 0.001$ and $P = 0.021$, respectively). Specifically, we observed significant differences between Group A and B and between Group A and C in relation to taste ($P = 0.008$ and P = 0.001, respectively), and between Group A and C in relation to texture ($P = 0.029$). No significant differences were observed in relation to global satisfaction. European seabass taste scores varied less significantly, with Group B scoring highest (7.91 ± 1.78) but with a borderline significant *P*-value (0.086). No statistical differences in pairwise analyses were observed ($P > 0.05$ in all cases).

Thicklip grey mullet showed significant taste improvement in Group C (6.98 ± 2.35) compared to Group A ($P = 0.046$). Specifically, significant differences between Group A and C in relation to taste were observed ($P = 0.039$). No other significant differences were observed in relation to texture and global satisfaction.

Table 11. Sensory analysis of fish between different groups (*).

	Gilthead seabream			
	Group A	**Group B**	**Group C**	*P* value[#]
Taste (mean ± (SD))	6.87 ± 2.15	7.95 ± 1.76	8.00 ± 1.63	0.001
Median (range)	7.40 (0 – 10)	8.12 (2.1 – 10)	8.33 (2.8 – 10)	0.001
Texture (mean ± (SD))	7.22 ± 1.96	7.94 ± 1.92	8.00 ± 1.60	0.021
Median (range)	6.60 (0.6 – 10)	8.33 (2.0 – 10)	8.23 (3.4 – 10)	0.022
Global (mean ± (SD)	7.43 ± 1.66	7.78 ± 1.48	7.96 ± 1.40	0.117
Median (range)	7.92 (1.9 – 10)	7.92 (3.5 – 10)	8.33 (2.9 – 10)	0.132
	European seabass			
	Group A	**Group B**	**Group C**	
Taste (mean ± (SD))	7.10 ± 1.90	7.91 ± 1.78	7.51 ± 2.15	0.086
Median (range)	7.29 (0.3 – 10)	8.33 (1.4 – 10)	8.12 (0 – 10)	0.040
Texture (mean ± (SD))	7.33 ± 1.98	7.83 ± 1.68	7.66 ± 2.09	0.351
Median (range)	7.60 (0.3 – 10)	8.12 (2.7 – 10)	7.92 (0 – 10)	0.339
Global (mean ± (SD)	7.28 ± 1.84	8.07 ± 1.34	7.53 ± 2.03	0.063
Median (range)	7.39 (0.3 – 10)	8.23 (3.9 – 10)	8.0 (0 – 10)	0.084
	Thicklip grey mullet			
	Group A	**Group B**	**Group C**	
Taste (mean ± (SD))	6.00 ± 2.38	6.28 ± 2.27	6.98 ± 2.35	0.046
Median (range)	6.04 (0 – 10)	6.46 (1.3 – 10)	7.40 (0 – 10)	0.032
Texture (mean ± (SD))	6.41 ± 2.43	6.60 ± 2.29	7.14 ± 2.15	0.159
Median (range)	6.66 (0.9 – 10)	6.87 (1.9 – 10)	7.71 (0 – 10)	0.170
Global (mean ± (SD)	6.32 ± 2.36	6.56 ± 2.16	7.13 ± 2.12	0.093
Median (range)	6.66 (0 – 10)	6.66 (1.0 – 10)	7.60 (0 – 10)	0.089

Abbreviations: SD, standard deviation.
[#]Anova t test was used for mean comparissons; Kruskal Wallis was used for median comparissons.
(*) Group A: Participants who were unaware of the fish species and their production method before tasting; Group B: participants who knew the fish species but not their production method before tasting; Group C: participants who had all the information before tasting.

Overall, knowledge of both species and production methods (Group C) positively influenced sensory ratings across all fish types, especially for gilthead seabream and thicklip grey mullet, highlighting the impact of consumer awareness on perception. The global assessment scores, however, showed less significant variation, suggesting that while specific sensory attributes are influenced by awareness, the overall impression might be more consistent.

5. DISCUSSION

Information campaigns have proven successful both in introducing or promoting products (advertising) and in health or prevention strategies (e.g., road safety, healthy lifestyle habits). However, for potential consumers to benefit from such campaigns, they must first understand the basic concepts related to the product, which in the context of this research are somewhat technical. Our findings indicate that terms such as hydroponics or aquaponics are unfamiliar to more than one-third of respondents, and concepts like aquaculture or circular economy are less known among younger population segments. Considering that information and promotion

campaigns are more effective when aimed at specific population segments (Woodside et al., 1993), results highlight the need for informative strategies to help consumers understand the objectives behind introducing farmed thiklip grey mullet to the market.

Data show a significant association between educational level and familiarity with these concepts, which could help define target populations and marketing strategies. While these terms may seem technical, the sampled population intuitively recognizes them as "positive" both economically (e.g., job creation) and environmentally. Consumers generally evaluate products favorably when they perceive them as environmentally friendly (Aibar-Guzmán & Somohano-Rodríguez, 2021), suggesting that this attribute should be emphasized when designing market introduction strategies. In line with the present results, other authors have found that European consumers associated farmed fish with greater sustainability, local provenance, environmental benefits, socio-economic advantages, and fairer pricing compared to wild-caught fish. In contrast, wild-caught fish was perceived as more humane and organic but less environmentally friendly (López-Mas et al., 2023).

According to official data, in 2023, first sale of farmed fish in the Canary Islands reached 6.9 million kilograms, compared to over 8 million kilograms of captured fish (GOBCAN, 2024b). This means aquaculture accounted for 45.7% of total fish sales. However, this perception does not align with market realities, as approximately 70% of aquaculture production is exported. The discrepancy between local production and consumption of farmed fish can be partially explained by negative consumer perceptions within the local market. Other factors may include higher profit margins in foreign markets. Taken together, it helps to explain the discrepancy between local production and consumption of farmed fish. Despite the FAO reported that farmed fish production surpassed wild-caught fish (FAO, 2024), the present results show that 17.2% of participants claimed to rarely consume farmed fish, and 50% reported being unaware of the origin of the fish they consumed. This indicates a lack of consumer information, which may arise from two factors: either consumers are indifferent to the origin, or consumers lack the information necessary to make informed choices.

Although the sample size was small, participants who reported not consuming farmed fish (n = 13) primarily cited organoleptic reasons, suggesting that their preference is deliberate and informed. Given the age and educational differences in the frequency of consuming such products, results suggest that the ideal target population for introducing farmed thiklip grey mullet into the market includes individuals under 25 years old with lower educational levels

(non-university). Purchasing power is a key co-variable here, as younger individuals with less education tend to have lower incomes and are more likely to buy frozen fish, which is more affordable than fresh or farmed alternatives. Indeed, 24.9% of participants reported consuming less fish due to its price, and 34.9% considered the high cost of fish to be a significant disadvantage.

This consumer profile contrasts with findings from other studies, which observed that certain population segments are more likely to consume fish: women, older individuals, those with higher education levels, and those with healthier lifestyles (e.g., non-smokers) (Marinac Pupavac et al., 2022).

Taste and food safety were the most important factors influencing fish consumption, while price and origin were less influential. In fact, environmental impact and animal welfare were among the least considered factors when consuming fish. Previous studies have shown that information significantly affects consumer acceptance, particularly concerning the perceived image of farmed fish, even though sensory differences between wild-caught and farmed fish are generally undetected (Claret et al., 2016).

Overall, these data suggest that the advantages of farmed fish should be emphasized, especially regarding environmental impact and food safety, as no significant sensory differences are observed. Other studies support this observation, finding that consumers cannot differentiate between wild-caught and farmed fish in blind sensory tests but tend to perceive farmed fish as inferior when its origin is disclosed (Cantillo et al., 2023).

Although aquaculture is often perceived negatively, the origin of the fish appears to be less critical than its taste (inherent to the species) and price (Can et al., 2015). Interestingly, a quarter of respondents knew that gilthead seabream and European seabass were farmed, and the majority lacked knowledge about fish consumption and perception. This highlights the need for information campaigns (Claret et al., 2016).

Consumer perception and acceptance of a food product are multifactorial. Implicit factors include sensory attributes inherent to the species, as well as preconceptions, attitudes, or beliefs about the product, particularly with new foods (Claret et al., 2014). For example, most respondents (n = 919) in a prior study (Claret et al., 2014) believed wild-caught fish to be of higher quality and better taste than farmed fish (average scores: 5.2 and 5.6 out of 7, respectively), a finding reaffirmed by this study. However, consumers are often unaware of

aquaculture's advantages, such as sustainability, affordability, or year-round availability (Cantillo et al., 2023).

Historically, thiklip grey mullet has been consumed in the Canary Islands but represents a negligible share of official fish sales. In 2023, only 634.5 kilograms of thiklip grey mullet were sold, at a total value of 1,044.94 euros (1.65 euros per kilogram in first sale) (GOBCAN, 2024c). For comparison, amberjack sales reached 78,814.68 kilograms, valued at 470,543.27 euros (5.97 euros per kilogram). According to data, one-third of respondents were unaware of thiklip grey mullet's existence before the tasting, with significant age-related differences: over half of participants under 25 years old (58.1%) were unfamiliar with this species. Nevertheless, most respondents (72.6%) viewed using locally sourced ingredients for farming thiklip grey mullet positively.

This finding is significant, given that one-third of respondents viewed thiklip grey mullet's feeding habits negatively. These highlight again the influence of preconceptions on consumption habits, as reported in previous studies (Claret et al., 2014). Although 42.3% of participants had not previously consumed thiklip grey mullet, 75.1% expressed willingness to try the farmed version, with women being the most hesitant. While preferences for certain species must be acknowledged (e.g., 20% disliked its taste), 17.5% rejected thiklip grey mullet due to perceived nutritional quality. This rejection is influenced by demographic factors, particularly age, but could be addressed in the context of farmed thiklip grey mullet (Harb Rabia et al., 2022). The development of new feeds can enhance nutritional value and also help reduce the contaminant load associated with fish consumption (Harb Rabia et al., 2022).

When considered as a whole, consumer perception when purchasing fish seems to be influenced by two key factors: the quality-price balance and preconceived notions regarding the species and its origin. For instance, thiklip grey mullet is often rejected due to its perceived low nutritional value and feeding habits, but its acceptance improves when identified as farmed, even though aquaculture in general is less well-regarded than wild-captured fish. These results contrast with those found by other researchers. For instance, López-Mas et al. have recently published a study demonstrating that European consumers generally perceived wild-caught fish as being of higher quality. However, the respondents recognized farmed fish as superior in terms of control over production processes, price, and availability. Furthermore, European consumers held the belief that farmed fish was less fresh and contained higher levels of pharmaceuticals compared to wild-caught fish (López-Mas et al., 2021) . Other factor influencing this perception

is the quality-price dynamic: while price acts as a barrier to fish consumption, lower-priced options are often assumed to be of inferior quality. Demographic factors, particularly age and education level (closely tied to economic status), strongly influence these views, according to the present results.

It is clear that consumer education plays a critical role, significantly shaping preferences for fish species and origins (Govzman et al., 2021). This complex dynamic is further determined by the cultural background of the population under study.

The sensory analysis of the three fish species examined in this study places thiklip grey mullet at a clear disadvantage in terms of taste, texture, and overall evaluation. However, respondents who were already familiar with the production methods of these species rated thiklip grey mullet's organoleptic characteristics more favorably. This contrasts with the results for seabass, whose scores declined within this informed group. Thus, thiklip grey mullet presents a paradoxical case, suggesting that its acceptance may improve when consumers are aware of its aquaculture origin.

This scenario is exceptional, as studies generally indicate that consumers tend to reject farmed fish (Marinac Pupavac et al., 2022). Nevertheless, it creates a promising opportunity within the framework of local production. With a market price of under €2 per kilogram, the potential investment and profit margins in thiklip grey mullet aquaculture undoubtedly warrant further detailed examination.

Despite its limitations as a species in terms of consumer perception, farmed thiklip grey mullet appears viable for the local market if accompanied by appropriate information strategies tailored to demographic factors such as age and education. Traditional media (television, press) are suitable for older populations, while social media is ideal for younger and less-educated individuals, with governmental and scientific endorsements adding credibility. These findings align with most published studies indicating that demographic factors such as age, education and religion influence preferred information channels and the credibility of the received information (Arshad et al., 2022; Nesterenko, 2023).

6. CONCLUSIONS

1. The sensory evaluation demonstrated that thicklip grey mullet was generally well-received by consumers, indicating its potential for commercialization and acceptance in the market.

2. Sensory analysis revealed that consumer preferences varied across the three fish species. While gilthead seabream and European seabass were generally preferred, thicklip grey mullet was still considered acceptable, particularly when presented with appropriate information.

3. Aquaculture fish consumption was notably low. Socioeconomic factors, such as age, education, and income, significantly influenced consumer perceptions of fish, particularly regarding sustainability and quality. Older individuals and those with university education tended to consume farmed fish more frequently.

4. Providing consumers with information about the fish species and production method positively influenced their perception and acceptance of thicklip grey mullet. This suggests that targeted information campaigns can effectively enhance consumer understanding and preferences. For a marketing campaign, older adults (65+) should be targeted through TV and press, emphasizing government-backed information. For younger audiences, particularly those with less formal education, social media should be utilized

REFERENCES

Aibar-Guzmán, C., & Somohano-Rodríguez, F. M. (2021). Do Consumers Value Environmental Innovation in Product? *Administrative Sciences*, *11*(1).

APROMAR. (2023a). *La acuicultura en España 2023*. Cádiz (Spain): Asociación Empresarial de Acuicultura de España Retrieved from https://observatorio-acuicultura.es/sites/default/files/images/adjuntos/libros/apromar_la_acuicultura_en_espana_2022.pdf

APROMAR. (2023b). *Memoria de Sostenibilidad 2022*. Cádiz (Spain): Asociación Empresarial de Acuicultura de España Retrieved from https://apromar.es/wp-content/uploads/2024/07/MEMORIA-DE-SOSTENIBILIDAD-2023-de-Acuicultura-de-Espana.pdf

AquaMaps. (2019). *Computer generated distribution maps for Chelon labrosus (Thicklip grey mullet)*. FishBase. Retrieved 26/11/2024 from https://www.aquamaps.org/receive.php?type_of_map=regular&map=cached

Arshad, A., Saleem, Q. U. A., & Mahmood, K. (2022). Predictors affecting personal digital information management activities: A hierarchical regression analysis. *Journal of Information Science*, *49*(6), 1677-1691. https://doi.org/10.1177/01655515211072299

ASPROCAN. (2023). *Estadísticas 2023 de Producción y Comercialización de Plátano de Canarias IGP*. Santa Cruz de Tenerife (Spain): Asociación de Organizaciones de Productores de Plátano de Canarias Retrieved from https://platanodecanarias.es/wp-content/uploads/2024/05/PdC_Anuario-Estadistico_23.pdf

Can, M. F., Günlü, A., & Can, H. Y. (2015). Fish consumption preferences and factors influencing it. *Food Science and Technology*, *35*.

Cantillo, J., Martín, J. C., & Román, C. (2023). Understanding consumers' perceptions of aquaculture and its products in Gran Canaria island: Does the influence of positive or negative wording matter? *Aquaculture*, *562*, 738754. https://doi.org/https://doi.org/10.1016/j.aquaculture.2022.738754

Chary, K., van Riel, A., Muscat, A., Wilfart, A., Harchaoui, S., Verdegem, M., Filgueira, R., Troell, M., Henriksson, P. J. G., de Boer, I. J. M., & Wiegertjes, G. F. (2023). Transforming sustainable aquaculture by applying circularity principles. *Reviews in Aquaculture*, *16*(2), 656-673. https://doi.org/10.1111/raq.12860

Claret, A., Guerrero, L., Gartzia, I., Garcia-Quiroga, M., & Ginés, R. (2016). Does information affect consumer liking of farmed and wild fish? *Aquaculture*, *454*, 157-162. https://doi.org/https://doi.org/10.1016/j.aquaculture.2015.12.024

Claret, A., Guerrero, L., Gines, R., Grau, A., Hernandez, M. D., Aguirre, E., Peleteito, J. B., Fernández-Pato, C., & Rodriguez-Rodriguez, C. (2014). Consumer beliefs regarding farmed versus wild fish. *Appetite*, *79*, 25-31. https://doi.org/10.1016/j.appet.2014.03.031

FAO. (2020). *Management of the aquaponic systems*. Rome (Italy): The Food and Agriculture Organization of the United Nations (FAO) Retrieved from https://www.fao.org/family-farming/detail/en/c/1617686/#:~:text=Aquaponics%20is%20the%20integration%20of%20recirculating,aquaculture%20and%20hydroponics%20in%20one%20production%20system.

FAO. (2024). *The State of World Fisheries and Aquaculture 2024: Blue Transformation in action*. Rome (Italy): Food and Agriculture Organization of the United Nations Retrieved from https://openknowledge.fao.org/items/06690fd0-d133-424c-9673-1849e414543d

García-Márquez, J., Galafat, A., Alarcón, F. J., Figueroa, F. L., Martínez-Manzanares, E., Arijo, S., & Abdala-Díaz, R. T. (2021). Cultivated and Wild Juvenile Thick-Lipped Grey Mullet, Chelon labrosus: A Comparison from a Nutritional Point of View. *Animals*, *11*(7).

GOBCAN. (2014). *Plan Estratégico de la Acuicultura en Canarias PEACAN (2014-2020)*. Santa Cruz de Tenerife (Spain): Gobierno de Canarias Retrieved from https://www.gobiernodecanarias.org/agricultura/doc/pesca/doc/cultivosmarinos/peacan.pdf

GOBCAN. (2024a). *Evolución de la producción en peso por especies acuícolas (2007-2024)*. Santa Cruz de Tenerife (Spain) Retrieved from https://www.gobiernodecanarias.org/agpsa/sgt/temas/estadistica/pesca/index.html

GOBCAN. (2024b). *Evolución de la producción en peso por tipo de pesca. 2007-2024*. Santa Cruz de Tenerife (Spain): Gobierno de Canarias Retrieved from https://www.gobiernodecanarias.org/agpsa/sgt/temas/estadistica/pesca/index.html

GOBCAN. (2024c). *Evolución de la producción en valor y peso por islas y especies. Datos mensuales. 2007-2024*. Santa Cruz de Tenerife (Spain): Gobierno de Canarias Retrieved from https://www.gobiernodecanarias.org/agpsa/sgt/temas/estadistica/pesca/index.html

Govzman, S., Looby, S., Wang, X., Butler, F., Gibney, E. R., & Timon, C. M. (2021). A systematic review of the determinants of seafood consumption. *Br J Nutr*, *126*(1), 66-80. https://doi.org/10.1017/S0007114520003773

Guillen, J., Asche, F., Borriello, A., Carvalho, N., Druon, J.-N., Garlock, T., Llorente, I., & Macias, D. (2025). What is happening to the European Union aquaculture production? Investigating its stagnation and sustainability. *Aquaculture*, *596*, 741793. https://doi.org/10.1016/j.aquaculture.2024.741793

Harb Rabia, S., Luzardo, O. P., Pozo, R., Abbassy, M., Zumbado, M., Elalfy, I., Robaina, L., & Gines, R. (2022). Determination of heavy metals from Aloe vera by- product in golden mullet (Liza aurata); A consumer health risk assessment. *Food Chem Toxicol*, *169*, 113418. https://doi.org/10.1016/j.fct.2022.113418

Kamleshbhai, B., Iqbal, G., & Bambhaniya, I. (2023). Integrated Multi-Trophic Aquaculture System (IMTA). In (pp. 109-125).

López-Mas, L., Claret, A., Arvisenet, G., del Castillo, R. R., Kallas, Z., Zuccaro, M., & Guerrero, L. (2023). European consumers' beliefs about the main pillars of the sustainability: a comparison between wild and farmed fish. *Aquaculture International*, *31*(4), 2035-2055. https://doi.org/10.1007/s10499-023-01070-2

López-Mas, L., Claret, A., Reinders, M. J., Banovic, M., Krystallis, A., & Guerrero, L. (2021). Farmed or wild fish? Segmenting European consumers based on their beliefs. *Aquaculture*, *532*, 735992. https://doi.org/https://doi.org/10.1016/j.aquaculture.2020.735992

MAPA. (2022). *Estadísticas Agrarias. Platanera: análisis provincial de superficie, árboles diseminados, rendimiento y producción, 2021*. Madris (Spain): Gobierno de España Retrieved from https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/2022/default.aspx?parte=3&capitulo=07&grupo=9&seccion=16

Marinac Pupavac, S., Kenđel Jovanović, G., Linšak, Ž., Glad, M., Traven, L., & Pavičić Žeželj, S. (2022). The influence on fish and seafood consumption, and the attitudes and reasons for its consumption in the Croatian population [Original Research]. *6*. https://doi.org/10.3389/fsufs.2022.945186

MITECO. (2024). *Economía Circular: tus actos, tu huella.* Madrid (Spain): Ministerio para la Transición Ecológica y el Reto Demográfico (Gobierno de España) Retrieved from https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular.html

Mitra, S., Khatun, M. N., Prodhan, M. M. H., & Khan, M. A. (2021). Consumer preference, willingness to pay, and market price of capture and culture fish: Do their attributes matter? *Aquaculture*, *544*, 737139. https://doi.org/https://doi.org/10.1016/j.aquaculture.2021.737139

Muscat, A., de Olde, E. M., Ripoll-Bosch, R., Van Zanten, H. H. E., Metze, T. A. P., Termeer, C., van Ittersum, M. K., & de Boer, I. J. M. (2021). Principles, drivers and opportunities of a circular bioeconomy. *Nat Food*, *2*(8), 561-566. https://doi.org/10.1038/s43016-021-00340-7

Nesterenko, V. (2023). Influence of socio-demographic factors on the development of marketing communications. *Scientific Bulletin of Mukachevo State University Series "Economics"*, *10*. https://doi.org/10.52566/msu-econ2.2023.09

Pujante-Rodríguez, I. M. (2019). *Fisiología y bioquímica digestiva de la liseta (Chelon labrosus)* Facultad de Ciencias del Mar y Ambientales de la Universidad de Cádiz]. Cádiz (Spain). https://rodin.uca.es/bitstream/handle/10498/21268/Tesis%20Final%20Entera.pdf?sequence=1

Ramírez-Bolaños, S., Díaz, S., Ventura-Castellano, A., Quirós-Pozo, R., Rodríguez-Rodríguez, Á., Castro, P., & Robaina, L. (2023). Assessing the growth and physiological performance of juvenile tilapia (Oreochromis niloticus) with the inclusion of new banana by-products in starter diets. *Aquaculture Reports*, *28*, 101453. https://doi.org/https://doi.org/10.1016/j.aqrep.2022.101453

Verreth, J. A. J., Turchini, G. M., & Roy, K. (2023). Circular bio-economy in aquaculture. *Reviews in Aquaculture*, *15*(3), 944-946. https://doi.org/10.1111/raq.12812

Woodside, A. G., Beretich, T. M., & Lauricella, M. A. (1993). A meta-analysis of effect sizes based on direct marketing campaigns. *Journal of Direct Marketing*, *7*(2), 19-33. https://doi.org/10.1002/dir.4000070205