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Garfish (Belone belone) in Çanakkale, Turkey as a functional seafood: Nutritional profile and antioxidant activity

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Abstract

In this study, the nutritional content of garfish (Belone belone) was investigated. The results showed that garfish meat contains a high protein content of 71.6% that indicating its value as a quality animal protein source. The crude fat content was determined as 15.2%. The tocopherol (vitamin E) content was measured at 27.9 mg/kg, highlighting the fish's role in protecting cells against oxidative stress through its antioxidant properties. Antioxidant capacity analyses demonstrated that garfish exhibits strong free radical scavenging activity. DPPH radical scavenging assay results confirmed a high level of antioxidant effectiveness. In mineral analyses, macro-elements such as calcium (6306.17 mg/kg), potassium (4587.2 mg/kg), and sodium (1615.21 mg/kg) were present in notable amounts. This suggests that garfish can contribute significantly to bone health, muscle function, and electrolyte balance. In terms of trace elements, zinc (33.81 mg/kg), iron (25.42 mg/kg), copper (5.93 mg/kg), and manganese (0.16 mg/kg) were measured. These minerals play critical roles in immune function, oxidative defense, and various metabolic processes. Vitamin analysis revealed 27.9 mg/kg of vitamin E and 1.73 mg/kg of vitamin A. These vitamins are known to enhance antioxidant capacity and support immune and cellular health. In conclusion, garfish is considered as an important resource in both nutrition and aquaculture sectors due to its high protein content and functional nutritional components. Its rich mineral and

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vitamin profile supports its potential as a functional food, offering health-promoting benefits. Sustainable fishing practices for garfish are essential for maintaining ecological balance and ensuring long-term economic benefits. These characteristics highlight the strong potential of garfish as a functional food with health-supporting properties.

Keywords: Garfish (Belone belone); Tocopherol; Mineral; DPPH.

1. Introduction

Seafood holds significant importance in human nutrition due to its rich nutritional value and positive health effects. Fish, shellfish, and other marine products are natural sources rich in high-quality proteins, essential omega-3 fatty acids, vitamins (particularly A, D, and B12), and minerals (such as iodine, selenium, and zinc) (Bourre and Paquotte, 2008; Aleruchi *et al*., 2023; Rifat *et al*., 2023). This composition makes seafood an indispensable component of a balanced and healthy diet. In particular, omega-3 fatty acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) provide numerous health benefits, including reducing the risk of cardiovascular diseases, supporting brain development and function, and reducing inflammation (Bradbury, 2011; Cardoso *et al*., 2016; Smolińska, *et al.*, 2024). Therefore, regular seafood consumption is recommended for maintaining heart health, nervous system development, and overall metabolic functions. Furthermore, due to their low saturated fat content and high bioavailable protein levels, seafood plays an important role in preventing obesity and chronic diseases. In terms of vitamin and mineral content, seafood provides critical nutrients, especially necessary for children, pregnant women, and the elderly. However, controlling biological and chemical risks such as heavy metal accumulation and microbial contamination is essential in seafood consumption (Hosomi *et al*., 2012; Liu and Ralston, 2021; Chen *et al*., 2022; Abera and Adimas, 2024; Taylor *et al*., 2025). Enhancing access to safe and high-quality seafood through sustainable fisheries and aquaculture practices is of great importance for public health. Finally, seafood occupies a priority position in global nutrition policies due to its nutritious and functional components that support human health. It is regarded as one of the key food groups in the development and maintenance of healthy lifestyles.

Garfish (Belone belone) is a marine fish species that is important for both its high nutritional value and its commercial and recreational importance (Uckun *et al*., 2004; Tufan *et al*., 2018; Chaari, *et al*., 2022). In terms of nutritional composition, garfish stands out with its high protein content and balanced lipid profile. Its elevated protein level makes garfish meat a valuable source of high-quality animal protein, while the presence of essential fatty acids, particularly omega-3 fatty acids contributes positively to human health. Additionally, garfish offers a rich profile in minerals and vitamins, making it a functional and nutritious seafood option (Koral *et al*., 2009; Balçık Mısır, 2010; Merdzhanova *et al*., 2012; Atik *et al*., 2023). From a fisheries perspective, garfish is commonly found in regions such as the Mediterranean, Aegean, and Black Seas. Its seasonal presence in coastal waters during the summer months and its migratory behavior influence fishing seasons (Uckun *et al*., 2004; Samsun and Erdoğan Sağlam, 2021). Garfish

is typically caught using traditional methods such as hand lines, fishing lines, and nets. In commercial fisheries, garfish is marketed both as a fresh product and as a processed seafood item. However, for the sustainability of catch volumes, regular monitoring of stock levels and the enforcement of fishing bans are essential. In conclusion, due to its high nutritional value and economic significance, garfish is recognized as a valuable resource for both nutrition and the seafood industry. Sustainable fishing practices and the conservation of natural stocks are critical to maintaining the species' importance as a food and commercial resource in the future.

2. Material and method

2.1. Sample collection and preparation

The fish garpikes were obtained from fish markets in Çanakkale, Turkey. Fish were placed into plastic bags and kept on ice until return to the laboratory. The samples were separated into skin and flesh, after which the fish flesh was homogenized using a kitchen blender. For mineral content, heavy metal analysis, and antioxidant measurements, the samples were dried prior to analysis.

2.2. Crude oil, Ash, Protein and Moisture analysis

AOAC (2000) standard methods were used to determine the ash and protein contents in garfish (Belone belone). Protein determination was performed using the Kjeldahl method. For this, 0.5 g of homogenized sample was placed into Kjeldahl tubes, followed by the addition of concentrated sulfuric acid (96% H_2SO_4), hydrogen peroxide (35% H_2O_2), and a Kjeldahl catalyst tablet. Digestion was carried out at 420 °C for approximately 2–3 hours. After cooling, 50 mL of distilled water and 50 mL of 33% NaOH were added to the tubes, and distillation was carried out. The released nitrogen vapor was collected in an Erlenmeyer flask containing a boric acid solution with methyl red indicator. Approximately, 100 mL of distillate was then titrated with 0.1 N HCl to calculate the nitrogen content, from which the protein content was determined. Ash content was determined according to the AOAC (2000) method. First, porcelain crucibles were preheated at 550 °C for 1 hour to ensure cleanliness, then cooled and weighed to record their tare weights using a precision balance. Roughly, in each crucible, 2 g of fish sample was used. The samples were incinerated in a muffle furnace at 550 °C for about 4–5 hours until they reached a light gray, cigarette ash-like color. After incineration, crucibles were cooled in a desiccator and weighed again to determine the ash content. Ash content was calculated using the Equation (1).

Fat content was determined according to the method described by Erickson (1993). For the analysis, 20 g of sample was homogenized with 100 ml of a methanol/chloroform mixture (1:2, v/v). After homogenization, the residue was rinsed with an additional 20 ml of the same solvent mixture and filtered into a volumetric flask. Then, 20 ml of 4% $CaCl_2$ solution was added to the filtrate, and the flask was sealed and kept in a dark environment overnight to allow phase separation. After separation, the lower (chloroform) phase was collected,

and the solvent was removed using a rotary evaporator at 60 °C. The obtained oily residue was placed in an oven at 65 °C for 2 hours, then cooled in a desiccator and weighed to determine the fat content. Crude fat content was calculated using the Equation (1). Moisture content was determined according to the method described by Mo and Neilson (1994). The sample was dried in an oven at 105°C. After reaching constant weight, the moisture content of the samples was calculated using the Equation (1).

% = [(Final Weighing-Initial Weighing) × 100]/ Sample Weight (1)

2.3. Analysis and preparation of the methanol extract for Antioxidant activity

The amount of 50 grams of the dried and powdered fish materials were extracted with methanol (HPLC grade) using a Soxhlet apparatus at 80 °C for 8 hours. The fish extracts were filtered and concentrated under vacuum at 50 °C using a rotary evaporator. Finally, the extracts were dried and stored in the dark at 4 °C until use. The DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging method was applied to determine the antioxidant activities of the samples (Brand-Williams *et al.*, 1995). In this method, the stable and purple-colored DPPH radical is used to measure the radical scavenging capacity of the sample. A specific volume of DPPH solution was mixed with the sample solution, and the mixture was allowed to stand for 30 minutes. After incubation, the absorbance was measured at 515 nm wavelength. Antioxidant activity was calculated using the absorbance values of the control and the sample according to the Equation (2):

DPPH (%) = [(A control – A sample)/A control] × 100 (2)

2.4. Determination of calorie values

The calorific values of the samples were determined using a bomb calorimeter at the Central Laboratory of Çanakkale Onsekiz Mart University (ÇOBİLTUM) with a LECO-AC (350) device (Lamare and Wing, 2001). A measured amount of dried sample was combusted in an oxygen-rich environment using the bomb calorimeter, and the calorific value of each sample was obtained. The device was calibrated using standard benzoic acid.

2.5. Fat-soluble vitamin analyses and sample preparation

α-Tocopherol and retinol analysis was performed by HPLC (Kuhn *et al.*, 2008; Lopez-Cervantes *et al.*, 2006). Initially, samples were protein-precipitated using ethanol containing 1% pyrogallol. Then, saponification was carried out by homogenizing the samples with 3 M KOH at 65 °C for 30 minutes. To ensure effective vitamin extraction, the resulting solution was adjusted with phosphate buffer (0.2 M, 0.1% EDTA, pH 3.9). The solution was extracted with hexane (containing 1% pyrogallol), mixed for 5 minutes, and then centrifuged at 4000 rpm for 10 minutes to complete the extraction process. The obtained extract was dried using a nitrogen evaporator and then prepared for analysis by dissolving in an acetonitrile/methanol solution (1:1, v/v). The fat-soluble vitamins α-tocopherol (Vitamin E) and retinol (Vitamin A) were analyzed using a Shimadzu HPLC system. The HPLC setup included an SPD-M20A DAD diode array detector, Sil-20AC

auto injector, RF-10-AXL fluorescence detector, CTO-20A column oven, and LC-20AD pump components. Measurements were carried out with the diode array detector (DAD). Six-point calibration curves were prepared for α-tocopherol, retinol, and cholesterol analyses, and measurements were taken at 290 nm and 325 nm wavelengths. Methanol and acetonitrile were used as the mobile phase with a flow rate of 1.2 mL/min. A C18 column of 250 mm length and 4.6 mm diameter was employed for separation. A constant gradient method was applied during the analysis. Table 1 represnts the operating conditions for the HPLC. Additionally, the chromatograms and calibration curves for α-tocopherol and retinol are shown in Figure 1.

Table 1. Chromatographic analysis information of α-tocopherol and retinol by HPLC

Column Type				Heat	Flow Rate
Manufacturer	Type	Diameter*Length (mm)	ID (µm)	(°C)	(mL/min)
Inertsil	ODS-3 (C18)	4,6*250	5	35 °C	1,2

	Mobile Phase Information	
Time	A (Methanol)	B (Acetonitrile)
0 – 25 min	60%	40%

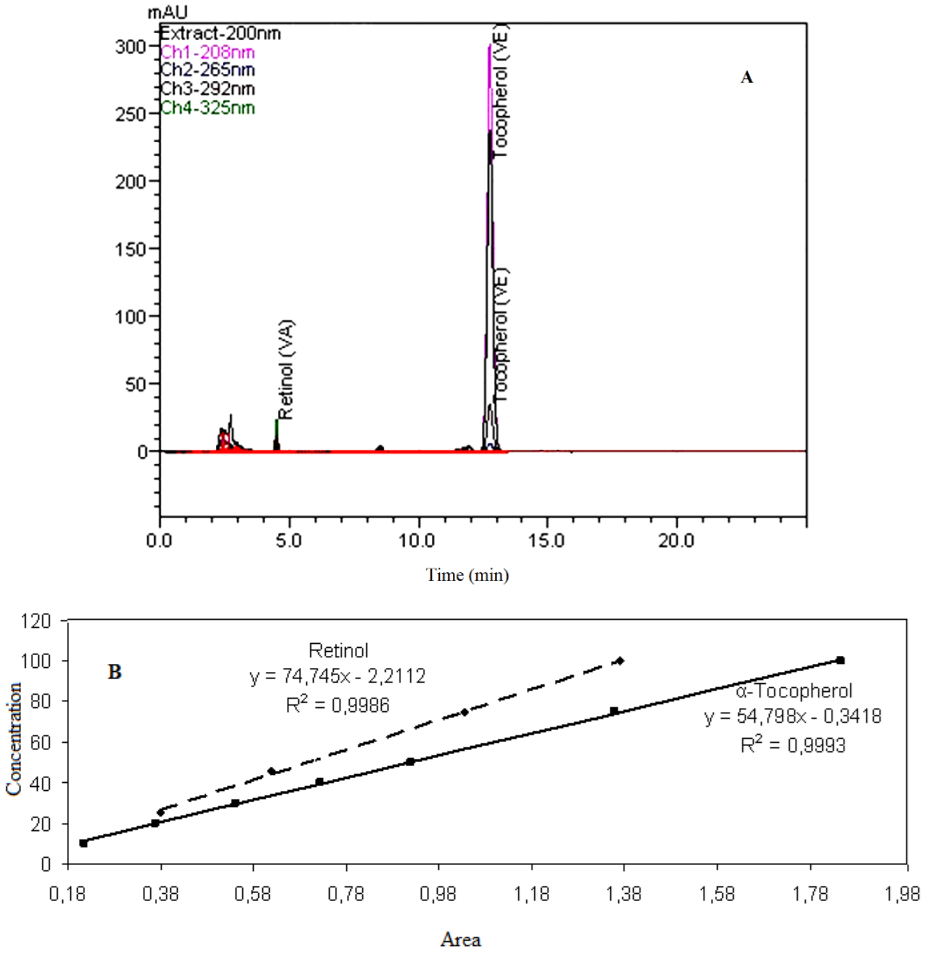


Figure 1. Peak chromatography (A) and calibration curve of α-Tocopherol and retinol (B) obtained by HPLC

2.6. Determination of Mineral and Element Contents

The samples were digested using microwave-assisted digestion method for dissolution. To determine the mineral contents, the samples were first digested following the method of Aydın (2008) using nitric acid (HNO_3) in a microwave digestion system. Precisely weighed samples were digested with an acid mixture in the microwave to achieve complete dissolution. After digestion, the samples were allowed to cool, then diluted with deionized water and filtered to prepare them for ICP-OES analysis. Mineral and heavy metal analyses were carried out at the Central Laboratory of Çanakkale Onsekiz Mart University (ÇOBİLTUM). Elemental measurements were performed using an ICP-AES instrument (PerkinElmer Optima 8000).

3. Results and Discussion

Seafood provides essential nutrients including superior quality proteins, omega-3 fatty acids, and a range of vitamins and minerals that are crucial for maintaining overall health. Regular seafood consumption supports cardiovascular well-being, enhances brain performance, and strengthens the immune response. The garfish (Belone belone) is distinguished by its high nutritional value, particularly its abundant protein and beneficial fatty acid profile, positioning it as a valuable functional food in human diets. It is commonly found in the Mediterranean, Aegean, and Black Sea regions, this species is traditionally caught and consumed either fresh or processed. The conservation of garfish stocks through sustainable fishing practices is crucial to maintaining its nutritional and economic value. The nutritional composition analysis of garfish (Belone belone) is presented in Figure 2. The data reveal that this species possesses high protein and fat content, making it a significant energy source. According to the results, garfish contains a notably high protein level of 71.6%, placing it among fish species rich in protein. This suggests that garfish meat could be a valuable animal protein source, especially for athletes and individuals with increased protein needs. The crude fat content was determined as 15.2%, indicating that garfish has a considerable fat content and high energy density. The detected 15.2% crude fat emphasizes the protein value of garfish while also establishing it as a significant source of energy and vital fatty acids.

A high crude fat level supports the potential presence of valuable fatty acids, beneficial to human health and contributes to richness in fat-soluble vitamins. This makes garfish particularly relevant for functional food applications and the fish oil industry. The high energy value of garfish, measured at 5178 kcal/kg, further supports these findings. This energy content indicates that garfish is a nutrient-dense food and can be considered a rich energy source. The elevated caloric value primarily stems from its fat and protein components, making garfish a suitable choice in dietary plans aimed at meeting energy requirements.

Furthermore, the utilization of garfish in functional food and sports nutrition product development is significant for obtaining energy-dense products from natural and

sustainable sources. The moisture content was measured at 73.6%, which aligns with the expected moisture range for fresh fish. High moisture content is crucial for maintaining freshness and biological value but requires careful attention during processing and storage. The ash content of 11.2% reflects a rich mineral profile, indicating the presence of calcium, phosphorus, and other trace elements, which are especially important for bone health-supporting nutrition. In summary, garfish stands out as a valuable seafood product due to its high protein and energy content, notable fat profile, and mineral richness. It is suitable for applications in functional foods, sports nutrition, and health-supportive diets. Furthermore, its natural antioxidant capacity, consistent with previous findings, enhances its importance as a functional and health-promoting food source.

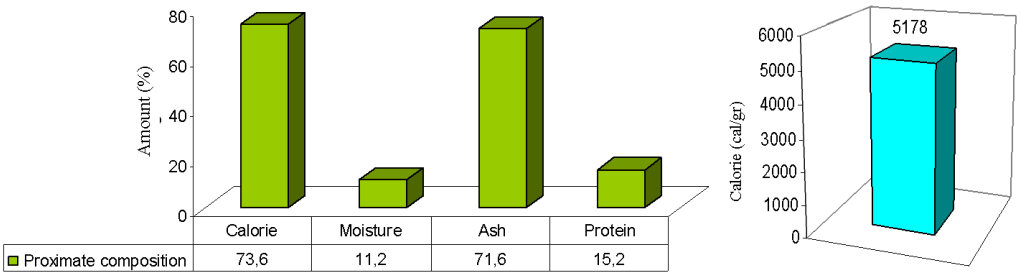


Figure 2. Crude fat, raw ash, protein, moisture and calorific values of garfish

Vitamin analyses of garfish are presented in Figure 3. The contents of tocopherol (vitamin E) and vitamin A were found to be 27.88 mg/kg and 1.73 mg/kg, respectively, providing important insights into the nutritional value and functional properties of this species. These vitamins play critical roles in human health and are among the fat-soluble vitamins naturally present in seafood. Tocopherol is a potent antioxidant vitamin that protects cell membranes from oxidative damage caused by free radicals. The measured tocopherol level of 27.88 mg/kg in garfish indicates a significant contribution to the fish's natural antioxidant defense mechanisms. Vitamin E is also important in functional foods due to its roles in enhancing immune function, supporting cell regeneration, and preventing chronic diseases. Consequently, the antioxidant properties of garfish are enhanced by its various nutritional components as well as its high tocopherol content. Moreover, vitamin E contributes positively to skin health, nervous system function, and cardiovascular health, making it an essential nutrient in the diet.

Vitamin A, measured at 1.73 mg/kg in garfish, is indispensable for several vital biological functions, including maintaining vision, cell growth and differentiation, and regulating the immune system. Seafood is generally rich in fat-soluble vitamin A, which enhances its absorption and bioavailability, providing additional health benefits. Adequate and balanced intake of these vitamins is crucial for reducing oxidative stress, supporting immune function, preventing cellular damage, and improving overall health status. The levels of tocopherol and vitamin A in garfish highlight that this fish is not only a rich source of protein and minerals but also a valuable food due to its functional and protective bioactive components. Consequently, the tocopherol and vitamin A contents enhance garfish's

potential as a functional food and suggest it could be an important alternative in health-supportive dietary strategies. These properties also present significant biochemical advantages for maintaining and enhancing antioxidant features in both processed and fresh garfish products.

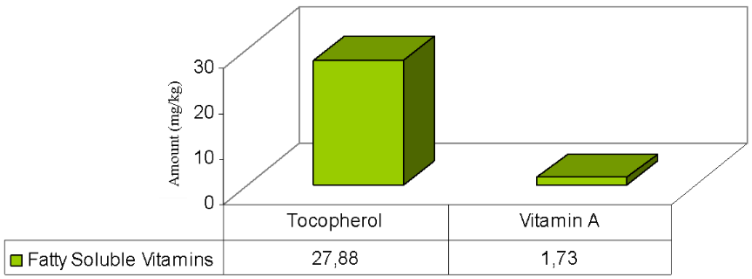


Figure 3. Tocopherol (vitamin E) and vitamin A content of garfish

The antioxidant capacities of garfish (Belone belone) extract and tocopherol were comparatively evaluated based on their DPPH free radical inhibition percentages, as presented in Figure 4. The analysis results demonstrated a significant increase in DPPH radical scavenging capacity with increasing concentration for both samples. This indicates a dose-dependent antioxidant effect for both garfish extract and tocopherol. At low concentration ranges (2.5–10 µg/mL), the garfish extract showed inhibition between 31% and 54%, while tocopherol exhibited inhibition between 33% and 57%. In this range, the inhibition percentages of both samples were quite close, highlighting that the garfish extract possesses prominent antioxidant activity even at low concentrations. The attainment of nearly 50% inhibition (IC_{50}) at these low concentrations further emphasizes the potential antioxidant capacity of the garfish extract. At medium concentration levels (20–40 µg/mL), the difference between the two samples became more pronounced. The garfish extract achieved 73%–91% inhibition, whereas tocopherol reached 83%–97%. These results indicate that while tocopherol has a higher antioxidant capacity compared to the garfish extract, the extract still demonstrates a strong free radical scavenging effect at these concentrations. It was observed that garfish extract and tocopherol reached the peak inhibition levels between 80–160 µg/mL amounts. On the other hand, inhibition values of garfish extract and reference tocopherol were calculated as 96% and 98%, respectively. This peak inhibition suggests that both samples reached their maximum inhibition capacity, and further increases in concentration did not significantly enhance antioxidant activity, indicating a saturation point. In summary, the garfish extract exhibits strong DPPH radical scavenging activity especially at medium and high concentrations, although its antioxidant effect is slightly lower than that of pure tocopherol. Nonetheless, the substantial antioxidant capacity of natural, marine-derived biomaterials such as garfish extract highlights their potential for applications in functional foods, pharmaceuticals, or cosmetics. Investigating bioactivities of such economically low-value, sustainably sourced materials is important both environmentally and economically. Overall, the data from this study show that garfish extract possesses significant antioxidant activity and, despite having somewhat lower

efficacy compared to tocopherol, can be considered a promising alternative natural antioxidant source. The high antioxidant capacity of garfish meat supports its evaluation not only as a protein source providing essential nutrients, but also as a functional food component with health-promoting properties. Antioxidants play a critical role in reducing oxidative stress caused by free radicals and preventing resulting cellular damage. Given the role of oxidative stress in the development of chronic diseases, regular consumption of antioxidant-rich marine products like garfish may help strengthen the immune system, slow cellular aging, and contribute to the prevention of health issues such as cardiovascular diseases. Therefore, incorporating garfish meat into functional food formulations holds significant potential for both individual health benefits and the development of sustainable, natural nutrition strategies for public health.

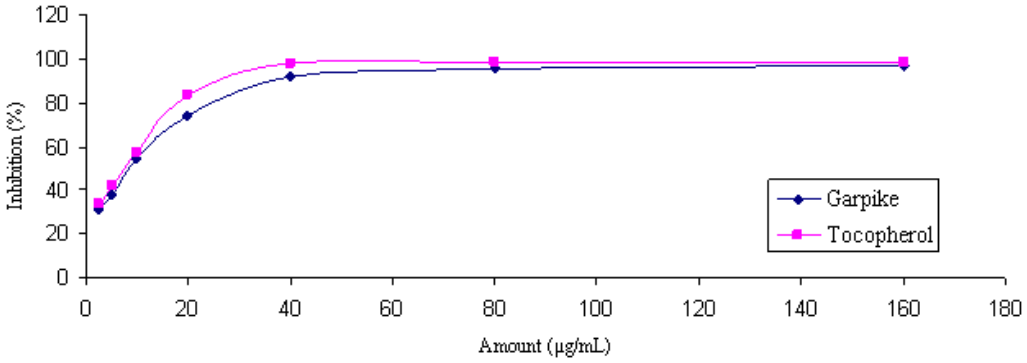
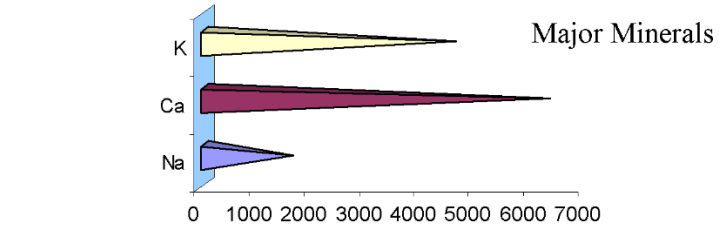


Figure 4. Comparison of the radical scavenging effect (DPPH) of garfish with α-tocopherol (% inhibition)

Elemental analysis results of garfish (Belone belone) are presented in Figure 5. It was determined that essential minerals such as sodium (Na), calcium (Ca), and potassium (K) are present at significant levels. According to the data obtained, garfish contains 1615.21 mg/kg sodium, 6306.17 mg/kg calcium, and 4587.2 mg/kg potassium. These results indicate that garfish is a mineral-rich nutritional source. Particularly notable is the high calcium content. Calcium plays a crucial role in many physiological processes, including maintaining bone and dental health, regulating muscle function, and nerve transmission. The calcium level measured in garfish is higher than that found in many other fish species, making garfish meat a valuable candidate for dietary programs aimed at preventing calcium deficiency. Potassium, found at 4587.2 mg/kg in garfish, is essential for maintaining intracellular fluid balance, muscle contraction, and regulating heart rhythm. Consumption of potassium-rich foods is associated with reduced risk of hypertension and positive effects on cardiovascular health. Sodium content was measured at 1615.21 mg/kg, which falls within expected ranges for marine fish. Sodium is necessary for maintaining water-electrolyte balance and nerve function in the body; however, its daily intake should be controlled. The sodium level in garfish can be considered a natural source of salt and may contribute positively to health when consumed in appropriate amounts as part of a balanced diet.

In conclusion, garfish stands out with its high calcium and potassium content, making it a mineral-rich animal food source. These characteristics not only add value to garfish in terms of protein and fat content but also highlight its importance regarding mineral composition. Consequently, garfish represents a promising species to be considered in the development of functional food products.

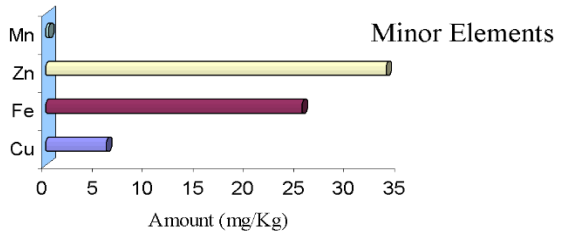


	Na	Ca	K
Garpike	1615,21± 12	6306,17± 59	4587,2± 36

Figure 5. Sodium (Na), calcium (Ca), and potassium (K) values of garfish

Elemental analysis of garfish (Belone belone) revealed the minor element levels of copper (Cu), iron (Fe), zinc (Zn), and manganese (Mn), as shown in Figure 6. According to the results, garfish contains 5.93 mg/kg copper, 25.42 mg/kg iron, 33.81 mg/kg zinc, and 0.16 mg/kg manganese. These values indicate that garfish is not only rich in essential macro-nutrients, but also serves as a valuable source of trace elements necessary for various biological functions. Particularly noteworthy are the high levels of zinc and iron. Zinc is a crucial mineral involved in supporting immune system functions, cell regeneration, enzyme activities, and wound healing. The detected 33.81 mg/kg zinc content suggests that garfish can significantly contribute to fulfilling dietary zinc requirements. Iron, a key component of hemoglobin and myoglobin, plays an essential role in oxygen transport and energy metabolism. The measured iron content of 25.42 mg/kg positions garfish as a potential alternative to traditional iron sources such as red meat, making it beneficial in nutritional strategies aimed at reducing iron-deficiency anemia.

Copper content was measured at 5.93 mg/kg. Copper is involved in iron metabolism, connective tissue formation, nervous system health, and antioxidant defense mechanisms. The copper levels in garfish support adequate intake for human health. Manganese, measured at 0.16 mg/kg, although required in very small amounts, plays roles in energy metabolism, bone development, and as a component of antioxidant enzymes. The manganese concentration in garfish falls within normal limits and can be considered a complementary dietary source. In summary, garfish exhibits a balanced and rich profile of minor elements. Its significant zinc and iron content enhances its value as a functional and health-supporting food in human nutrition. Furthermore, the presence of copper and manganese at balanced levels indicates that garfish also contributes to micronutrient intake. These findings highlight garfish's potential not only as a source of macro-nutrients, but also as a mineral-rich functional food with important implications for health-promoting diets.



	Cu	Fe	Zn	Mn
Garpike	5,93 ±0,01	25,42±0,6	33,81±27	0,16±0,01

Figure 6. Copper (Cu), iron (Fe), zinc (Zn), and manganese (Mn) values of garfish

Garfish (Belone belone) emerges as a significant seafood species with high nutritional value and functional properties based on comprehensive nutritional and compositional analyses. Its rich protein and energy content position it as an effective source for supplying essential building blocks and energy required by the body. Additionally, its balanced fat content and notably natural antioxidant capacity suggest potential to prevent oxidative deterioration of nutrients and provide protective effects at the cellular level. In terms of mineral composition, garfish exhibits a rich profile of both macroelements and trace elements.

The high levels of important minerals such as calcium and potassium contribute to supporting fundamental physiological processes including bone health, muscle function, and electrolyte balance. The presence of trace elements like iron, zinc, copper, and manganese indicates a balanced supply of micronutrients essential for immune functions, combating oxidative stress, and cellular metabolism. Its vitamin profile further enhances garfish's value as a functional food. Fat-soluble vitamins such as vitamin E and vitamin A strengthen antioxidant defenses, support the immune system, and play key roles in maintaining cellular health. The abundant presence of these vitamins indicates that garfish not only meets basic nutritional needs but also offers biological activities that support health.

Considering all these characteristics, garfish can be regarded as a valuable seafood resource, providing a rich source of protein and energy alongside health-promoting functional components. Its natural antioxidant capacity and balanced mineral-vitamin content demonstrate its potential as an important alternative in functional food applications, health-supporting products, and sustainable seafood utilization. Moreover, garfish's versatile nutritional profile allows practical applications such as improving the quality and extending the shelf life of processed fish products. In conclusion, garfish stands out as a natural resource with significant potential in health and nutrition, aligning well with current dietary demands and functional food trends.

Conclusion

Seafood provides essential nutrients, including superior quality proteins, omega-3 fatty acids, and a range of vitamins and minerals that are crucial for maintaining overall health. Regular seafood consumption supports cardiovascular well-being, enhances brain

performance, and strengthens the immune response. The garfish (Belone belone) is distinguished by its high nutritional value, particularly its abundant protein and beneficial fatty acid profile, positioning it as a valuable functional food in human diets. The results obtained in this study demonstrate that garpike (Belone belone) extract possesses a significant DPPH free radical scavenging capacity. Although the inhibition percentages are somewhat lower compared to purified and well-known strong antioxidants such as tocopherol, garpike extract exhibits a remarkable antioxidant effect, especially at medium and high concentrations.

From a nutritional perspective, this finding highlights that a marine resource like garpike is valuable not only for its protein and fatty acid content, but also for its natural antioxidant compounds. The high antioxidant capacity supports the potential of garpike meat as a functional food ingredient. Considering the critical role of antioxidants in preventing oxidative stress caused by free radicals, species like garpike gain importance as foods that may contribute positively to human health. Moreover, determining the antioxidant capacity of garpike is essential for its application in processed fish products such as canned, dried, or smoked forms, regarding shelf life and quality control. The naturally occurring antioxidants in fish meat are believed to delay lipid oxidation and prevent nutritional degradation. In this regard, garpike can be regarded not only as a protein source but also as a marine product with potential as a natural antioxidant additive. In conclusion, the DPPH inhibition data obtained in this study emphasize the nutritional composition and functional properties of garpike and indicate that this species can be considered in health-focused and functional food development efforts.

Conflict of Interest

The authors declare that there is no conflict of interest.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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