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Nutritional quality of cultured Asian seabass *Lates calcarifer* in Khulna-Satkhira region of Bangladesh: comparative analysis of two size classes

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Abstract

Asian seabass *(Lates calcarifer)*, locally known as Bhetki or Koral, is a native species to the Indo-Pacific region and is farmed on a small scale in the Southern coastal regions of Bangladesh. This study analyzed the nutritional composition of cultured Asian seabass to identify the nutritionally superior size to aid consumers in making informed choices and to help farmers in determining optimal culture duration. Individuals of two different size classes, (512.06 ± 14.5 g and 1003.5 ± 36.64 g) collected from Khulna and Satkhira districts, were analyzed during this study. The results revealed significant differences ($p < 0.05$) between the two groups in their proximate composition except for ash content. The smaller size group had higher moisture content (74.96 ± 0.04%), while the larger group showed higher protein (20.48 ± 0.1%) and fat (5.34 ± 0.18%) content. Fatty acid profiles also indicated variation between the two groups with larger fish containing higher levels of saturated (SFAs) and monounsaturated fatty acids (MUFAs) whereas smaller fish had more polyunsaturated fatty acids (PUFAs) and a more favorable n-3/n-6 ratio. Undecanoic acid and α-linolenic acid were predominant in both groups, while MUFA composition varied: palmitoleic acid and oleic acid were higher in the smaller and larger groups respectively. All essential amino acids (EAAs) were present except tryptophan. Lysine was the most prominent in both groups with 5.53 ± 0.44 g/100 g dry weight and 3.91 ± 0.32 g/100 g dry weight in the smaller and larger group, respectively. These findings suggest that smaller seabass offer superior nutritional quality and may support more profitable farming through shorter culture cycles.

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1. Introduction

The Asian seabass (*Lates calcarifer*), locally called Bhetki/koral, is a catadromous teleost fish native to the Indo-Pacific region, widely recognized for its rich flavor, high economic value, and nutritional benefits[1]. Over the past decades, rising global demand for Asian seabass has driven the expansion of intensive aquaculture in various countries such as the Philippines, Vietnam, Malaysia, India, Australia, Saudi Arabia, etc.[1]. In Bangladesh, the natural production of Asian seabass has decreased drastically over the past few decades, which has triggered the cultivation of Asian seabass in an extensive way in the southern region of Bangladesh to meet rising consumer demand. In addition, the traditional shrimp farming in the southern region is facing a serious disease outbreak, which also leads the farmers to culture Asian seabass to reduce farming losses[2].

Several studies have shown that Asian seabass is a nutritious species. However, the nutritional composition can vary depending on the culture practices, as the nutrient composition of fish varies widely even among individuals of the same species due to multiple influencing factors, including size, season, location, habitat, age, sex, and whether the fish was wild-caught or farm-raised[3,4]. In Bangladesh, previous research has explored nutritional differences across the developmental stages of wild Asian seabass[5,6]. On the other hand, studies in other countries have compared wild and cultured seabass where limited attention has been given to how nutritional composition may vary across marketable sizes of cultured seabass during their production cycle.

To address this gap, this study explored the nutritional composition of two marketable-sized groups of cultured Asian seabass. This study aimed to (i) compare proximate composition, (ii) assess fatty acid profiles and (iii) evaluate essential amino acid composition of that two size classes.

By providing size-specific nutritional data, this study will support sustainable aquaculture, food security, and informed consumer choices along with market positioning of Asian seabass in Bangladesh and beyond.

2. Materials and Methods

2.1 *Sample collection*

Eight individuals of Asian seabass were collected from two different polyculture farms of Paikgacha upazila in Khulna. Among them, 4 fish (512.06 ± 14.50 g) were collected on December 19-20, 2023 and the rest (1003.50 ± 36.64 g) were collected from same farms on May 15-16, 2024. The fish were collected based on predefined size groups which are more abundant in market. After collecting, the samples were placed in iceboxes with sufficient ice and transported to the Department of Fisheries, University of Dhaka.

2.2 Laboratory Analysis

Sample Preparation

After arriving at the laboratory, the samples were put on a stainless-steel tray. After that, individual samples were eviscerated and filleted with a clean stainless-steel knife. Then the fillets were blended into a fish mince. The prepared fish pastes were then stored in labeled bags at -20°C for further analysis. During these processes, all equipment was washed properly before starting sample preparation to avoid human error.

Proximate Composition Analysis

The moisture, protein, fat, and ash contents were analyzed using AOAC methods[7]. Each experiment was conducted in triplicate and values are expressed as mean ± SEM.

Extraction and determination of fatty acids

Fat was extracted using the Randall modification of the standard Soxhlet extraction method following Thiex *et al.*[8] with the Soxhlet apparatus (E-500, BUCHI Labortechnik AG, Switzerland) where petroleum ether was used as the solvent. The fat-solvent mixture was evaporated in a fume hood. Then, the extracted fat was trans-esterified using sodium methoxide into Fatty Acid Methyl Esters (FAME), which improves its volatility for Gas Chromatography-Mass Spectrometry (GC-MS) analysis. The resulting FAME samples were then analyzed using a Shimadzu GC-MS QP2010 Ultra (Nishinokyo-Kuwabara-Cho, Kyoto, Japan), with nitrogen as the carrier gas. Fatty acids were identified and quantified by the retention times (RT) and using specific ions.

Extraction and determination of Amino Acids

Amino acids were extracted and determined by following Otter *et al.*[9]. Dry sample weighing 0.2 g was hydrolyzed with 25 ml of 7N HCl at 110°C for 24 hours. After neutralization with 7.5N NaOH, the volume was adjusted to 250 ml using buffer (pH 3.4), filtered and diluted tenfold. 100 µL of sample was mixed with 900 µL buffer and analyzed via HPLC (Sykam S 7130, Sykam GmbH, Germany) with pre-column derivatization. Amino acids were identified and quantified based on retention times.

2.3 *Statistical analysis*

Data were analyzed using R (v4.4.1). Significance was assigned at the 0.05% level. The mean values of proximate composition (moisture, ash, fat and protein), fatty acids and amino acids concentration of the two different size groups were compared to see the significant difference through independent t-test.

3. Results and discussions

3.1 *Proximate composition*

The proximate compositions of the two size groups varied significantly ($p < 0.05$) from each other except for ash content (Table 1). Between the two groups, the smaller-sized group had significantly higher ($p < 0.05$) moisture content compared to the larger fish group while the scenario was opposite in case of fat content. Previous studies have also reported that moisture content of an organism in inversely correlated with the fat content[10]. The tendency of larger fish to store more fat as energy reserves during slower growth phases might be the cause for this[11]. The larger size group also had significantly higher ($p<0.05$) protein content possibly reflecting their dietary shifts from omnivorous to carnivorous feeding as seabass mature[12,13]. However, previous studies have reported a typical trend of higher protein in rapidly growing, smaller fish[11]. Ash content, though not significantly differed, was slightly higher in smaller fish. This could be attributed to feeding across multiple trophic levels, leading to greater mineral retention[14,15].

Table 1. Proximate composition of Asian seabass. Values are expressed as mean ± SEM. Values with different superscripts within the row are significantly different at $p < 0.05$

Proximate ingredient	This Study		Previous studies on wild-caught Asian seabass[5,6]
	Smaller size Fish (g/100g muscle)	Larger size Fish (g/100g muscle)	
Moisture	74.96 ± 0.04^{a}	70.75 ± 0.17^{b}	69% (adult male) to 74% (juvenile)
Ash	2.99 ± 0.46^{a}	2.43 ± 0.15^{a}	3.25 ± 0.14% (juvenile) to 5.30 ± 0.52% (adult female)
Fat	2.33 ± 0.14^{a}	5.34 ± 0.18^{b}	3.25 ± 0.14% (juvenile) to 5.30 ± 0.52% (adult female)
Protein	18.72 ± 0.33^{a}	20.48 ± 0.1^{b}	17.70 ± 0.23% (spent female); 20.45 ± 0.38% (juvenile) & 22.94 ± 0.255% (adult male)

When compared to the proximate composition of wild-caught Asian seabass[5,6], the cultured fish displayed similar range of moisture, fat and protein content but had lower ash content, possibly due to limited feed or suboptimal culture conditions[14,16]. Despite this, fat content remained within the normal range, potentially due to the catadromous nature of the species which promotes fat synthesis as an adaptive energy reserve during environmental stress.

3.2 *Fatty acid composition*

The two groups of cultured Asian Seabass significantly differed ($p < 0.05$) in their fatty acid composition. Fatty acid profiles reveal that between the two groups, the larger group had higher levels of saturated and monounsaturated fatty acids (SFAs and MUFAs), while smaller fish exhibited higher polyunsaturated fatty acids (PUFAs) content. These results align with similar trends in *Tenualosa ilisha*[17]. The differences observed between the groups likely stem from ontogenetic dietary shifts, as seabass go through a transition from omnivorous to carnivorous habits[13].

Among SFAs, Undecanoic acid (C11:0), a plant-derived component, was dominant (~40%) in both groups, suggesting considerable presence of plant-origin components in the diet of cultured seabass. Other major SFAs included palmitic (C16:0), stearic (C18:0), and myristic (C14:0) acids. Among these the content of undecanoic, palmitic and myristic acids was significantly higher ($p < 0.05$) in the larger group, while stearic (C18:0) and pentadecanoic (C15:0) acids were more abundant in the smaller group. The concentration of three SFAs (Caproic (C6:0), Heneicosanoic (C21:0) and Tricosanoic (C23:0)) was found to be below the detection range in the larger size fish while they were present in considerable amount in the smaller sized ones (Table 2).

Among MUFAs, oleic acid (C18:1) was the most dominant in the larger group and palmitoleic acid (C16:1) was abundant in the smaller group. The larger group showed significantly higher ($p < 0.05$) levels of oleic, palmitoleic and arachidic (C20:1) acids, while the smaller group had more heptadecenoic acid (C17:1). The concentration of Pentadecenoic (C15:1) and Eicosatrienoic (C20:3) was below the detection level in larger fish. In case of polyunsaturated fatty acids (PUFAs), 10 were identified in the smaller fish group and 8 in the larger. Dominant n-3 PUFAs included α-Linolenic acid (C18:3), EPA (C20:5), and DHA (C22:6) which is consistent with findings from previous studies on seabass and related species[18,19]. α-linolenic acid (C18:3), primarily plant-derived[20], was more abundant in smaller fish, indicating higher assimilation of plant-origin feed. Smaller fish also showed comparatively higher EPA content, while in the larger ones DHA was more prevalent. The two groups also differed in their n-6 PUFAs content with linoleic acid (C18:2) being the dominant in larger fish while γ-linolenic acid (C20:3) was dominant in smaller fish. Both groups showed a low proportion of long-chain fatty acids, possibly due to limited elongation capacity (Table 3)[21].

Table 2. Concentration of saturated fatty acids (SFAs) (mg/100g dry weight) in muscle of cultured Asian seabass. Values are expressed as mean ± SD. Values with different superscripts within the row are significantly different at $p < 0.05$

Saturated Fatty Acid (SFA)	Concentration in smaller size fish (mg/100g dry weight)	Concentration in larger size fish (mg/100g dry weight)
Caproic (C6:0)	123.3 ± 31.9	Not detected
Caprylic (C8:0)	14.1 ± 11.5[a]	42.2 ± 16.3[a]
Capric acid (C10:0)	357.1 ± 161.8[a]	732.5 ± 49.6[b]
Undecanoic (C11:0)	2754.6 ± 494.4[a]	4588.8 ± 397.6[b]
Lauric (C12:0)	36.7 ± 32.3[a]	50.3 ± 25.6[a]
(C13:0) Tridecanoic	30.1 ± 11.1[a]	73.7 ± 16[b]
Mysteric (C14:0)	332.9 ± 104.1[a]	1465.9 ± 173.6[b]
Pentadecanoic (C15:0)	227.6 ± 44.6[a]	66.6 ± 7.1[b]
Palmitic (C16:0)	1366.1 ± 248.8[a]	4476.4 ± 455.5[b]
Heptadecanoic (C17:0)	41.3 ± 3.4[a]	42.6 ± 16.1[a]
Stearic (C18:0)	1345.8 ± 123.8[a]	366.1 ± 134.4[b]
Arachidic (C20:0)	43.6 ± 19.2[a]	41.2 ± 15.4[a]
Heneicosanoic (C21:0)	45.2 ± 22.9	Not detected
Behenic (C22:0)	16.6 ± 1[a]	43.6 ± 2.7[b]
Tricosanoic (C23:0)	26.4 ± 7	Not detected
Lignoceric (C24:0)	48.2 ± 22[a]	146.8 ± 45.3[b]
∑ SFA	6809.6 ± 1339.8	12136.7 ± 1355.2

The major fatty acids, such as undecanoic acid (C11:0) has antimicrobial properties, which make it valuable in treating skin infections and promoting skin health[22]. Palmitic and myristic acids affect cholesterol levels[23]. On the other hand, stearic acid (C18:0) is metabolically neutral[23] and Pentadecanoic(C15:0), Palmitoleic (C16:1) and Oleic acid (C18:1) have anti-inflammatory and metabolic benefits[24], Myristoleic (C14:1) acid has anti-cancer properties and prevents non-alcoholic fatty liver disease[25]. Additionally, C18:3 (α-Linolenic) acid, EPA and DHA support cardiovascular health, reduce inflammation and provide antioxidant benefits. The n-3/n-6 ratio was 1.37 in smaller fish and 0.91 in larger ones, both of which exceeded the minimum recommended value of 0.2[18], confirming their nutritional value for cardiovascular health.

Table 3. Concentration of unsaturated fatty acids (mg/100g dry weight) in muscle of cultured Asian seabass. Values are expressed as mean ± SD. Values with different superscripts within the row are significantly different at $p < 0.05$

Unsaturated Fatty Acid	Concentration in smaller size fish (mg/100g dry weight)	Concentration in larger size fish (mg/100g dry weight)
Myristoleic (C14:1)	344.5 ± 87^a	287 ± 29.6^a
Pentadecenoic (C15:1)	17.3 ± 5.1^a	Not detected
Palmitoleic (C16:1)	654.4 ± 94.9^a	1303.8 ± 146.4^b
Heptadecenoic (C17:1)	71.5 ± 14^a	28.1 ± 1.7^b
Oleic (C18:1)	462.2 ± 57.9^a	1848 ± 390.6^b
Eicosenoic (C20:1)	43.1 ± 11.3^a	118.5 ± 19.3^b
Docosenoic (C22:1)	34.4 ± 2.7^a	47.3 ± 7.5^a
Nervonic (C24:1)	30.2 ± 11.1^a	50.7 ± 9.8^a
α-Linolenic (C18:3)	121.2 ± 19.4^a	59.8 ± 9^b
Eicosatrienoic (C20:3)	36.9 ± 10.5^a	Not detected
Eicosapentaenoic (EPA) (C20:5)	83.4 ± 16.2^a	57.6 ± 3.7^a
Docosahexaenoic (DHA) (C22:6)	13.6 ± 1^a	27.9 ± 2.7^b
Linoleic (C18:2), n-6	18.6 ± 2.9^a	79.2 ± 15.1^b
Gamma-Linolenic (C18:3), n-6	79.9 ± 17.4^a	24.5 ± 2.6^b
Gamma-Linolenic (C20:3), n-6	88 ± 10.3^a	56.2 ± 9.2^b
Linolelaidic (C18:2) (trans)	86.7 ± 23.1^a	81.1 ± 15.9^a
Eicosadienoic (C20:2)	13.9 ± 1.3^a	36.3 ± 2.8^b
Docosadienoic (C22:2)	13.4 ± 0.5^a	36.9 ± 2.3^b
∑ MUFA	1657.6 ± 278.9	3683.4 ± 604.9
∑ n-3 PUFA	255.1 ± 47.1	145.3 ± 15.4
∑ n-6 PUFA	186.5 ± 30.6	159.9 ± 26.9
∑ PUFA	555.6 ± 102.6	495.6 ± 63.3

3.3 *Amino acid composition*

Amino acids (AAs) are fundamental for building tissue proteins and are involved in synthesizing vital compounds such as glutathione, creatine, thyroid hormones, melanin, and melatonin[24,26]. The amino acid profile of cultured Asian seabass muscle revealed the presence of 17 different amino acids including Essential, Semi-essential and Non-essential Amino Acids (EAAs. SAAs and NAAs, respectively) (Table 4).

Table 4. Amino Acids (AAs) concentration (mg/100g dry weight) in muscle of cultured Asian seabass. Values are expressed as mean ± SD. Values with different superscripts within the row are significantly different at $p < 0.05$

Essential Amino Acid	Concentration in smaller size fish (mg/100g dry weight)	Concentration in larger size fish (mg/100g dry weight)
Arginine	3.66 ± 0.28^{a}	2.44 ± 0.15^{b}
Histidine	1.52 ± 0.12^{a}	1.17 ± 0.14^{b}
Isoleucine	1.73 ± 0.06^{a}	1.14 ± 0.07^{b}
Leucine	4.97 ± 0.1^{a}	3.27 ± 0.18^{b}
Lysine	5.53 ± 0.44^{a}	3.91 ± 0.32^{b}
Methionine	2.01 ± 0.45^{a}	1.36 ± 0.08^{a}
Phenylalanine	2.47 ± 0.17^{a}	2.18 ± 0.2^{a}
Threonine	2.69 ± 0.17^{a}	1.85 ± 0.13^{b}
Valine	1.46 ± 0.09^{a}	1.03 ± 0.09^{b}
Semi-essential Amino acid		
Cysteine	0.39 ± 0.07^{a}	0.34 ± 0.03^{a}
Non-essential amino Acid		
Alanine	3.67 ± 0.14^{a}	2.85 ± 0.11^{b}
Aspartic	7.61 ± 0.78^{a}	5.38 ± 0.46^{b}
Glutamic	12.67 ± 0.68^{a}	8.86 ± 0.45^{b}
Glycine	2.2 ± 0.17^{a}	2.94 ± 0.17^{b}
Proline	1.69 ± 0.06^{a}	2.1 ± 0.19^{b}
Serine	1.91 ± 0.13^{a}	2.7 ± 0.19^{a}
Tyrosine	2.51 ± 0.15^{a}	1.18 ± 0.42^{b}

Among the EAAs, Lysine was the most abundant followed by leucine and arginine. Tryptophan was not found in the muscle of the studied samples. The two sized groups showed significant difference ($p < 0.05$) in their amino acid content with smaller size group having higher levels of EAAs except for methionine and phenylalanine. Although these EAAs were apparently higher in this group but the difference was not significant. Among NAAs, glutamic acid was the most prevalent, followed by aspartic acid and alanine. All NAAs, except serine, differed significantly between the groups, where glutamic acid, aspartic acid, alanine, and tyrosine were higher in the smaller group, while glycine and

proline were more abundant in the larger group. Though amino acid composition is known to vary with biological and environmental factors, these patterns align with previous findings on seabass and related species[27]. The EAA/NAA ratios were 0.81 and 0.71 for the smaller and larger groups, respectively, both above the standard of 0.6[28], indicating high protein quality in both size groups. Furthermore, all functional amino acids such as arginine, aspartate, cysteine, glutamine, glycine, histidine, leucine, methionine, proline, threonine, tryptophan and tyrosine were present. These amino acids play key roles in supporting health, growth, reproduction and immunity[29].

4. Conclusion

The results of this study demonstrate that cultured Asian seabass is nutritionally rich, particularly in protein, essential amino acids, and beneficial fatty acids. Thus, it can be regarded as a sustainable and nutritious alternative in coastal aquaculture. Between the two groups, the smaller size group fishes (512.06 ± 14.5 g) exhibited superior essential amino acid content, a more favorable n-3/n-6 ratio, and higher EPA levels, indicating greater dietary value compared to the larger group (1003.5 ± 36.64 g). These findings suggest that earlier harvesting of seabass during the mid-point of the culture cycle not only enhances nutritional quality but may also reduce production risks and costs along with the multiplication of cycles annually which will result in greater benefit. Overall, this research provides a practical framework for selecting nutritionally superior fish sizes, guiding market preferences, optimizing harvest strategies and promoting consumer health.

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