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LOW-COMMERCIAL NATIVE FISH FROM NORTHERN SINALOA AND THEIR POTENTIAL FOR EXPLOITATION

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Abstract -- The municipality of Ahome, in northern Sinaloa, is characterized by its intense fishing activity, which represents a primary source of income for coastal communities. However, these communities face economic and social challenges stemming from marginalization and dependence on overexploited commercial species, such as shrimp. In this context, the bycatch obtained during shrimp fishing includes undervalued species, which represent a resource with high potential for utilization but currently lack adequate valuation. This article presents the results of the characterization of the physicochemical and nutritional properties, according to AOAC methods [1], of two underutilized native species, identifying their viability for the development of value-added products with the aim of reducing dependence on overexploited commercial species, diversifying fishermen's sources of income, and promoting sustainable use. The comprehensive approach is to transform undervalued species into a driver of regional development, contributing to the well-being of communities and the responsible management of fishery resources.

Keywords: economic development, commercial fishing, value-added.

Abstract --Ahome, in northern Sinaloa, is characterized by its intense fishing activity, which represents a primary source of income for coastal communities. However, these communities face economic and social challenges stemming from marginalization and dependence on overexploited commercial species, such as shrimp. In this context, the bycatch obtained during shrimp fishing includes undervalued species, which represent a resource with high potential for utilization but currently lack adequate valuation. This article presents the results of characterizing the physicochemical and nutritional properties, according to AOAC [1] methods, of two undervalued native species, identifying their viability for developing value-added products with the aim of reducing dependence on overexploited commercial species, diversifying fishers' income sources, and promoting sustainable use. The comprehensive approach is to transform undervalued species into a driver of regional development, contributing to the well-being of communities and the responsible management of fishery resources.

Key words **–** added value, commercial fishing, economic development.

INTRODUCTION

The northern region of Sinaloa is an area where fishing constitutes a strategic activity for coastal communities, both from an economic and social standpoint. The historical dependence on commercially exploited species, such as shrimp, has created significant vulnerability in the region's fishing grounds, where marginalization and limited diversification of income sources are recurring problems. In this context, it is important to note that shrimp fishing, both in bays and on the high seas, yields approximately 14 kilograms of bycatch for every kilogram of shrimp caught [2], which includes a significant volume of undervalued species with an under-studied potential for utilization. In addition, 106 species and 76 genera belonging to 45 families of fish, which represents a significant source of information [3].

Among the underutilized species are the pámpano, sardine, gallo, toro, and mojarra, which, although their consumption is limited to residents of fishing villages and some local markets, possess properties that position them as ideal candidates for the industrial processing and marketing of value-added products.

Furthermore, fish muscle generally provides a high amount of easily absorbed protein and unsaturated fats, which constitute an important supplement to the human diet [4]. Unsaturated fats composed of long-chain omega-3 fatty acids have also been associated with beneficial effects in the prevention of cardiovascular disease, neurological development in children, and the control of inflammatory processes [5].

It is important to note that incorporating fish into the daily diet provides essential micronutrients such as iron, iodine, selenium, calcium, and phosphorus, deficiencies of which have been identified in at-risk populations [6].

This article describes important characteristics of some of the undervalued native species, identifying their potential for the development of innovative and sustainable products, addressing the need to diversify income sources for residents in indigenous communities in local fishing grounds, as well as the urgency of mitigating the overexploitation of commercial species.

There are eight fishing villages along the coast of the municipality of Ahome [7]; however, marginalization is often a common denominator among them. According to the website PueblosAmerica.com [8], based on the 2020 Population and Housing Census, the demographic and geographic data for the fishing villages in the municipality of Ahome, Sinaloa, are as follows:

El Colorado
It is located approximately 32 kilometers west of the city of Los Mochis. The population consists of 1,440 women and 1,542 men, for a total of 2,982 inhabitants, of whom 4.43% identified as belonging to an indigenous community.

El Jitzamuri
An indigenous town in the municipality of Ahome located approximately 70 kilometers north-northwest of the city of Los Mochis. The population consists of 626 women and 650 men, for a total of 1,276 people, of whom 2.12% belong to indigenous ethnic groups.

Topolobampo
Located 21.5 kilometers north of the city of Los Mochis. The total number of registered residents in 2020 was 6,198, comprising 3,085 women and 3,113 men. Only 1.53% of the total population belongs to indigenous cultures.

Paredones
A fishing village located 14 kilometers north of the city of Los Mochis, with a population of 457 women and 485 men, for a total of 942 inhabitants, of whom 10.4% identified as members of indigenous communities.

Las Lajitas
Located 51 kilometers southwest of the city of Los Mochis, this fishing village has only 68 residents, of whom 24 are women and 44 are men. None of the residents identified as belonging to any indigenous ethnic group.

Lázaro Cárdenas
The fishing village of Lázaro Cárdenas, also known as Muellecito, is located 21.6 kilometers north of the city of Los Mochis. Its 822 residents include 409 women and 413 men. It is important to note that 53.5% of them belong to indigenous communities.

El Hecho
This community, located 55.9 kilometers south of Los Mochis, has a population of 227, comprising 108 women and
119 men, with 13.22% belonging to indigenous ethnic groups.

Bacorehuis
This fishing village, located 75 kilometers north-northwest of the city of Los Mochis, has 2,049 inhabitants, 976 women and 1,073 men. A significant 69.6% reported belonging to indigenous communities.

The species caught as bycatch vary in commercial value, including some that are undervalued but possess nutritional potential worthy of study. Among the species with low commercial value, whose consumption is limited to the inhabitants of the fishing villages and some local markets, are:

Pámpano
Found in different varieties (*Trachinotus kennedyi, Trachinotus paitensis, Trachinotus rhodopus, Chaetodipterus zonatus*), it is not considered a primary target of commercial fishing; however, its potential for fresh or processed marketing can be exploited [2].

Sardine
Although sardines are typically consumed in canned form, the various species (*Opisthonema libertate, Anchovia macrolepidota, Centengraulis*

mysticetus) are caught in significant quantities as bycatch in shrimp fishing, generating high expectations for their utilization [2].

Roosterfish
The gallo fish (*Nematistius pectoralis*) is a coastal species widely distributed in the tropical eastern Pacific, from Baja California and the Mexican Pacific coast to Ecuador and Peru. It is a species characteristic of sandy beaches and shallow areas, very common in the states of Sinaloa, Nayarit, and Baja California Sur, where it constitutes a significant portion of coastal, artisanal, and sport fishing catches [9]. Its white, tender flesh makes it suitable for culinary use, just like other species of higher commercial value.

Toro
The dogtooth tuna (*Caranx caninus*) is a marine fish species of the *Carangidae* family, widely distributed throughout the eastern Pacific: its range extends from the coasts of southern California (U.S.) to Peru, including the Gulf of California [10]. Its robust build yields large quantities of fillet per individual.

Mojarra
In all its varieties (*Eucinostomus currani, Eucinostomus gracilis, Diapterus brevirostris, Eugerres axillaris, Gerres cinereus*), the mojarra is widely known and consumed in the towns of northern Sinaloa, which underscores the importance of studying its processing to provide it with added value both commercially and from a nutritional standpoint [2].

The objective of this study is to characterize the physicochemical and nutritional properties of undervalued native fish from the fishing grounds of the municipality of Ahome, in order to identify their potential for sustainable use and promote their valorization in the food and economic sectors. To this end, the following objectives are established: to identify the species of undervalued native fish present in the fishing grounds of the municipality of Ahome, considering their availability and abundance; to evaluate the physicochemical properties (moisture, ash) and nutritional profile (proteins, lipids) of the selected species; to investigate possible technological developments for the analyzed and subsequently selected species, proposing value-added products that contribute to the social development of fishing communities. The aim is to identify opportunities to utilize undervalued native species, diversifying the income sources of local fishermen and reducing dependence on overexploited commercial species.

DEVELOPMENT

Methodology

Personal interviews were conducted with 25 fishermen, 15 from the Topolobampo fishing ground and 10 from Paredones, primarily to obtain sociodemographic data and information about the species caught, including both commercial species and those rarely valued for human consumption.

Raw Material: Two fish species with no commercial value were collected in July at the port of Topolobampo (a fishing ground with a distinctively indigenous population) in the northern part of the state of Sinaloa. This location was selected because it is the second most important port in the state of Sinaloa and the largest fishing ground in the northern region. The species collected were *Nematistius pectoralis*, commonly known as roosterfish, and *Caranx caninus*, known as bullfish. These were processed fresh for morphological measurements. The fillets (edible portion) obtained were dried at 70 °C for 12 hours, vacuum-packed, and kept away from light for subsequent analyses.

Physical parameters: For the collected fish, size measurements (length, width, and height in centimeters) and weight measurements (total weight in grams, percentage of viscera, and fillet weight) were determined using an ichthyometer and a Fowler vernier caliper (±0.05 mm precision). Weight was recorded using an AND GX-2000 electronic scale (±0.01 g accuracy). Subsequently, the fish were gutted, washed, and filleted to obtain the edible portion.

Proximate analysis: moisture content was determined in accordance with Mexican standard NOM-116-SSA1-1994 [12]. The procedure consisted of the complete removal of water content by oven drying (Ecoshel model 9025H) at 100° ± 2 °C.

The fat content of the samples was determined using the Soxhlet method, in accordance with Mexican standard NMX-F-615-2018 [13]. Three grams of sample were weighed and carefully transferred to an extraction cartridge, where they were covered with a small layer of cotton (fat-free) to prevent sample loss. The cartridge containing the sample was placed in the extraction flask of the Soxhlet apparatus, using petroleum ether (approximately 250 mL or the amount necessary for two siphoning cycles in the apparatus). The assembly was placed over a heat source, and the temperature was adjusted so that the drip rate in the extractor was approximately two drops per second. Extraction was carried out for a period of 4 to 6 hours, sufficient time to ensure the repeated solubilization and transport of lipids from the sample to the collection flask. Once the extraction was complete, the solvent in the flask was evaporated at a low temperature to avoid overheating that could degrade the extracted lipids. After the solvent had evaporated, the flask was returned to the oven to complete drying, where it was kept until a constant weight was reached. Subsequently, it was placed in a desiccator to cool prior to final weighing. Total fat content was reported as grams of total fat per 100 grams of dry sample.

The protein content was determined using the Kjeldahl method, established for the quantification of total nitrogen in food products in accordance with Mexican standard NOM-131-SSA1-1995 [14]. One gram of sample was weighed and transferred to the Kjeldahl flask, where the digestion mixture consisting of 2 g of copper sulfate (Frama), 10 g of anhydrous sodium sulfate (Faga Lab), and 25 mL of concentrated sulfuric acid (Frama) was added, along with boiling chips to ensure uniform heating. The flask was initially placed at a low temperature, allowing the mixture to begin carbonizing in a controlled manner. Subsequently, the temperature was gradually increased until the contents took on a completely clear and transparent appearance, indicating the complete digestion of organic nitrogen and its conversion to ammonium sulfate. This process constituted the digestion stage. Once digestion was complete, the flask was allowed to cool slightly and was connected to the distillation system. The distillate was collected in a 500 mL Erlenmeyer flask, which contained 50 mL of boric acid solution (Faga Lab) and a few drops of Wesslow's indicator. At the same time, approximately 400 mL of distilled water was added to the Kjeldahl flask containing the digested residue to completely dissolve the salts present, ensuring adequate carryover during the distillation stage. The mixture was allowed to cool again, and 6 to 7 zinc pellets were added without stirring the mixture; 50 mL of sodium hydroxide solution (Faga Lab) was then carefully added. Finally, distillation was initiated, allowing the ammonia to be carried over into the receiving solution until approximately 300 mL of distillate was obtained. Once distillation was complete, the receiving flask was removed, and the contents were titrated with a 0.1 N hydrochloric acid solution until the indicator changed color. The volume of titrant consumed allowed for the calculation of the total nitrogen present in the sample, and subsequently the amount of protein, using the corresponding conversion factor. The total protein content was reported as grams of protein per 100 grams of dry sample.

Ash content was determined in accordance with Mexican standard NMX-F-066-1978 [15]. This method is based on the complete removal of the organic fraction present in the sample through high-temperature combustion, leaving only the minerals naturally present in the fish tissue as residue. One gram of sample was weighed directly into a crucible. The assembly was initially placed over a burner to perform controlled pre-drying and carbonization of the sample, preventing sudden loss of material due to violent volatilization. Subsequently, the crucibles were transferred into a muffle furnace (Fisher Scientific model 650-58) preheated to 600 °C, allowing for the complete incineration of the organic tissue. This process was continued until white or light gray ash was obtained, indicating total oxidation of the organic fraction; approximately 6 h. Ash results were reported as g of ash per 100 g of dry sample.

DISCUSSION AND ANALYSIS OF RESULTS

The responses obtained from the 25 fishermen interviewed indicate significant biases in the demographic values, as well as similarities in some of the responses obtained. Figure 1 shows a summary of the fishermen's ages:

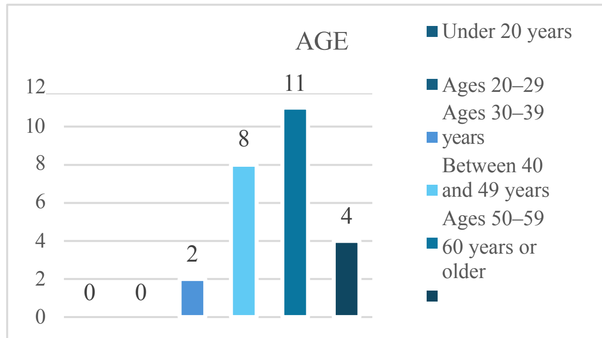

Figure 1. *Age range reported by respondents*
Source: Author's *own compilation*.

As can be seen, the predominant age range among the interviewed fishermen is between 50 and 59 years old, with 11 out of 25 responses, while the range between 40 and 49 years old ranks second. None of the fishermen reported being under 30 years old.

It should be noted that all 25 fishermen interviewed are male; no women were found among the active fishing community.

Regarding the length of time they have been engaged in fishing, the respondents answered as shown in Figure 2:

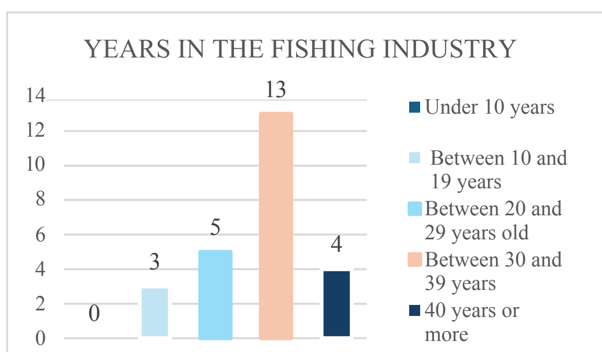

Figure 2. *Time spent fishing.*
Source: Author's *own work*.

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As shown in Figure 2, most of the interviewees reported having spent between 30 and 39 years engaged in fishing, and it can be observed that only 3 of them reported less than 20 years of fishing experience.

The socioeconomic context of the fishing communities in northern Sinaloa has been characterized by high rates of marginalization and dependence on shrimp fishing, despite the abundance of available marine resources [2,7]. The literature on fisheries development emphasizes that diversifying income sources, particularly by involving women in processing and marketing activities, can improve the economic resilience of these communities [22]. In this regard, various authors have noted that the valorization of bycatch species not only has food and economic potential but also helps reduce fishing pressure on overexploited species, promoting more sustainable management of fishery resources [17,18].

When asked which fish were in highest demand, the interviewees agreed that the corvina (*Cynoscion othonopterus*), the snapper (*Lutjanus guttatus*), the sierra (*Scomberomorus sierra*), the botete (*Sphoeroides annulatus*), and the cochito (*Balistes polylepis*) were the best-selling species, while the least commercially viable were catfish (*Bagre bagre*), gallo (*Nematistius pectoralis*), sardines (*Opisthonema libertate, Anchovia macrolepidota, Centengraulis mysticetus*), and toro (*Caranx caninus*). The latter are sold as bait for commercial and sport fishing, yielding between 5 kg and 20 kg per boat per fishing day.

The utilization of undervalued marine species has been a topic of growing interest in the scientific literature, especially in regions where fishing depends on a few commercial species and the bycatch represents an underutilized resource. In the Mexican Pacific, particularly in Sinaloa, ichthyological studies have documented a high species diversity, with 106 species and 76 genera belonging to 45 families in the bays of Ohuira, Topolobampo, and Santa María [3]. This richness contrasts with the limited commercial attention many of these species receive, a phenomenon attributed to sociocultural factors such as consumer unfamiliarity, unappealing appearance, or a historical preference for species like shrimp, corvina, and snapper [2,18].

From a nutritional standpoint, various authors have noted that fish in general provides highly digestible proteins and unsaturated lipids beneficial to human health [4]. In particular, long-chain omega-3 fatty acids (EPA and DHA) have been associated with protective effects against cardiovascular diseases, as well as with neurological development in children and the modulation of inflammatory processes [5]. Furthermore, fish consumption contributes to the intake of essential micronutrients such as iron, iodine, selenium, calcium, and phosphorus, deficiencies of which are common in at-risk populations [6]. However, most nutritional studies have focused on species of high commercial value. Research on underutilized species from the Mexican Pacific has begun to reveal that these species possess protein and lipid profiles comparable to those of traditionally marketed species [16], suggesting that their marginalization in the market is not due to nutritional inferiority, but rather to economic and cultural factors [18,19].

In the technological sphere, it has been documented that processing undervalued fish using techniques such as drying, producing fish meal, or creating value-added products (pâtés, sausages, canned goods) constitutes a viable strategy for increasing their commercial acceptance and generating supplementary income for fishing communities [20,21]. These processes not only extend shelf life but also concentrate nutrients and allow for the utilization of both the edible portion and byproducts (scales, skin, bones) to obtain functional ingredients or animal feed [6,17].

The species analyzed were chosen for their seasonal availability, specifically the roosterfish and the bullfish, which were purchased from the San Carlos Cooperative in the Topolobampo fishing grounds.

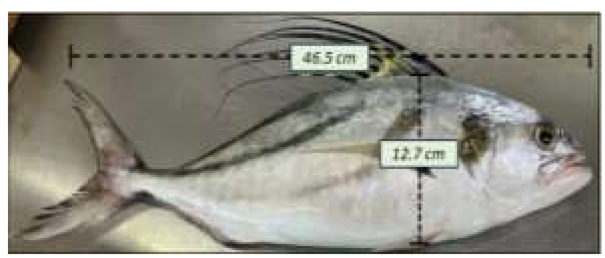

Figure 3. *Roosterfish (Nematistius pectoralis).*
Source: Author's *own work*.

Figure 3 shows the main dimensions of the roosterfish, which is characterized by a greater length relative to its width. Its striking dorsal fin makes it attractive for sport fishing; however, this study aims to justify its use as food and/or as a raw material for the production of byproducts.

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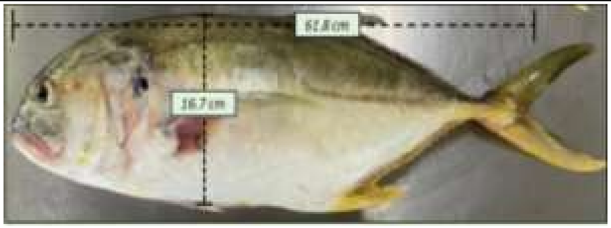

Figure 4. *Dogfish (Caranx caninus).*
Source: Author's *own work.*

Figure 4 shows the basic dimensions of the bullfish, highlighting its considerable length. Its red flesh suggests high mineral content, primarily iron. The proportion of the edible portion and the portion usable for byproducts makes it an interesting subject for this study.

The results of the analyses performed on individuals of both species are described in Table 1, which presents the means and standard deviations of the physical parameters of the two species analyzed prior to drying. The measurements recorded were: total weight, body dimensions (length, width, and height), as well as the weight of the viscera and fillet of four roosterfish specimens and two bullfish specimens, yielding the proportions of material considered waste and usable. These data allow for the characterization of the initial physical state of the samples and serve as a reference for evaluating the changes generated during the drying process.

Table 1. *Summary of physical parameters for both species.*

PHYSICAL PARAMETER	SPECIES	
	ROOSTERFISH	BULLFISH
Weight (g)	1153 ± 27.01	3207 ± 787.72
Visceral content (%)	9.51 ± 1.07	12.59 ± 2.37
Fillet (%)	43.85 ± 2.24	34.86 ± 0.12
Usable non-edible (%)	46.42 ± 1.25	52.55 ± 2.48
Length (cm)	46.5 ± 1.29	61.75 ± 5.30
Width (cm)	12.7 ± 0.48	16.69 ± 2.00
Height (cm)	4.53 ± 0.21	8.62 ± 0.62
Moisture (%)	69.77 ± 0.76	70.68 ± 0.19
Ash (g/100g)	1.72 ± 0.11	1.78 ± 0.52

Source: Author's *own work*.

The weights of the four roosterfish specimens analyzed show marked homogeneity among them, which is favorable for the comparison of subsequent results, reducing the variability attributable to the size and weight of the organism. Total weights ranged from 1118 to 1178 g, with a relatively small difference between individuals, suggesting that the fish belong to a similar age and developmental range.

Regarding the body dimensions of the roosterfish, length showed a gradual increase from 45 to 48 cm, while width decreased slightly from 13.1 to 12.0 cm as length increased. This pattern may be related to the species' characteristic body conformation, where longer specimens tend to be more slender. Height remained relatively constant (4.3–4.7 cm), indicating a uniform body shape among the sampled organisms.

Regarding visceral weight, values ranging from 100 to 130 g were observed, representing a small fraction of the fish's total weight—between 9% and 12% of material considered disposable. These variations can be attributed to individual physiological differences, such as nutritional status or the degree of digestive tract filling at the time of sampling. On the other hand, fillet weight showed consistent values, ranging from 479 to 519 g, indicating a relatively stable yield of the edible portion among the specimens analyzed. The ratio of total weight to fillet weight suggests a fillet yield of 41% to 46%, a range that can be considered significant for the utilization of the species; furthermore, this proportion is relevant for drying studies and subsequent analyses, since the fillet constitutes the fraction of greatest interest for the evaluation of physicochemical parameters, such as moisture loss and nutrient concentration.

The weight of the non-edible usable portion, consisting of scales, skin, and bones, shows little variability among specimens, representing 45% to 47% of the total weight of the fish, thus constituting a source of raw material for the production of byproducts such as fish meal or for the extraction of collagen. Overall, the initial data confirm that the roosterfish samples exhibit comparable physical characteristics, which provides an adequate basis for evaluating the effects of the drying process without the observed differences being primarily due to the morphological variability of the organisms.

Regarding the bullfish, a notable difference is observed between the two specimens analyzed, primarily associated with body size. Total weight showed a wide range, from 2,650 to 3,764 g, indicating variability in the organisms' stage of development with a possible influence on the material's behavior during drying.

As for body dimensions, length increased from 58 to 65.5 cm as the fish's weight increased, which is consistent with a positive relationship between body length and mass. Similarly, width and height showed higher values in the heavier specimen, reflecting a more robust build. These morphological differences are relevant, as larger fish typically exhibit slower heat and mass transfer, which can affect uniformity and the time required for drying.

The weight of the viscera ranged from 378 to 411 g, representing a fraction of between 11% and 14% of the total body weight. The slight variation observed can be attributed to individual physiological factors, such as nutritional status or the contents of the digestive tract at the time of sampling. Meanwhile, the fillet weight was considerably higher in the second specimen (1309 g) compared to the first (926 g), demonstrating a significant increase in the absolute yield of edible muscle as fish size increases. However, the fillet weight as a percentage of the total weight of the specimens is around 35% in both cases.

It is important to note that the proportion of scales, skin, and bones ranges from 51% to 54%, slightly higher than that recorded for the roosterfish, further highlighting the blue jack as a source of raw material for fish meal production or collagen extraction.

Overall, the initial results for the Spanish mackerel indicate that the size and body conformation of the specimens are key factors that must be considered when interpreting the effects of drying. The variability observed among the specimens can influence moisture loss and the final product quality; therefore, these initial physical parameters serve as an essential reference for analyzing subsequent results.

The reported moisture content of around 70% in both species studied is consistent with values reported for other species such as snapper and flounder (76%), dogfish (78%), rabbitfish (70%), and catfish (77%) [11].

The ash content of 1.72% and 1.78% for roosterfish and bullfish, respectively, can be considered slightly higher than that reported in fish in high demand for human consumption, such as snapper, which has a reported ash content of 1.31%, while sole has a reported ash content of 1.18% [11].

Table 2. *Nutritional parameters in fresh product for both species.*

NUTRITIONAL PARAMETER	SPECIES	
	ROOSTERFISH	BULLFISH
Protein (%)	18.24 ± 1.01	18.96 ± 0.60
Fat (%)	6.13 ± 1.04	5.07 ± 0.69

Source: Author's *own calculations*.

The results shown in Table 2 indicate that the two species compare favorably with fish in high demand for human consumption; for example, snapper contains 19.2% total protein and 1.23% total lipids, while sole contains 21.43% protein and 1.24% total lipids [11], suggesting that the species analyzed in this study may contain higher amounts of omega-3 oil, making them a potential source of this important dietary supplement. Studies conducted on underutilized marine species from the Mexican Pacific have reported comparable protein contents under similar analytical conditions, which supports the consistency of the results obtained in the present study [16].

Table 3. *Dry matter nutrient parameters for both species*

NUTRITIONAL PARAMETER	SPECIES	
	ROOSTERFISH	BULLFISH
Protein (%)	60.33 ± 3.34	64.65 ± 2.06
Fat (%)	20.77 ± 3.43	17.29 ± 2.37

Source: Author's *own work*.

Analyses conducted on the dry matter basis of the edible portion of both species yield interesting results, as shown in Table 3, where the high protein content in both species can be observed, with a slightly higher percentage in the bullhead, which could be utilized in the production of fish meal and used in animal feed production.

CONCLUSIONS

In marine ecosystems, there are a considerable number of undervalued, underutilized, or under-exploited fish species. These species, even though they are a natural part of the catch, tend to receive little commercial attention due to factors such as low consumer recognition, their appearance, size, processing difficulty, or simply the market's preference for a few high-value species.

The results of this study have shown that the two species analyzed have nutritional profiles comparable to those of species traditionally marketed for human consumption, making their underutilization a significant loss from a food, economic, and ecological standpoint (17). These species are rich in micronutrients; combined with the above, this makes them an important option for sustaining populations. Consequently, it is evident that their marginalization in the market is not due to a lack of quality, but rather to sociocultural and economic factors (18,19).

The information compiled from the results obtained demonstrates an alternative with nutritional value comparable to that of species of higher commercial value, while also providing relevant data given the scarcity of published studies on these species. Furthermore, it positions both species as sources of raw material, particularly for the production of fish meal, functional ingredients, or value-added products, while also guiding decisions regarding the utilization of underutilized marine resources.

The application of rigorous procedures for determining moisture and ash content yielded robust and reproducible results. This methodological process not only strengthened the study's validity but also provided clarity regarding the chemical behavior of dehydrated tissues, demonstrating that drying yields concentrated matrices with high nutritional content. The information generated therefore represents a technical foundation that can be used in future projects, whether to determine amino acid profiles, evaluate lipid quality, or develop food prototypes based on dried fish.

From a technological standpoint, the high fat content suggests that the evaluated species have potential for the production of high-energy-value products, such as pâtés, spreads, or fish sausages, where the lipid fraction contributes favorably to the product's texture, palatability, and yield. This type of product has been reported in the literature as an effective alternative for the valorization of species with low commercial utilization, contributing to the diversification of the food supply and the economic strengthening of local fishing communities (20). However, it also implies the need to implement lipid oxidation control strategies during processing and storage.

Based on nutritional profiles, it is possible to design strategies for the valorization and preservation of undervalued fish in indigenous communities within the region's fishing grounds, prioritizing strategies that are easily accessible and implementable, allowing for easy commercialization over an acceptable shelf life.

It is possible to design prototypes of value-added fish-based products (21) by considering the characteristics of products already produced by indigenous communities in the fishing grounds of the municipality of Ahome, Sinaloa.

Furthermore, it is feasible to propose a training workshop to promote the adoption of the new products and improve the quality of life in fishing communities (22).

Overall, the results obtained demonstrate that the species evaluated have a nutritional profile suitable for processing into value-added products, supporting their sustainable use and their integration into regional fisheries development strategies.

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