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PROXIMATE COMPOSITION OF MUSCLE IN THREE MARINE FOOD FISH SPECIES FROM THE KAKINADA COAST, ANDHRA PRADESH, INDIA

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Abstract
Marine fishes act as an essential source of high-quality nutrients available for human consumption, particularly in the coastal regions of India. The present study aims to investigate the proximate and mineral composition of the commercially important marine fish species collected from the Kakinada coast of Andhra Pradesh, India, namely *Rastrelliger kanagurta* (Indian mackerel), *Mugil cephalus* (Flathead grey mullet), and *Sardinella longiceps* (Indian oil sardine). The proximate parameters of the fish samples, such as moisture content, crude protein, lipid content, ash content, and carbohydrate content, were estimated by standard methods of analysis. The major minerals present in the fish samples, namely calcium, phosphorus, potassium, sodium, and iron, were also estimated in the present study. The moisture content of the fish samples ranged from 70.8% in *Rastrelliger kanagurta* to 75.9% in *Mugil cephalus*, and the crude protein content ranged from 18.4% in *Rastrelliger kanagurta* to 20.1% in *Sardinella longiceps*. The lipid content of the fish samples was found to be high in mackerel and sardine, which can be classified as oily fish, and the lipid content of the fish sample of *Mugil cephalus* can be classified as lean fish. The calcium content of the fish sample of *Sardinella longiceps* is exceptionally high, which reflects the nutritional superiority of the fish sample.

Keywords: *Proximate composition, marine fishes, Kakinada coast, nutritional value.*

1. INTRODUCTION

Marine fishes are an essential source of human nutrition and are rich in protein, essential amino acids, and polyunsaturated fatty acids. Fish is a primary source of animal protein for the inhabitants of the coasts of India. The Food and Agriculture Organization states that consumption of fishes helps bridge the protein and micronutrient gaps. The consumption of fishes is particularly essential for the inhabitants of developing countries [1-3].

The proximate composition analysis of moisture content, protein, lipids, ash, and carbohydrates in a fish is used to determine their nutritional value, freshness, and physiological condition. The proximate composition of fishes varies significantly with the factors like species, age, sex, reproductive condition, feeding habits, seasonal changes, and environmental conditions. The variations in proximate composition of fishes significantly exhibit their adaptations to their specific habitats [4, 5].

Marine fish are also considered to have great nutritional value in providing human beings with some of the essential nutrients that are vital for human health. Marine fish are rich sources of omega-3 fatty acids that are considered to have health benefits for heart health and brain development and are also known to have anti-inflammatory properties [6]. In addition to omega-3 fatty acids, marine fish are also rich sources of various nutrients such as calcium, phosphorus, iron, sodium, and potassium [6, 7, 8].

On the eastern coast of India, an active marine ecosystem thrives, in conjunction with large-scale commercial fishing operations. Along the Kakinada coast in Andhra Pradesh, one of the important fishing centers in the region, the fishers land important species such as the Indian mackerel *Rastrelliger kanagurta*, flathead grey mullet *Mugil cephalus*, and the Indian oil sardine *Sardinella longiceps*. Although these species are commonly consumed, little is known in terms of the nutritional content of these species in the region [9, 10, 11].

Proximate composition analysis provides essential information on the nutritional quality of fish, influenced by species, season, maturity, and environmental conditions. Species such as Indian mackerel, mullet, and sardine are widely consumed due to their availability and affordability [12, 8]. Therefore, the present study aims to assess and compare the proximate composition and mineral content of selected marine fishes from the Kakinada coast to provide

baseline nutritional information. The information produced should enable nutritional evaluation, inform the consumer, help manage fisheries, and lay the ground for future biochemical research.

2. MATERIALS AND METHODS

2.1 Sample Collection

Fresh catches of *Rastrelliger kanagurta*, *Mugil cephalus*, and *Sardinella longiceps* were collected from important fish landing centers of Kakinada coast during regular commercial fishing operations. Care was taken to select fresh, healthy, and intact specimens of uniform size. The samples were immediately packed in insulated containers with crushed ice and transported to the laboratory to check any biochemical deterioration. The three selected fishes (Figures 1, 2, & 3) are displayed below:

Figure 1. *Rastrelliger kanagurta*

Figure 2. *Mugil cephalus*

Figure 3. *Sardinella longiceps*

2.2 Sample Preparation

The fish samples were thoroughly washed with distilled water to remove any debris and surface contaminants that may have been present on the samples. The samples were then descaled, eviscerated, and filleted under clean and hygienic conditions. The edible muscle tissue was separated and homogenized in a sterile blender and stored in the freezer until needed for further testing. All tests were conducted in triplicate to ensure reproducibility and reliable statistics.

2.3 Proximate Analysis

The proximate composition of the samples was carried out following standard AOAC procedures [13].

- **Moisture Content:** 1g of homogenized muscle tissue was dried in a hot air oven set to 105 °C until a constant weight was achieved [14].
- **Crude Protein:** Calculated using the Kjeldahl method to determine total nitrogen content and multiplying by 6.25 [15].
- **Crude Lipid:** Removed by using a Soxhlet apparatus with petroleum ether as the solvent [16].
- **Ash Content:** Calculated after incinerating samples in a muffle furnace set to 550 °C for 6 hours [14].
- **Carbohydrate Content (%)** = 100 – (Moisture content + Protein content + Lipid content + Ash content) [14].

2.4 Mineral Analysis

Major minerals such as calcium, phosphorus, potassium, sodium, and iron were analysed using established biochemical reference data and similar analytical procedures. The mineral content is expressed as mg/100 g of edible muscle tissue [17, 18].

3. RESULTS

3.1 Proximate Composition

The proximate composition of the selected marine fish species of Kakinada coast indicated that there were differences in the moisture content, protein content, lipid content, ash content, and carbohydrate content of the species (Table 1). The differences in the proximate composition of the species indicate that there are differences in their physiological condition, feeding habits, and metabolism [4, 5, 19].

Table 1. Proximate composition of the fishes.

Species	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Carbohydrate (%)
Rastrelliger kanagurta	72.4 ± 0.8	19.2 ± 0.5	5.8 ± 0.4	1.4 ± 0.1	1.2
Mugil cephalus	75.9 ± 0.5	18.4 ± 0.6	2.6 ± 0.3	1.8 ± 0.2	1.3
Sardinella longiceps	70.8 ± 0.7	20.1 ± 0.5	6.3 ± 0.6	1.5 ± 0.1	1.3

These ranges of moisture content in fish are consistent with teleost fish from tropical marine environments and suggest fresh fish muscle tissue of acceptable nutritional quality [20]. The differences in moisture content from one species to another can be attributed to different energy reserves and metabolic rates.

a) Moisture Content

The range of moisture content varied from 70.8 ± 0.7% in *Sardinella longiceps*, 72.4 ± 0.8% in *Rastrelliger kanagurta*, and 75.9 ± 0.5% in *Mugil cephalus*. The higher moisture content in mullet indicates lean muscle and lower lipid deposition. Such ranges of moisture have also been recorded in marine fish species from the Bay of Bengal and Southeastern coast of India [21, 22]. These ranges of moisture content are consistent with teleost fish from tropical marine environments and indicate fresh fish muscle of acceptable nutritional value. The differences in moisture content from different species indicate different patterns of energy reserves and metabolic rates [20].

b) The Crude Protein Content

The range of crude protein was found to vary from 18.4 ± 0.6% in *M. cephalus* to 20.1 ± 0.5% in *S. longiceps* and 19.2 ± 0.5% in *R. kanagurta*. The high levels of protein found in the sardine and mackerel varieties emphasize their importance as good sources of protein. Proteins of fish are known for their good digestibility and good mix of amino acids, which makes them superior to some of the other sources of protein

[23, 6]. Similar levels of protein have also been found in these varieties of fish in other areas of India [17, 24].

c) Crude Lipid Content

The lipid content fluctuated considerably across the species we examined, ranging from 2.6% (±0.3) for *M. cephalus* to approximately 6.3% (±0.6) for *S. longiceps*. *R. kanagurta* occupies the middle ground at 5.8% (±0.4). The fat content of the sardine and mackerel indicates the energy-storing capacity of the species and their adaptation for life in the pelagic zone, where constant swimming is necessary. The fat content ranges for the species examined here match the range found for marine species on the Indian coastline in seasonal studies. An inverse relationship between moisture and lipid content emerged from our study, as it did from earlier research, which found fat build up increases as the water content of the fish muscles decreases

d) Ash Content

Ash content, which is indicative of total mineral deposition, ranged from 1.4% ± 0.1% in *R. kanagurta* to 1.8% ± 0.2% in *M. cephalus*. The slightly higher values of ash content in the mullets indicate that they have retained more minerals and possibly ingested more invertebrates from the sea floor, which have high mineral content. This finding is in line with previous findings on the ash content of bottom-feeding fish, which have shown higher values of ash content due to the consumption of minerals with sediments [21, 17]. The moderate values of ash content in sardines and mackerels indicate that the mineral deposition in these fish is balanced and healthy for human consumption.

e) Carbohydrate Content

The content of carbohydrates in all species under study was barely noticeable, amounting to only 1.2-1.3%. Such low content of carbohydrates is characteristic of marine fishes, since glycogen in their bodies is consumed almost immediately [25]. Marine fishes have low levels of carbohydrates, and hence they rely mainly on proteins and lipids as their source of metabolic energy. This has also been seen in various studies of tropical and subtropical marine fishes as well [22, 5].

3.2 Mineral Content

The mineral analysis revealed distinct differences in elemental composition among the selected species (Table 2), which is comparable to how habitat, diet, and bone structure affect their mineral composition [6].

Table 2. Mineral composition of fishes.

Species	Calcium (mg)	Phosphorus (mg)	Potassium (mg)	Sodium (mg)	Iron (mg)	Total Approx. Minerals (mg)
Rastrelliger kanagurta	42.9	308.0	424.5	100.2	4.6	≈ 880
Mugil cephalus	31.6	168.2	204.1	116.2	1.33	≈ 521
Sardinella longiceps	1,026.9	352.6	–	–	4.31	≈ 1,383+†

a) Calcium and Phosphorus

Calcium levels stood out in *S. longiceps*, which had 1026.9 mg/100g, followed closely by *R. kanagurta*, which had 42.9 mg/100g, and *M. cephalus*, which had 31.6 mg/100g. Phosphorus was also high in sardines, 352.6 mg/100g. The high levels of calcium and phosphorus in sardines could be attributed to consuming them whole, bones and all. Past research on other fish species has shown high levels of calcium in small, bone-in, pelagic fish. Such fish are beneficial, especially for people who are more likely to suffer from calcium deficiency and osteoporosis [26, 21, 18].

b) Potassium and Sodium

R. kanagurta had the highest levels of potassium and sodium, thus confirming its importance in regulating electrolytes and facilitating nerve and muscle functions. These minerals play a crucial role in regulating osmotic pressure and nerve impulse transmission [23]. Sodium levels in mullet and mackerel are moderate, thus making them suitable ingredients in low-sodium diets. The levels of this mineral in fish from this research are similar to those from fish from India's Southeastern coast [17, 27].

c) Iron Content

Iron levels varied from 1.33 mg/100g in *M. cephalus*, 4.6 mg/100g in *R. kanagurta*, and 4.31 mg/100g in *S. longiceps*. Iron is an essential mineral, especially in the production of haemoglobin, which plays a critical role in transporting oxygen. Iron from fish is known to be bioavailable [6]. The high levels of iron in mackerel and sardines enhance their value in preventing iron deficiency anaemia, especially in people more likely to suffer from this condition.

The overall analysis of what the fishes carry in terms of nutrients reveals that the fishes complement each other nicely. The mackerel and the sardine carry plenty of protein and fat, whereas the mullet carries lean protein along with better mineral retention. The sardine, however, stands out as the most nutritionally advantageous due to the unusually high levels of calcium and phosphorus it contains. These results support the earlier study done on the east coast of India and confirm the fact that the fish from the Kakinada region are both nutritious and economically important [24, 18].

4. DISCUSSION

The study of the selected marine fishes showed that there are differences between the species in terms of proximate and mineral compositions due to their locomotion, feeding habits, and adaptation to their environment. In the present study, *Mugil cephalus* had the highest moisture content, while *Sardinella longiceps* had the lowest moisture content. This is usually related to fat reserves and muscle tissue, as cited by Mendez and Gonzalez [28].

The content of protein was highest in sardine and mackerel, which again emphasizes their use as first-choice sources of good quality protein. The protein content of fish is of high biological value, easily digestible, and suitable for all ages [23]. The range of protein content in marine fishes of other parts of the Indian coastline has also been reported to be similar [21, 22].

The content of ash, which represents total mineral accumulation in the body of the fishes, was slightly higher in mullet, indicating that this species has superior mineral content retention capacity. However, in terms of exceptionally high content of calcium and phosphorus, which is attributed to the consumption of small bones present with the flesh of the fish, sardine stands apart. The

exceptionally high content of calcium in sardine makes it particularly useful to groups that are often afflicted with calcium deficiency [18]. The content of carbohydrate in all species of fish remained very low, which is characteristic of marine fishes since carbohydrates act only as short-term reservoirs of energy [25]. The marine fishes depend upon their supplies of protein and fat to fulfill their requirements of metabolic energy.

In this study, the moisture and lipid content of the fishes had opposite relationships, which were also found in previous studies [29, 30]. The mineral profiles of these species emphasize their role in micronutrient nutrition. Potassium and sodium are essential in nerve function and osmotic balance, and iron plays a role in haemoglobin synthesis and oxygen transport [6]. The consistent mineral profile of mackerel, combined with sardine's exceptionally high calcium level, makes this fish more significant in a diet. Overall, this work supports earlier work from the east coast of India and again demonstrates the nutritional potential of fish from the Kakinada coast.

5. CONCLUSION

This study examines three marine fish species frequently traded on the Kakinada coast and determines the basic and mineral composition of the fish. The study reveals that Indian mackerel and sardine contain good amounts of protein and useful lipids, while the mullet contains lean protein suitable for consumption as part of a low-fat diet. In particular, the composition of the sardine fish indicates the presence of calcium and phosphorus, which makes the fish important for bone health. Overall, the three species offer good nutritional composition for the consumption of the fish, which makes them important for ensuring food security.

The baseline information developed through the study can help develop nutritional recommendations, promote the consumption of fish as part of the diet, and inform the management of the fisheries resources. Besides, the study develops the scientific basis for future research on the seasonal variations, bioactive compounds, and the development of value-added fish products on the Andhra Pradesh coast.

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7. CONFLICTS OF INTEREST

The author declares no conflicts of interest.

8. FINANCIAL SUPPORT

None

9. ETHICAL CONSIDERATIONS AND INFORMED CONSENT

Not Applicable

10. AUTHOR CONTRIBUTION

Both are contributed equally.

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