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ARTICLE

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ASSESSMENT OF PROXIMATE COMPOSITION IN SELECTED FISH SPECIES FROM EASTERN GHATS OF ODISHA, INDIA

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Fishes form an integral part of the diet, being the easily available and cheap source of animal protein. The present study focused on the proximate composition of the most commonly available fish species from Koraput of southern Odisha by considering four large fish varieties and four small fish varieties. Among the large fish varieties, the protein was observed to be maximum in G. catla (12.885± 1.207%), while minimum in O. mossambicus (5.213±0.115%), fat was maximum in L. rohita (5.863±0.410%), and minimum in G. catla (2.278±0.166%). The ash content was maximum in O. mossambicus (8.855±3.623%) while minimum in G. catla (4.250±0.212%). Moisture was found to be similar for all the species ranging within 78-82%. Among the small fish varieties protein and fat content was found to be maximum in P. conchonius i.e. 22.752±2.389% and 8.021±0.573% respectively. Moisture content was found to be maximum in P. dorsalis (74.434±1.021%). The components were observed to vary significantly (p<0.05) within the species. Overall proximate composition showed significant variation among the small and large fishes (p<0.05), with the maximum protein and fat in small fishes while moisture content was higher in larger fishes, Instead of size variation, both the large and small-sized fishes have similar ash content, highlighting the good amount of mineral content among them. Though the small fishes are neglected as food fishes, the present study revealed them to be comparatively better option in having higher amounts of protein, fat, and ash content.

Introduction

Fishes account for more than 40 % of all vertebrates worldwide, and with variety of sizes and shapes, are important components of aquatic ecosystems. Positioned near the top of the food chain, their presence indicates a healthy aquatic ecosystem[1,2]. From ancient ages, fish have been an integral part of the diet and a significant source of animal protein, particularly in underdeveloped nations[3] especially in South Asian countries like Bangladesh, India, Maldives, Sri Lanka, Nepal, Bhutan, and Pakistan[4]. In today's world, the fisheries and aquaculture sectors are contributing hugely to combat malnutrition and food insecurity[5, 6].

The average global fish production had been expected to reach a value of about 184.6 million metric tons in the year 2022 indicating a surge of about 30 million metric tons from the past decade. China is the topmost producer of fish, yielding 11.8 million metric tons in 2022[7] while according to Ngasotter *et al.* (2020)[8] India ranks third for overall fish production.

India's diverse landscape includes numerous large water bodies that support a rich variety of fish species. Fish are widely recognized as an economical, high-quality source of animal protein and are considered a premium protein for human consumption. They are essential for improving nutrition, ensuring food security, promoting

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heart health, and addressing various health concerns[9]. As an important part of the diet, fish supply essential fatty acids, amino acids, and key vitamins and minerals necessary for a healthy life[9,10].

EPA (Eicosapentaenoic acid) and DHA (Docosahexaenoic acid), long-chain polyunsaturated Omega-3 fatty acids primarily found in fish, are key to the health benefits of fish consumption[11]. Rich in DHA and PUFA (Polyunsaturated fatty acids), fish aids brain, nerve, and eye development and lowers the risk of cardiovascular diseases, cancer, inflammation, and cognitive disorders[12, 13, 14]. This makes fish ideal for infants during early development. The high PUFA content in fish suggests that both fish meat and fish oil can help reduce serum cholesterol levels[11].

The chemical makeup of fish flesh serves as a dependable indicator of the fish's quality, nutritional value, physiological condition, and habitat[15]. Fish predominantly consist of 66%-81% water, 16%-21% protein, 1.2%-1.5% minerals, 0.2%-25% fat, and 0%-0.5% carbohydrates[16]. As per Begum *et al*. (2012)[17], approximately 96%-98% of a fish's body composition comprises moisture, protein, fat, and ash. The assessment of these constituents is referred to as the 'proximate composition' of fish[18].

Understanding the proximate composition of fish is essential for assessing their energy value and determining the optimal methods for industrial and commercial processing[19]. Additionally, the importance of proximate composition extends to the study of fish bioenergetics and the impact of pollutants[20]. The proximate composition of various fish species can be influenced by factors such as food composition, feeding habits, feeding rate, age, size, sex, habitats, genetic characteristics, and seasonal migration[21, 22].

The quantitative process of determination of a mixture (as food) representing the percentage of the lipids, protein, moisture, and ash content is part of the proximate composition method [4, 23] which represents the quality of fish[24]. In most cases of fish, it has been seen that carbohydrates and non protein compounds are present in negligible amounts about <0.5% [25, 26]. The moisture, protein, lipids, vitamins, and minerals are significant macronutrients and micronutrients that suggest that fish meat has nutritional significance[27], hence being a better choice than other animal foods and shielding people from a variety of global diseases [28].

With nearly 95% of India's population consuming fish, there is a significant demand[29], particularly for larger fish. Despite small indigenous fish species being nutrient-dense, they are often overlooked in developing countries[30]. The biochemical composition of a fish is influenced by complex interactions of factors such as size, sex, temperature, food availability, and reproductive age[31]. Assessing the proximate composition is crucial for determining fish quality and water quality, which affects proximate composition through food intake.

Koraput, located in southern Odisha is a part of northern Eastern Ghats, bestowed with a large number of river systems, and is home to a large number of ichthyofaunal diversity thereby forming a major source of animal protein for the local people. Many works had been concentrated on the biochemical or proximate composition in large fishes by Gandotra *et al*. (2017)[23] on *Labeo baga*, Mohamed *et al*. (2016)[32] on *Oreochromis niloticus*, Sankar and Ramachandran (2001)[33] on *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*, Mallipudi *et al*. (2020)[34] on *Puntius thomassi*, Mandal and Chanda (2017)[35] on *Trichogaster fasciata*, *Parambassis ranga*, *Esomus danricus*, *Puntius sophore*, *Chanda nama*, *Amblypharyngodon mola*, *Neotropius mitchelli*, *Mystus cavasius*, *Osteobrama cotio cotio*, *Parambassis lala*, *Salmophasia bacaila*. The present study focuses on understanding the proximate composition between the two different groups, four large varieties vis-à-vis four small indigenous fishes (SIFs). The large variety includes three carps (*Labeo rohita*, *Gibelion catla*, *C. mrigala)* and a cichlid variety namely *Oriochromis mossambicus* and four small indigenous fishes (SIFs) including barbs (*Puntius sophore*, *Puntius dorsalis*, *Pethia ticto* and *Pethia conchonius*) (Figure 1). The study also focuses on the water quality parameters thereby understanding the quality of the habitat for the fishes.

Materials and Method

Collection of Samples: Fish samples of eight species, *L. rohita*, *G. catla*, *C. mrigala*, *O. mossambicus*, *P. sophore*, *P. dorsalis*, *P. ticto* and *P. conchonius* were collected in morning hours (0900 - 1130 hrs) from local markets at Ghatguda closer to Kerandi Nallah a tributary of Kolab River (18º45′31.68′′ N, 82º49′17.49′′ E) near Sunabeda Town of Koraput which is a lotic water stretch and Jagannath Sagar (18º51′29″ N, 82º33′5″ E) at Jeypore Town of Koraput, which is a lentic water stretch (Figure 2, Table 1). After the collection of samples, the fresh specimens were photographed and immediately brought to the laboratory of the Department of Biodiversity and

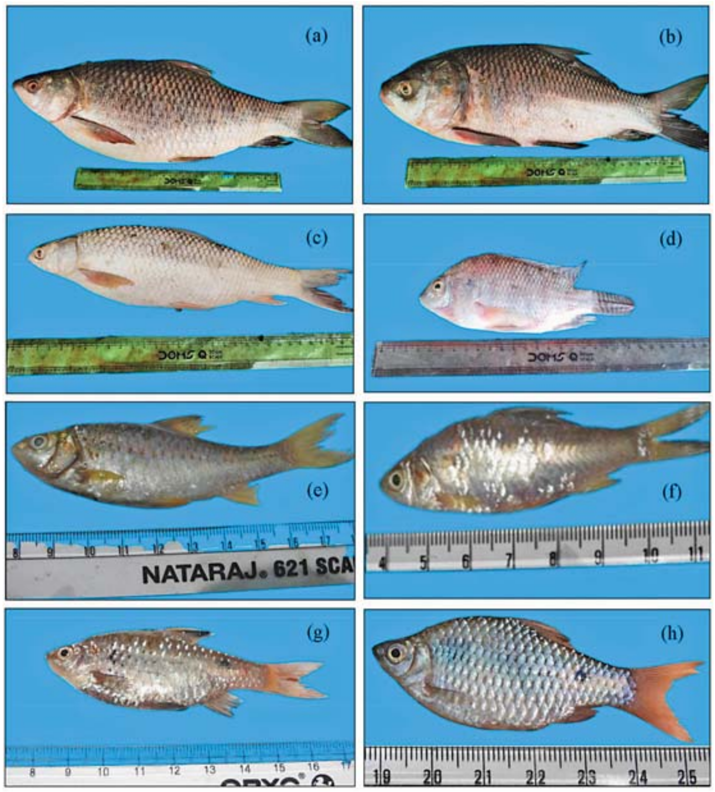

Fig. 1: Sampled fish for proximate analysis in Koraput, Odisha. (a) *Labeo rohita*, (b) *Gibelion catla*, (c) *Cirrhinus mrigala*. (d) *Oriochromis mossambicus*, (e) *Puntius sophore*, (f) *Puntius dorsalis*, (g) *Pethia ticto*, (h) *Pethia conchonius*

Conservation of Natural Resources, Central University of Odisha, and identified based on veritable keys developed by Talwar and Jhingram (1991)[36] and Jayaram (2010)[37].

Water Quality Parameters

The samples of water were taken from each location in sterilized Tarson bottles to analyse specific physicochemical characteristics. Temperature, pH, air temperature, relative humidity, electrical conductivity, and Total Dissolved Solids (TDS) were some water parameters measured on the spot. The water samples were brought to the laboratory for analysis to estimate other parameters such as Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), salinity, free carbon dioxide, nitrate, and phosphate. These parameters were analysed as per APHA (2005)[39].

Analysis

The statistical analysis was performed by using Microsoft Excel 2010 and PAST Software Ver 3.3[40] and was presented in the form of mean ± standard deviation. The results for all the proximate compositions were subjected to one-way Analysis of Variance (ANOVA) to find out significant differences within the sampled fish species (*L rohita*, *G catla*, *C. mrigala*, *O. mossambicus*, *P. sophore*, *P. dorsalis*, *P. ticto* and *P. conchonius*) and among the large and small fish species group. $p<0.05$ in ANOVA stands for a significant variation. Regression Analysis was done for all the fish species to understand the linear dependence of moisture with protein, fat, and ash. Correlation Co-efficient value for the proximate composition (taking moisture as the independent variable and protein, fat, and ash as the dependent variable) for all the eight species, Bray-Curtis dendrogram, and PCA was done to find out the similarity and grouping among the eight species based on proximate composition.

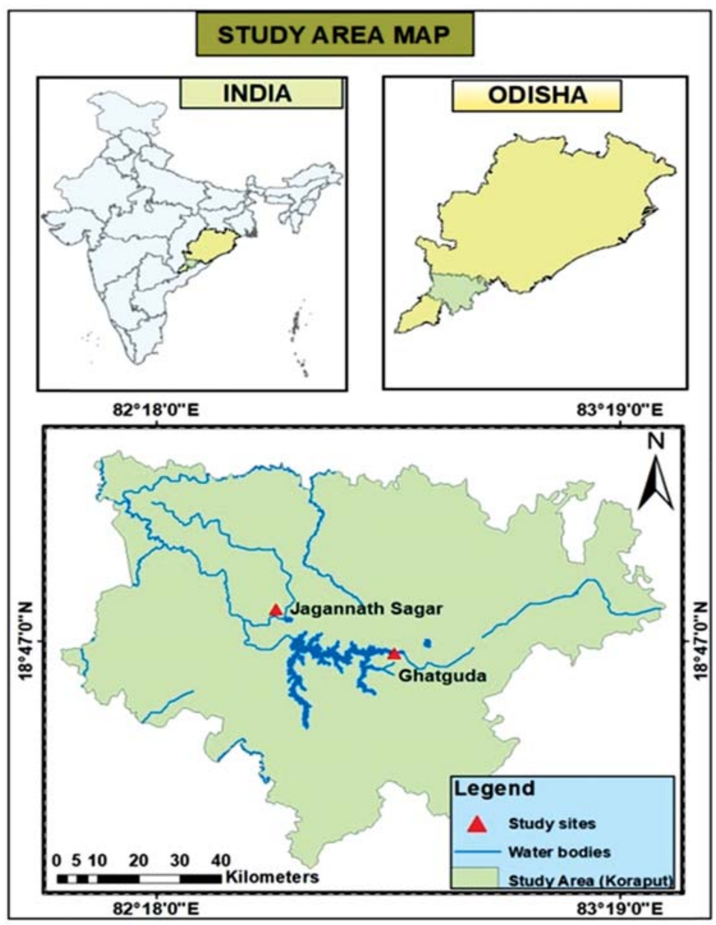

Fig. 2: Map showing the study sites of fish sample collection in Koraput, Odisha

Table 1: Fishes Collected from Lotic and Lentic Sites for Sampling

Sl. No.	Fishes Sampled	Average Length (cm)	Average Weight (gm)	Lotic	Lentic
1.	*Labeo rohita* (N=1)	45.0	1100	+	-
2.	*Gibbelion catla* (N= 1)	40.0	1050	+	-
3.	*Cirrhinus mrigala* (N= 1)	40.0	900	+	-
4.	*Oreochromis mossambicus* (N=1)	25.0	300	+	-
5.	*Puntius sophore* (N=10)	7.88± 8.46	7.02± 1.55	+	+
6.	*Puntius dorsalis* (N=10)	7.55± 4. 213	4.85± 0.724	+	+
7.	*Puntius ticto* (N=10)	5.33± 3.39	1.971± 0.423	-	+
8.	*Puntius conchonius* (N= 10)	5.96± 5.99	3.55±0.64	-	+

+ : sampled ; - : not sampled

Result and Discussion

Comparison Among the Species: Protein Content: The protein content among the sampled species was found to be prominently varying between 5.213± 0.115 % - 22.752 ± 2.389 %. The minimum value of protein content was observed in the order of *O. mossambicus* < *L. rohita* < *C. mrigala* <*G. catla* < *P. dorsalis* < *P. sophore*< *P. ticto* < *P. conchonius* (Table 2). The variation in protein content was observed to vary significantly ($p<0.05$) (Table 3).

Fat Content: Fish meat is considered to be favourable over other white or red meats on account of low lipid content and more water than beef or chicken[41, 42]. The fat content was observed to vary within a range of 2.278±0.166 % to 8.021±0.573 % for the sampled fish species and in an order of *G. catla* < *O. mossambicus* < *C. mrigala* < *P. sophore* < *L. rohita* < *P. dorsalis* < *P. ticto* < *P. conchonius* (Table 2), which was observed to be significantly varying ($p<0.05$) (Table 3). Based on the classification of Bennion and Scheule (2000)[43], the fat content of most of the species was noticed to be less than 5 % in the present study, thereby being categorized as lean fish except for *P. dorsalis*, *P. ticto* and *P. conchonius.*

Ash Content: The ash content of the fishes showed the mineral contents of the fishes. The variation in the ash content may be due to the size variation of the samples. The maximum amount of ash content was observed in *O. mossambicus* while the minimum was observed in *G. catla* (Table 2). However, the ash content for the small fish varieties (*P. sophore*, *P. dorsalis*, *P. ticto*, and *P. conchonius*) was recorded to be more or less 5.65 % (Table 2) which is a result of small sized body having minimal bone amount[29]. The variation of ash content showed significant variation among the species ($p<0.05$) (Table 3).

Table 2: Variation in protein, fat, ash, and moisture content (%) among different sampled species

Species	Protein (%)	Fat (%)	Ash (%)	Moisture (%)
Large Fish				
O. mossambicus	5.213±0.115	3.366±0.910	8.855±3.623	82.566±2.160
L. rohita	9.528±0.448	5.863±0.410	6.171±0.168	78.438±0.563
C. mrigala	10.203±0.11	4.078±0.063	5.050±0.524	80.667±0.229
G. catla	12.885± 1.207	2.278±0.166	4.250±0.212	80.587±0.630
Average	9.549±2.655	3.716±1.437	5.636± 2.749	77.840±5.702
Small Fish				
P. sophore	17.348± 3.508	4.129±2.399	5.554±0.167	72.969±3.822
P. dorsalis	13.768±1.725	6.479±0.494	5.913±0.710	73.84±1.021
P. ticto	17.982±1.325	7.564±0.814	5.955±0.581	68.499±7.208
P. conchonius	22.752±2.389	8.021±0.573	5.719± 0.298	63.508±1.664
Average	17.545± 3.824	8.643± 3.229	5.647± 0.525	70.258± 5.731

Moisture Content: Moisture content was observed to vary significantly (Table 3) with a maximum amount of moisture content in *O. mossambicus* while a minimum was observed in *P. conchonius* (Table 2).

The proportion (%) of proximate composition for individual species (Figure 3), depicted that the major proportion was contributed by moisture [44] followed by protein and fat, forming the major constituent of the nutritional status of the fishes[45].

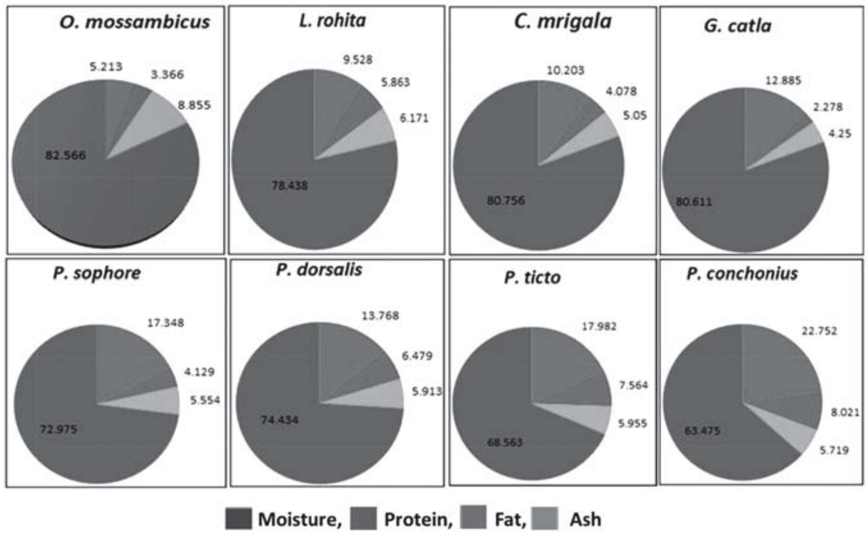

Fig 3: % contribution of the proximate composition in the sampled fishes

Table 3: p-value of ANOVA Analysis for protein, fat, ash, and moisture among the large fish group, small fish group, and between the large and small group

Proximate composition parameters	Large Fish group	Small Fish group	Between Large and Small Fish Group
Protein(%)	5.85E-19	4.47E-07	4.18E-16
Fat (%)	6.85E-09	2.62E-20	6.28E-14
Ash (%)	4.01E-06	0.036334	0.979731
Moisture (%)	0.000507	1.72E-06	2.6E-08

During the present study, protein (%) (r= -0.511) and fat (%) (r= -0.393) were observed to be significantly and negatively correlated with moisture (%) ($p<0.05$) (Figure 4, Table 4).

However, ash (r= 0.319) showed a positive but significant correlation with moisture content for all the eight sampled species (Figure 3, Table 4).

Based on proximate composition, the Bray-Curtis dendrogram broadly divided the eight species into two groups i.e. large fish group consisting of *L. rohita*, *G. catla*, *C. mrigala*, *O. mossambicus* and the small fish species group consisting of *P. sophore, P. dorsalis, P. ticto and P. conchonius* (Figure 5)

Moreover, the Principal Component Analysis (PCA) extracted four Principal Components with PC1 showing the maximum variance of 92.985 %. *P. sophore, P. dorsalis, P. ticto* and *P. conchonius* were observed to be grouped in PCA bi-plot positive side with fat and protein. While the four large fishes were found to be grouped on the negative side of the PCA bi-plot with fat and ash (Figure 6).

Comparison between large and small fish varieties

The proximate composition showed to have significant variation ($p<0.05$) (Table 3) among the large fishes which constituted the species group i.e. *O. mossambicus, G. catla, L. rohita* and *C. mrigala* while the small fishes constituted of *P. sophore, P. dorsalis, P. ticto and P. conchonius*. The present study showed protein (17.545±3.824 %) and fat (8.643±3.229 %) content to be higher in small fishes in comparison to large fishes having protein and fat content, 9.549±2.655 %

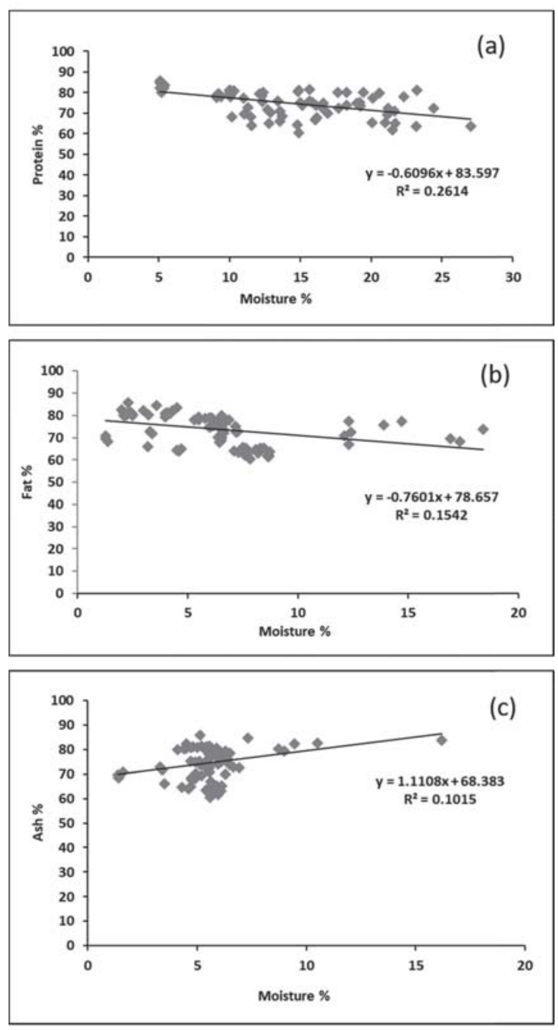

Fig. 4: Linear Regression graph showing estimation of protein (%), fat (%) and ash(%) on the basis of moisture (%) for the sampled fish species

Table 4: Regression equation, r^2 value and r value for the estimation of protein(%), fat (%) and ash (%) as a function of moisture content (%) for all the sampled fish species

Proximate Components (%)	Regression Equation (Y=bx+a)	r^2 value	r value
Protein- Moisture	Y= -0.6096x+83.597	0.2614	-0.511
Fat- Moisture	Y= -0.7601x+78.657	0.1542	-0.393
Ash- Moisture	Y= 1.1108x+68.383	0.1015	0.319

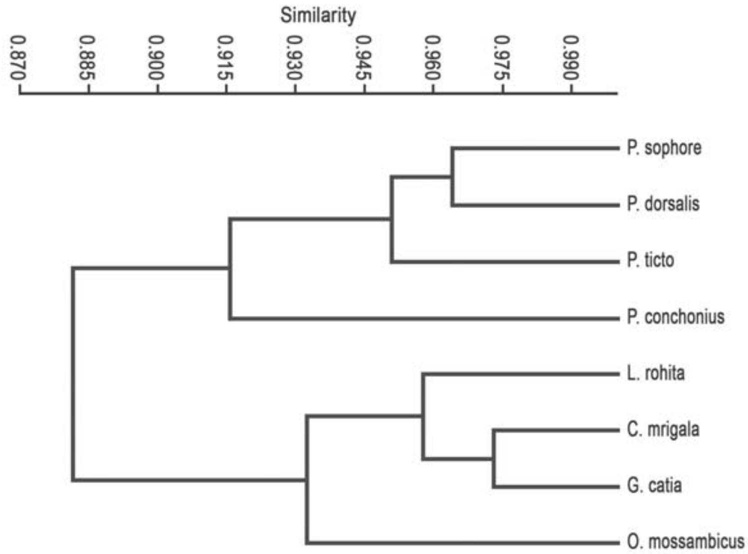

Fig. 5: Bray Curtis Dendrogram showing the groupings of the sampled fish species based on proximate composition

and 3.716±1.437 % respectively (Table 2, Figure 7). The ash content (5.6 %) (Table 2, Figure 7) was found to be almost similar. The moisture content was higher in large fishes (77.84±5.701 %) than the small species (70.258±5.731 %) (Table 2, Figure 7), which may be due to the smaller-sized body thereby having less water-holding capacity and more concentration of fat.

Water Quality Parameters

In the present study, the values of pH, EC, DO, BOD, and salinity were observed to be high in Ghatguda whereas water temperature, TDS, Free CO, and Phosphate were high in Jagannath Sagar. Apart from these, Nitrogen content was observed to be high in both the water bodies. All the parameters were observed to vary within the permissible limit as guided by ISO 2296 (Table 5). The study of water parameters is important as they directly or indirectly influence the food intake of the fish, thereby their nutritional properties. Sharma and Giri (2018)[46] highlighted that Net Primary Productivity can influence nutrient levels in fishes.

The result of the regression analysis (Figure 3) of the present study was found to be similar with the findings of Prakash *et al*.

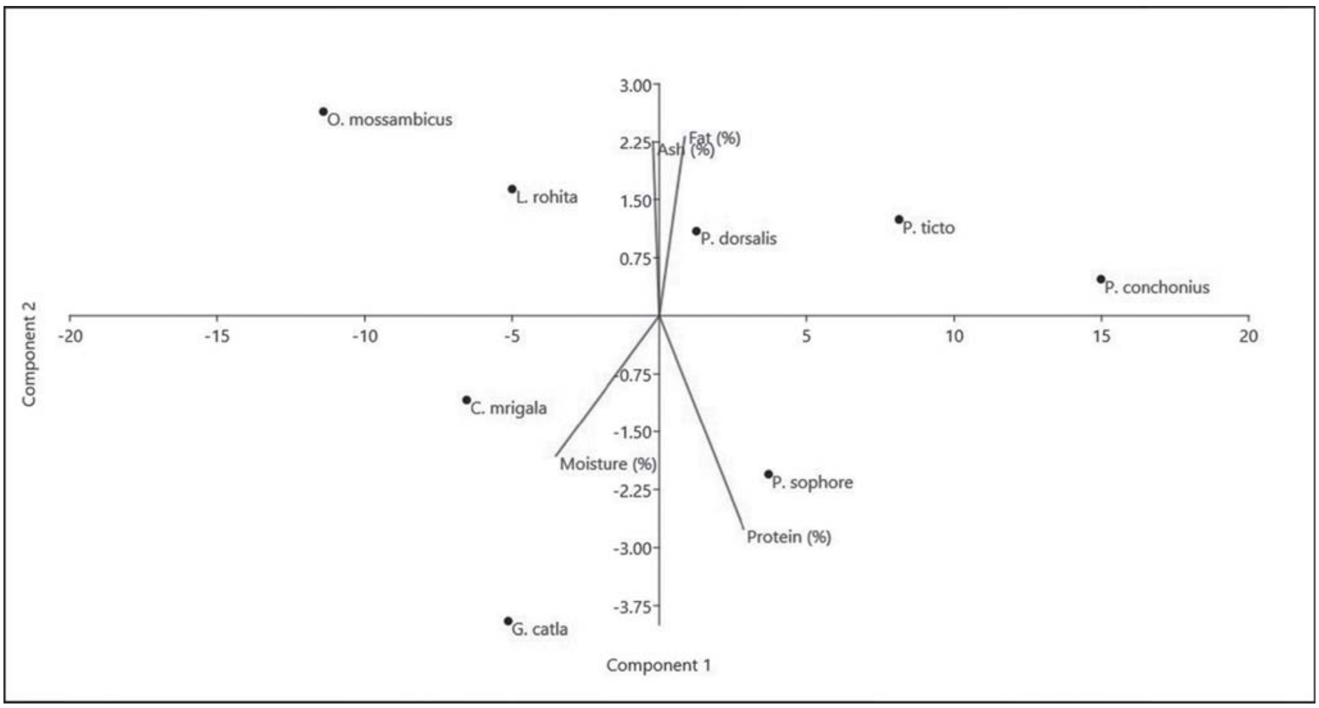

Fig. 6: Principal Component Analysis of the sampled fish species based on proximate composition analysis

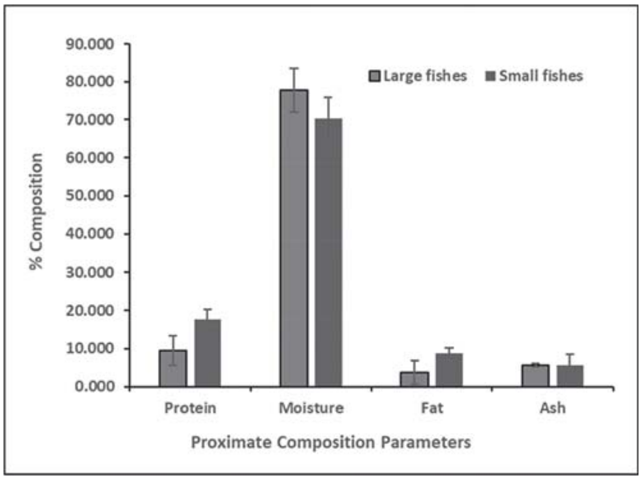

Fig. 7: Bar chart showing variation in proximate composition (%) between the large and small fish groups.

(2021)[47] and Rajesh and Verma (2021)[48] i.e. lipid and protein content decrease with increase in moisture. As a possible source of animal protein and important nutrients for humans, fish has drawn more attention as a dietary component owing to its higher nutritional importance than other animal tissue[49]. Variation in the proximate composition of fish also varies with species, season, geographical location, age, and feeding habits of the fish [50, 51].

The results of the present study show similarity with the findings of Jena *et al.* (2018)[29], who found that the protein, fat, ash, and moisture content to be 14.44±0.29 %, 6.19±0.12 % and 4.29±0.11 %, and 70.65±0.33 %, respectively for *P. sophore*, while showed deviation from the findings of Prakash *et al.* (2021)[47] on the proximate composition of *C. catla* in context to ash content but the similarity with protein, moisture, and fat. In the context of *O. mossambicus,* the present study showed deviation from the findings of Bolawa *et al*. (2011) [45]. The findings of Sankar and Ramachandran (2001)[33] concerning *C. catla*, *C. mrigala* and *L. rohita* was found to be similar to the present findings. The minor deviation may be due to the habitat parameters of the two study sites (Table 4) and also due to physiological adaptation in environmental conditions i.e. spawning, heavy feeding, or starvation [47].

The present findings revealed that small fish have significant nutritional properties, as highlighted by Bolawa et al. (2011)[45], who identified protein and fat as key contributors to their nutritional value. Despite their small size, these fish are rich in minerals like calcium, potassium, zinc, iron, and magnesium, as they are consumed along with their small bones, enhancing their mineral content[52]. This study aligns with Mazumder et al. (2008)[44], which found that small indigenous fish species are more nutritious than large carps, capable of meeting nutritional needs while being more affordable.

Conclusion

Assessing the proximate composition of major food items is essential for understanding the link between food production, nutrient intake, and consumption. This helps in designing initiatives, policies, and programs to enhance production technologies[53] and ensure that the food supply meets dietary needs. The current study examines variations in the proximate composition of eight fish species from lentic and lotic freshwater bodies in Koraput. Small indigenous fish, which are affordable and readily available, have substantial nutritional value and can enhance the nutritional security of the community.

Fish proteins are highly valuable, superior to meat proteins, and, though slightly inferior to milk and egg proteins, have a stable composition of essential amino acids. They have minor deficiencies in methionine and

Table 5: Values for water parameters for fish culture (ISO 2296) and environmental parameters for both study sites during the sampling period

Parameters	Ghatguda	Jagannath Sagar	Standards for fish culture and wildlife propagation (max limits) as per ISO 2296
pH	7.1±0.692	6.65±0.353	8.5
Water temperature (Úc)	29±2.986	29.05±0.919	N.A.
Electrical conductivity (µs/cm)	71.966±8.55	343±0.060	1000
Total dissolved salts (ppm)	36.433±4.964	190.85±5.444	N.A.
Salinity (ppm)	54.733±7.327	0.2615±0.044	N.A.
Dissolved oxygen (ppm)	19.943±1.502	11.052±4.593	4 (MIN)
Biological oxygen demand (ppm)	4.473±0.685	2.877±0.391	N.A.
Free co, (ppm)	10.56±1.76	14.08±4.978	6
Nitrate (ppm)	15±0	15±0	50
Phosphate (ppm)	14.486±0.923	16.232±1.7	N.A.

threonine but an excess of lysine, which is crucial since cereals lack this amino acid. The protein content in the collected samples is notably high, likely due to the availability of nitrogenous substances in their habitat. This study highlights the proximate composition of both large and small fish, emphasizing the nutritional value of small fish.

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