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Seasonal Variations in Nutritional Profile of *Notopterus notopterus*: Implications for Consumer Choice, Aquaculture Diversification, and Food Security

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Abstract

This study investigated seasonal variations in the nutritional composition of *Notopterus notopterus*, a potential species for aquaculture diversification in India. Samples were collected across four seasons in Tripura, India, and analyzed for proximate composition and mineral content. Significant seasonal variations were observed in protein, lipid, ash, moisture content, and mineral composition ($p<0.05$). Protein content peaked during the pre-monsoon season (18.2±0.3%), while the highest lipid content was observed in winter (8.5±0.2%). Calcium and phosphorus levels were highest during the monsoon season (890±18 mg/100g and 320±7 mg/100g, respectively). The results indicate that *N. notopterus* can be marketed as a high-quality protein source with significant micronutrient content, particularly during the pre-monsoon and monsoon seasons. These findings have implications for consumer choice, market positioning, and addressing food security in the region, emphasizing *N. notopterus'* potential for sustainable aquaculture diversification and its suitability for small-scale farmers as both a nutritional resource and a complementary species to income-generating crops.

Keywords: *Notopterus notopterus*, nutritional composition, seasonal variation, consumer preferences, aquaculture diversification, food security, sustainable fish production

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Introduction

The diversification of aquaculture species is a critical strategy to meet the growing global demand for fish protein while reducing pressure on traditional species and wild fish stocks (Naylor et al., 2021). In this context, *N. notopterus* (Pallas, 1769), commonly known as the bronze featherback or grey featherback, has emerged as a species of interest, particularly in South and Southeast Asia (Talwar & Jhingran, 1991). *N. notopterus* is known for its distinctive body shape, featuring a long, laterally compressed body, a short dorsal fin, and an elongated caudal fin that extends along most of its underside. It is an opportunistic omnivore, feeding on small fish, insects, crustaceans, and plant matter, thereby contributing to the balance of aquatic food webs. Its ability to breathe atmospheric air through a modified swim bladder enables it to survive in oxygen-depleted waters, making it resilient to a range of environmental conditions (Kumari, Roy, & Ghosh, 2015).

Notopterus notopterus is a freshwater fish species that has long been part of local capture fisheries but has received limited attention in organized aquaculture practices (Talwar & Jhingran, 1991). Recognizing its potential, the National Bureau of Fish Genetic Resources (NBFGR, Lucknow) prioritized *N. notopterus* in 2011 for regional aquaculture in India, particularly in Tripura. However, despite this prioritization, information on captive breeding, seed production, and other production-related attributes remains limited, even after 13 years (NBFGR, 2011). In Tripura and other northeastern states, this fish is locally called "kanla" or "foloi" and is marketed at sizes as small as 20–30 g. It is consumed fresh, similar to other popular small indigenous species (SIS), such as mola carplets, Indian flying barbs, and sopore barbs. Its taste is well-regarded and is often attributed to its relatively high number of spines.

This characteristic is shared with its congener, *Chitala chitala* (Hamilton, 1822), which already enjoys substantial commercial value. Furthermore, *N. notopterus* is believed to possess medicinal properties, particularly in the treatment of measles, adding to its cultural importance in some communities (Yuvarajan, Chidambaram, & Lingam, 2021).

Despite its potential, research on *N. notopterus*, particularly in relation to its nutritional profile and seasonal variations, remains limited (Kulkarni & Sudarshan, 2020). Understanding these aspects is crucial for optimizing aquaculture practices, evaluating the species' potential contribution to human nutrition, and developing effective marketing strategies (Paul et al., 2019). In this context, the present study aims to investigate the seasonal variations in the proximate composition of *N. notopterus*, analyze the seasonal changes in mineral composition, and assess their implications for aquaculture, human nutrition, and market positioning by examining samples collected from the West Tripura district across four distinct seasons.

Materials and Methods

Samples of *N. notopterus* were collected from three farm ponds located at the ICAR Research Complex for NEH Region, Lembucherra, West Tripura (23°54'N 91°18'E). The ponds ranged in size from 0.1 to 0.2 hectares, with an average depth of 1.5-2.0 meters. Sampling was conducted across four seasons: pre-monsoon (March-May), monsoon (June-August), post-monsoon (September-November), and winter (December-February). For each season, 30 fish were randomly selected from cast net catches from each pond (total n=90 per season). Fish were categorized into three size classes based on total length: small (10-15 cm, 25.2-26.3 g), medium (15-20 cm, 45.6-47.1 g), and large (20-25 cm, 65.4-66.8 g) (Table 1). The maximum size recorded during the study period was 25 cm total length, with a corresponding weight of 66.8 g. All fish were euthanized humanely following approved protocols, and muscle tissue samples were immediately collected and stored at -20°C until analysis. To minimize habitat-related variations in nutritional composition, all samples were collected from the same three farm ponds throughout the study period

Protein content was determined using the Kjeldahl method (N×6.25), while lipid content was measured using the Soxhlet extraction method with petroleum ether as the solvent. Ash content was determined by incinerating pre-dried samples in a muffle furnace at 550°C for 6 hours until white ash was obtained. Moisture content was assessed by oven-drying 5 g samples at 105°C until a constant weight was reached (AOAC, 2019). All analyses were performed in triplicate, and results were expressed as percentages (wet weight basis). Crude fiber content was analyzed using the acid-alkali digestion method (AOAC, 2019). Nitrogen-free extract (NFE) was calculated by difference (FAO, 2003):

NFE = 100 - (protein + lipid + ash + moisture + crude fiber)

Fish muscle samples were thoroughly homogenized and dried at 105°C for 24 hours. The dried samples were then ground into a fine powder using a laboratory mill. For mineral analysis, 2 g of powdered sample was placed in pre-weighed porcelain crucibles and dry-ashed in a muffle furnace at 550°C for 6 hours until white ash was obtained. The ash was dissolved in 5 mL of 6 N HCl, filtered through Whatman No. 42 filter paper, and diluted to 50 mL with deionized water. Calcium, magnesium, iron, zinc, and manganese concentrations were determined using atomic absorption spectrophotometry (Perkin Elmer AAnalyst 400). Phosphorus content was determined colorimetrically using the molybdovanadate method with a UV-visible spectrophotometer at 400 nm (AOAC, 2019). Sodium and potassium levels were analyzed using flame photometry (Bhavan et al., 2010). All analyses were performed in triplicate.

Data were expressed as mean ± SE. Statistical analyses were performed using SPSS software version 21.0 (IBM Corp., Armonk, NY, USA). One-way ANOVA, followed by Tukey's post-hoc test, was used to determine significant differences among seasons ($p<0.05$). Fish were categorized into three size classes based on total length: small (10-15 cm), medium (15-20 cm), and large (20-25 cm). Pearson's correlation coefficients were calculated to determine the relationship between fish size and various nutritional components. The normality of the data was checked using the Shapiro-Wilk test, and homogeneity of variance was assessed using Levene's test before conducting parametric analyses.

Results and Discussion

Seasonal variations in the proximate composition of *N. notopterus* are presented in Table 2. Protein content exhibited notable seasonal variation, peaking during the pre-monsoon season (18.2±0.3%) and reaching its lowest point in the post-monsoon period (16.8±0.3%). This pattern may be attributed to increased feeding activity before the monsoon and the allocation of energy resources for reproduction (Datta, 2024). The observed protein levels are comparable to those of other freshwater fish species like *Catla catla* and *Labeo rohita* (Mohanty et al., 2019), highlighting *N. notopterus* as a valuable protein source for human consumption. Lipid content displayed an inverse trend to that of protein, with the highest values observed in winter (8.5±0.2%) and the lowest during the pre-monsoon season (6.8±0.2%). This pattern aligns with the tendency of many fish species to accumulate lipids as energy reserves for winter and subsequent spawning activities. In the case of *N. notopterus*, spawning occurs during the pre-monsoon and early monsoon months (March-July) when water temperatures rise and the photoperiod increases (Rao et al., 2013). Ash content showed slight variations across seasons, peaking during the monsoon (1.5±0.1%) and reaching its lowest in winter (1.2±0.1%). These fluctuations may reflect changes in mineral uptake due to environmental conditions and physiological demands (Shearer, 1994). Moisture content remained relatively stable across seasons, except for a significant decrease in winter (72.4±0.3%), corresponding with the increase in lipid content during this period. This inverse relationship between moisture and lipid content is a common observation in fish physiology (Love, 1980). The determination of crude fiber content was included in this study as it provides valuable information about the digestibility and nutritional quality of the fish. Although fish typically contain minimal fiber, measuring it is important for several reasons: (1) it helps to verify the purity of the muscle sample and detect any potential contamination from scales or connective tissues, (2) it contributes to comprehensive nutritional profiling required for food composition databases and labeling requirements, and (3) it aids in accurate calculation of nitrogen-free extract (NFE) by difference, ensuring a complete understanding of the fish's total nutritional composition (Stansby, 1962).

Seasonal variations in the mineral composition of *N. notopterus* are presented in Table 3. Calcium and phosphorus levels peaked during the monsoon season (890±18 mg/100g and 320±7 mg/100g, respectively). This may be attributed to increased mineral availability in the aquatic environment during this period (Roy & Lall, 2003). Iron and zinc also showed seasonal variation, with the highest concentrations recorded during the monsoon season (3.5±0.2 mg/100g and 1.9±0.1 mg/100g, respectively). These values are noteworthy, suggesting that *N. notopterus* could serve as a valuable dietary source of these essential micronutrients, particularly for addressing iron deficiency anemia and supporting immune function (Bogard et al., 2015).

The seasonal variations in the nutritional content of *N. notopterus* have important implications for consumer choice and market positioning. The high protein content, particularly during the pre-monsoon season, positions *N. notopterus* as a premium protein source for health-conscious consumers. This could be leveraged in marketing campaigns that emphasize the fish's nutritional benefits during specific seasons (Béné et al., 2015). The elevated levels of essential minerals, especially calcium, iron, and zinc, during the monsoon season present an opportunity to promote *N. notopterus* as a "superfood" for addressing micronutrient deficiencies, particularly in regions where such deficiencies are prevalent (Thilsted et al., 2016). These seasonal variations also suggest the potential for developing season-specific products or tailored marketing strategies. For instance, winter-harvested *N. notopterus*, with its higher lipid content, could be marketed for its potential omega-3 fatty acid content (subject to

Table 1. Seasonal variation in fish weight (g)

Season	Small (10-15 cm)	Medium (15-20 cm)	Large (20-25 cm)
Pre-monsoon	25.2±2.3^{a}	45.6±2.3^{a}	65.4 ± 2.4^{a}
Monsoon	25.8±2.4^{a}	46.2±2.4^{a}	66.1 ± 2.3^{a}
Post-monsoon	26.3±2.5^{a}	47.1±2.5^{a}	66.8 ± 2.5^{a}
Winter	25.5±2.3^{a}	45.9±2.3^{a}	65.7 ± 2.4^{a}

Values in the same column with the same superscripts are significantly not different (p>0.05).

further analysis), appealing to consumers seeking heart-healthy dietary options (Mozaffarian & Wu, 2011).

When compared to other popular freshwater fish species in the Indian markets, *N. notopterus* exhibits a distinctive nutritional profile that positions it favorably among both conventional carps and small indigenous species (SIS). Its protein content (16.8-18.2%) is notably higher than that reported for *Ompok bimaculatus* (11.42-14.45%) by Debnath and Sahoo (2013), indicating superior protein density. Additionally, *N. notopterus* has a lower moisture content (72.4-74.8%) compared to *O. bimaculatus* (78.13-82.44%), which may suggest better storage stability and higher nutrient concentration per unit weight. When compared with dried fish forms studied by Debnath et al. (2014), *N. notopterus* shows promising mineral content, although direct comparisons should be made cautiously due to differences in processing states,. Its calcium content (780-940 mg/100g wet weight) is competitive with species like *Colisa fasciata* (1.66% in dried form), especially when accounting for moisture differences. Similarly, the iron content in *N. notopterus* (2.5-3.8 mg/100g wet weight) represents a notable nutritional advantage, though not as high as found in dried *C. fasciata* (997.7 mg/kg), it remains substantial for a fresh fish product.

The nutritional value of *N. notopterus* is particularly noteworthy when considered alongside findings from Bogard et al. (2015), who analyzed the nutrient composition of important fish species in Bangladesh. Their study emphasized the role of small indigenous species in meeting recommended nutrient intakes, particularly for micronutrients. In this context, the calcium content (780-940 mg/100g) and iron levels (2.5-3.8 mg/100g) of *N. notopterus* position it as a valuable contributor for addressing micronutrient deficiencies, comparable to many SIS known for their high mineral content. When compared to major carps such as *Labeo rohita* and *Catla catla*, which typically have protein levels ranging from 15.9% to 16.2% (Mohanty et al., 2019), *N. notopterus* not only demonstrates higher protein content but also a superior mineral profile, particularly in terms of calcium. This combination of nutritional attributes suggests that *N. notopterus* could serve as both a primary protein source and a significant contributor

Table 2. Seasonal and size-based variations in the proximate composition of *N. notopterus* (% wet weight basis)

Size class (cm)	Season	Protein	Lipid	Ash	Moisture	Crude fiber	NFE
Small (10-15)	Pre-monsoon	17.2±0.3^{c}	5.8±0.2^{c}	1.2±0.1^{b}	74.8±0.4^{a}	0.4±0.1^{b}	0.6±0.2^{a}
	Monsoon	16.8±0.2^{c}	6.3±0.1^{c}	1.4±0.1^{a}	74.5±0.3^{a}	0.5±0.1^{ab}	0.5±0.1^{a}
	Post-monsoon	16.0±0.3^{c}	6.9±0.2^{b}	1.3±0.1^{ab}	74.8±0.3^{a}	0.4±0.1^{b}	0.6±0.2^{a}
	Winter	16.9±0.2^{c}	7.5±0.2^{b}	1.1±0.1^{b}	73.5±0.3^{b}	0.4±0.1^{b}	0.6±0.2^{a}
Medium (15-20)	Pre-monsoon	18.4±0.3^{b}	6.9±0.2^{b}	1.3±0.1^{ab}	73.4±0.4b	0.5±0.1^{ab}	0.5±0.2^{a}
	Monsoon	17.6±0.2^{b}	7.4±0.1^{b}	1.5±0.1^{a}	73.5±0.3^{b}	0.6±0.1^{a}	0.4±0.1^{b}
	Post-monsoon	16.9±0.3^{b}	8.0±0.2^{ab}	1.4±0.1^{a}	73.7±0.3^{b}	0.5±0.1^{ab}	0.5±0.2^{a}
	Winter	18.0±0.2^{b}	8.6±0.2^{ab}	1.2±0.1^{b}	72.2±0.3^{c}	0.5±0.1^{ab}	0.5±0.2^{a}
Large (20-25)	Pre-monsoon	19.0±0.3^{a}	7.7±0.2^{a}	1.4±0.1^{a}	72.9±0.4^{c}	0.6±0.1^{a}	0.4±0.2^{b}
	Monsoon	18.1±0.2^{a}	8.2±0.1^{a}	1.6±0.1^{a}	73.1±0.3^{b}	0.7±0.1^{a}	0.3±0.1^{b}
	Post-monsoon	17.5±0.3^{a}	8.8±0.2^{a}	1.5±0.1^{a}	73.2±0.3^{b}	0.6±0.1^{a}	0.4±0.2^{b}
	Winter	18.8±0.2^{a}	9.4±0.2^{a}	1.3±0.1^{ab}	71.5±0.3^{c}	0.6±0.1^{a}	0.4±0.2^{b}
Average*	Pre-monsoon	18.2±0.3^{A}	6.8±0.2^{C}	1.3±0.1^{B}	73.7±0.4^{A}	0.5±0.1^{B}	0.5±0.2^{A}
	Monsoon	17.5±0.2^{B}	7.3±0.1^{BC}	1.5±0.1^{A}	73.7±0.3^{A}	0.6±0.1^{A}	0.4±0.1^{B}
	Post-monsoon	16.8±0.3^{C}	7.9±0.2^{B}	1.4±0.1^{AB}	73.9±0.3^{A}	0.5±0.1^{B}	0.5±0.2^{A}
	Winter	17.9±0.2^{AB}	8.5±0.2^{A}	1.2±0.1^{B}	72.4±0.3^{B}	0.5±0.1^{B}	0.5±0.2^{A}

Different lowercase letters (a, b, c) within each column indicate significant differences between size classes within the same season. Different uppercase letters (A, B, C) in the "Average" row indicate significant differences between seasons across all size classes. Averages are calculated across size classes for each season.

to mineral nutrition, potentially offering advantages over traditional carp species in addressing multiple nutritional needs simultaneously.

The consistent protein content and significant levels of essential minerals across seasons suggest that *N. notopterus* could play an important role in diversifying aquaculture and supporting food security. Its ability to maintain a relatively stable nutritional profile throughout the year makes it an attractive option for year-round production (Naylor et al., 2021). Moreover, the species' adaptability to various freshwater environments, coupled with its nutritional benefits, positions it as a potential candidate for sustainable aquaculture practices. Incorporating *N. notopterus* into polyculture systems could enhance both the overall productivity and nutritional quality of aquaculture operations (Diana et al., 2013).

The nutritional profile of *N. notopterus* makes it a valuable contributor to human dietary needs. The edible portion of *N. notopterus* constitutes approximately 45-48% of its total body weight, with the remainder comprising the head, fins, scales, viscera, and bones. This fish is typically consumed fresh, either fried, in curries, or through other traditional preparations. Despite the presence of numerous small bones, local communities have developed skilled techniques for consuming it. Often, the fish is prepared in curries, where prolonged cooking softens the smaller bones, making them edible and contributing to calcium intake. The nutritional contribution of *N. notopterus* to daily dietary requirements is substantial, as demonstrated in Table 4. Based on its average composition, 100 kg of production can provide approximately 17,600 g of protein, 3,100 mg of iron, 846,000 mg of calcium, and 1,750 mg of zinc. These quantities are sufficient to meet a family's nutritional needs for extended periods - providing protein requirements for about 70 days, iron for 52 days, calcium for 188 days, and zinc for 44 days. This significant nutrient yield, particularly in terms of protein and essential minerals, highlights the species' potential role in addressing nutritional security at the household level. The notably high calcium contribution is especially valuable in regions where dairy consumption may be limited. Using the average protein content of 17.6 g per 100 g of the edible portion,

Table 3. Seasonal and size-based variations in mineral composition of *N. notopterus* (mg/100g wet weight)

Size class (cm)	Season	Ca	P	Mg	Na	K	Fe	Zn	Mn
Small (10-15)	Pre-monsoon	$780±15^c$	$270±8^c$	$32±2^c$	$60±3^c$	$320±10^c$	$2.5±0.1^c$	$1.4±0.1^c$	$0.25±0.02^c$
	Monsoon	$840±18^c$	$295±7^c$	$38±2^c$	$63±3^c$	$355±12^c$	$3.2±0.2^c$	$1.7±0.1^c$	$0.35±0.02^c$
	Post-monsoon	$810±16^c$	$285±6^c$	$34±2^c$	$62±3^c$	$340±11^c$	$2.9±0.1^c$	$1.6±0.1^c$	$0.30±0.02^c$
	Winter	$765±14^c$	$265±7^c$	$29±2^c$	$58±3^c$	$310±10^c$	$2.6±0.1^c$	$1.5±0.1^c$	$0.25±0.02^c$
Medium (15-20)	Pre-monsoon	$825±15^b$	$290±8^b$	$35±2^b$	$65±3^b$	$340±10^b$	$2.8±0.1^b$	$1.6±0.1^b$	$0.30±0.02^b$
	Monsoon	$890±18^b$	$320±7^b$	$42±2^b$	$68±3^b$	$380±12^b$	$3.5±0.2^b$	$1.9±0.1^b$	$0.40±0.02^b$
	Post-monsoon	$860±16^b$	$305±6^b$	$38±2^b$	$67±3^b$	$360±11^b$	$3.2±0.1^b$	$1.8±0.1^b$	$0.35±0.02^b$
	Winter	$810±14^b$	$285±7^b$	$33±2^b$	$63±3^b$	$330±10^b$	$2.9±0.1^b$	$1.7±0.1^b$	$0.30±0.02^b$
Large (20-25)	Pre-monsoon	$870±15^a$	$310±8^a$	$38±2^a$	$70±3^a$	$360±10^a$	$3.1±0.1^a$	$1.8±0.1^a$	$0.35±0.02^a$
	Monsoon	$940±18^a$	$345±7^a$	$46±2^a$	$73±3^a$	$405±12^a$	$3.8±0.2^a$	$2.1±0.1^a$	$0.45±0.02^a$
	Post-monsoon	$910±16^a$	$325±6^a$	$42±2^a$	$72±3^a$	$380±11^a$	$3.5±0.1^a$	$2.0±0.1^a$	$0.40±0.02^a$
	Winter	$855±14^a$	$305±7^a$	$37±2^a$	$68±3^a$	$350±10^a$	$3.2±0.1^a$	$1.9±0.1^a$	$0.35±0.02^a$
Average*	Pre-monsoon	$825±15^B$	$290±8^B$	$35±2^B$	$65±3^B$	$340±10^B$	$2.8±0.1^C$	$1.6±0.1^C$	$0.30±0.02^B$
	Monsoon	$890±18^A$	$320±7^A$	$42±2^A$	$68±3^A$	$380±12^A$	$3.5±0.2^A$	$1.9±0.1^A$	$0.40±0.02^A$
	Post-monsoon	$860±16^{AB}$	$305±6^{AB}$	$38±2^{AB}$	$67±3^{AB}$	$360±11^{AB}$	$3.2±0.1^B$	$1.8±0.1^B$	$0.35±0.02^{AB}$
	Winter	$810±14^B$	$285±7^B$	$33±2^B$	$63±3^B$	$330±10^B$	$2.9±0.1^C$	$1.7±0.1^C$	$0.30±0.02^B$

Different lowercase letters (a, b, c) within each column indicate significant differences between size classes within the same season ($p < 0.05$). Different uppercase letters (A, B, C) in the "Average" row indicate significant differences between seasons across all size classes ($p < 0.05$). Averages are calculated across size classes for each season.

Table 4. Estimated nutritional contribution of 100 kg *N. notopterus* to a family of five

Nutrient	Average content per 100g	Total in 100 kg	Daily family requirement*	Days of supply
Protein	17.6 g	17,600 g	250 g	70 days
Iron	3.1 mg	3,100 mg	60 mg	52 days
Calcium	846 mg	846,000 mg	4,500 mg	188 days
Zinc	1.75 mg	1,750 mg	40 mg	44 days

*Based on the approximate combined Recommended Dietary Allowance (RDA) for a family of five adults (Institute of Medicine, 2006)

approximately 1.42 kg of whole *N. notopterus* (yielding 653 g of the edible portion) would be needed to meet a family's daily protein requirement of 250 g. This calculation accounts for both the percentage of edible portion and the protein content of the flesh.

Furthermore, *N. notopterus* possesses several characteristics that make it particularly suitable for small-scale, low-input aquaculture systems. It is a self-recruiting species, meaning that once stocked in a pond, it can reproduce and sustain its population with minimal intervention. This trait significantly reduces the need for regular restocking, making it an economical choice for resource-limited farmers. Additionally, *N. notopterus* is known for its hardiness and ability to breathe air, allowing it to thrive in diverse aquatic environments, including those with low oxygen levels. These attributes make it an ideal candidate for co-culture with large carp species. In such systems, resource-poor farmers can utilize *N. notopterus* for family nutrition, benefiting from its rich nutritional profile, while simultaneously cultivating large carps as a cash crop for income generation. This integrated approach not only enhances food security at the household level but also creates opportunities for economic advancement through aquaculture diversification.

The food industry could leverage the nutritional profile of *N. notopterus*, although current aquaculture practices for this species remains limited. Despite being prioritized by the National Bureau of Fish Genetic Resources (NBFGR) in 2011 for regional aquaculture in India, particularly in Tripura, monoculture remains uncommon. Instead, the species is primarily co-cultured with major carps in traditional polyculture systems, serving both as a supplementary crop and a natural biological control agent for small, unwanted fish. The high protein and mineral content of *N. notopterus* makes it suitable for developing nutrient-dense processed products, such as fish-based protein powders or fortified snacks targeting bone health. Season-specific products could also be formulated based on observed nutritional variations. As a species well-adapted to polyculture systems, *N. notopterus* presents opportunities for sustainable aquaculture diversification, potentially reducing pressure on overfished species (Naylor et al., 2021). However, standardized culture protocols and seed production techniques will be essential for scaling up production to meet industrial demand.

While this study highlights the potential of *N. notopterus*, several challenges needs to be addressed. Further research is required to evaluate consumer acceptance of *N. notopterus*-based products, particularly in markets where the species is not traditionally consumed. Studies on optimal processing methods that retain the nutritional benefits of *N. notopterus* while extending shelf life will be crucial for successful commercialization. Additionally, research on feed formulation and culture conditions are necessary to optimize the nutritional profile of farmed *N. notopterus*. A comprehensive economic analysis of integrating *N. notopterus* into existing aquaculture systems would provide valuable insights for industry stakeholders. Finally, long-term assessments of the environmental impacts of *N. notopterus* aquaculture are essential to ensure its sustainability.

This study presents comprehensive data on the seasonal variations in the proximate and mineral compositions of *N. notopterus* from Tripura, India. The results demonstrate that *N. notopterus* is a good source of protein and essential minerals, with notable seasonal fluctuations in its nutritional profile. The highest nutritional value, particularly in terms of protein and micronutrients, was observed during the pre-monsoon and monsoon seasons. These findings have significant implications for aquaculture, human nutrition, and the food industry. For aquaculture, the data can inform optimal harvesting periods and guide feed formulation strategies to maximize the nutritional quality of farmed *N. notopterus*. From a nutritional perspective, the consistent protein content and substantial levels of essential minerals, especially iron and zinc, highlight its potential to help address nutrient deficiencies in the region. The species' potential in aquaculture diversification and its role in food security cannot be overstated. Its adaptability to diverse freshwater environments, combined with its nutritional benefits, positions *N. notopterus* as a promising species for sustainable aquaculture practices. However, realizing its full potential will require addressing several challenges, including the optimization of aquaculture practices, evaluation of consumer acceptance, and development of suitable processing methods. Future research should focus on these areas, as well as on conducting comprehensive economic and sustainability analyses.

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