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RESEARCH ARTICLE

Nutrient Profile of Giant River-Catfish *Sperata seenghala* (Sykes)

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Abstract The giant river-catfish (*Sperata seenghala*) contributes significantly to the inland fisheries production in the tropical rivers and also enjoys high consumer preference. The present study was undertaken to generate information on the nutrient profile of this commercially important species as such information is not available. Proximate composition analysis showed that moisture, crude protein, crude fat and ash contents are 79.40 ± 0.09, 20.06 ± 1.13, 1.40 ± 0.79 and 0.90 ± 0.08%, respectively. Amino acid analysis showed that the fish flesh is rich in the essential amino acids like histidine, threonine and leucine and the ratio of essential to non-essential amino acid is 0.89 indicating its superior protein quality. Fatty acid profiling showed that it is low in fat. The mineral profiles showed that this species is rich in zinc, iron and calcium. The present study showed that *Sperata seenghala* is a good source of lean meat and trace elements, especially zinc and iron.

Keywords Giant river-catfish · *Sperata seenghala* · Proximate composition · Amino acids · Fatty acids · Micronutrients · Nutrient profile

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Introduction

Fish is an important dietary component and is one of the cheapest sources of animal protein. It plays an important role in preventing kwashiorkor and marasmus; the chronic protein-calorie malnutrition diseases. Fish oil, especially from marine species, is rich in ω-3 polyunsaturated fatty acids (PUFAs) which are associated with a number of health benefits, preventing cardio-vascular diseases in the adults [1], dementia and age-related macular degeneration (AMD) in the elderly [2], attention-deficit hyperactive disorder [3] and asthma [4] in pediatric population. Fish is also an important source of micronutrients [5, 6]. Generating information on biochemical composition of fish is important as this will generate information on specific nutrient richness of particular species and will help the nutritionists and dieticians in issuing 'dietary guidelines' for societal benefit [7].

The Bagrid catfishes constitute a very important group of fishes having immense commercial importance. The 'giant river-catfish, *Sperata seenghala* (Sykes)' is perhaps the most important member of this family [8] and is distributed throughout India, Pakistan, Bangladesh, Afghanistan and Nepal [9]. Its contribution to the inland fish production is significant and it is a very important group having immense commercial importance in India as well as in other South-East Asian countries. *S. seenghala* is an important food fish and enjoys great consumer preference owing to its perceived superior nutritive value. However, there is a paucity of information on the nutritional composition of this economically important species. In the present study, we have generated information on proximate composition, amino acid, fatty acid, mineral and vitamin profiles of *S. seenghala*.

Materials and Methods

Collection of Samples

Fresh *S. seenghala* ($n = 20$) (avg. weight 619.66 ± 0.31 g, avg. length 48.16 ± 0.02 cm) were collected from river Ganga in and around Kolkata, India and stored at −40 °C until analysis. Fishes were dressed, deskinned and filleted. The fillets of anterior, middle and posterior portion of fishes were pooled, minced and used for analysis.

Proximate Composition Analysis

Moisture content was determined by drying minced wet sample in hot air oven at 105 ± 2 °C over night until weight became constant. Then reduction of weight was measured gravimetrically and moisture content was expressed in percentage. Crude protein and crude fat were determined according to the Kjeldahl and Soxhelet methods, respectively [10]. Ash was obtained after incineration of moisture free dry sample in a muffle furnace at 600 °C for 6 h until weight became constant. The ash content was also determined gravimetrically and expressed as percentage [11].

Fatty Acid Analysis

Pooled wet samples were extracted for lipid following the method of Folch et al. [12]. Fatty acid methyl esters (FAMEs) were prepared by transmethylation with boron trifluoride (BF_3) in methanol from lipids fractions according to Metcalfe et al. [13]. The fatty acid methyl esters were quantified by injecting 1 µL (30:1 split ratio) into a Gas Chromatograph (GC). The oven temperature was programmed from an initial temperature at 150 °C (35 min hold) rising to 220 °C at 30 °C min^{-1} and held isothermal (220 °C) for 5 min. Nitrogen gas used as a carrier gas at a flow rate of 2 mL min^{-1}. The injection port and the flame ionization detector were maintained at 275 °C. GC operating software "Chromcard" was used. Identification was made by comparison of retention times to those of standards (SUPELCO, Cat. No. 18919-1AMP) and quantified by comparing with respective peak areas.

Amino Acid Analysis

Acid Hydrolysis

The hydrolysis of fish muscle proteins was carried out with 6N HCl at 110 °C under nitrogen atmosphere for 24 h. The amino acids were analyzed by HPLC according to Ishida et al. [14] using amino acid analyzer (Shimadzu LC 10AS). The used column, detector and software were C-18 polystyrene column, FL 6A fluorescence detector and CR6A Chrom Pac recorder respectively. Amino acid standard solutions (Sigma-Aldrich, A2161-5ML) were used to calibrate the analyzer and to calculate the amount of amino acids in the samples.

Alkaline Hydrolysis

For the tryptophan analysis, samples were digested with 5 % NaOH for 24 h and were then neutralized to pH 7.0 with 6N HCl. Tryptophan content was measured spectrophotometrically at 530 nm as per Sastry and Tammuru [15].

Mineral Analysis

Samples were dissolved and oxidized by suprapure HNO_3 (E. Merck) in microwave oven (MDS-Anton Paar, Multiwave 3000) under controlled pressure. Homogenized powders (0.5 g) were weighted in glass digestion bombs and 3 mL suprapure HNO_3 was added to the samples. The bombs were firmly closed and put in the microwave oven for digestion. After digestion and cooling, the mineralized samples were diluted to 50 mL with milliQ water. The micro minerals iron, copper, zinc, manganese, arsenic and mercury were directly analyzed in ICP-MS (Thermo, X series 2). The macro elements were analyzed after appropriately diluting the mineralized samples. Quantification was done by comparing with multi elemental standard (1.09494.0100 and 1.09492.0100, E. Merck).

Vitamins

Oil was extracted from fresh meat (described earlier). About 150 mg fish oil was refluxed with 25 mL methanol and 150 % potassium hydroxide (KOH) in water bath for 30 min. Fat soluble vitamins were extracted with 50 mL petroleum ether. The petroleum ether layer was collected, concentrated and dissolved in 5 mL acetonitrile. Fat soluble vitamins were analyzed by injecting 20 µL of sample in HPLC (Shimadzu LC 10AS) equipped with C_{18} RP column and UV detector. The mobile phase of HPLC consists of acetonitrile (solvent A) and methanol (solvent B). A simple linear gradient system was used, starting from (solvent A/solvent B) 50/50 to 70/30 in 20 min. The mobile phase flow rate was 1 mL min^{-1}. The fat soluble vitamins were identified and quantified by comparing with the retention times and peak area of respective vitamins standards (Sigma-Aldrich)[16].

Statistical Analysis

All data are presented as average ± standard deviation. Student's *t*-test was employed to establish significant differences between means and standard deviation with 95(%) confidence level and correlations were estimated using *p*-value; $p < 0.05$.

Results and Discussion

Proximate Composition

Proximate composition of *S. seenghala* is presented in Table 1. All the data have been expressed in percentage on wet weight basis of minced fish flesh. The moisture, crude protein, crude fat and ash content were estimated to be 79.40 ± 0.09, 20.06 ± 1.13, 1.40 ± 0.79 and 0.90 ± 0.08%, respectively. Moisture content of *S. seenghala* is similar to that of catfish *Wallago attu* (78.08 ± 0.43 %) [17] and wild type *Labeo rohita* (78.93 ± 0.32 %) [18]. The protein content of *S. seenghala* is higher than that of many other catfishes like *Mystus vittatus* (15.62 ± 0.32 %), *Clarius batrachus* (14.78 ± 0.63 %), *W. attu* (17.00 ± 0.12 %) and is similar to bagridae catfish *Sperata aor* (19.05 ± 0.28 %) [17, 19]. Crude fat content of *S. seenghala* was found to be 1.40 ± 0.79 %, which is very low as compared to other catfishes such as *H. fossilis* (3.45 ± 0.92 %), *C. batrachus* (7.90 ± 1.91 %), *M. vittatus* (7.53 ± 1.10 %) [19], Indian major carp *L. rohita* (4.33 ± 0.08) [18], small indigenous fish *P. sophore* (5.59 ± 4.09 in male and 4.13 ± 2.25 in female) [20]. However, the crude fat content of *S. seenghala* is similar to that of its close relative *S. aor* (1.78 ± 0.21 %) [17]. As the crude fat content of *S. seenghala* was found to be quite low (1.40 ± 0.79 %) in comparison to many other large fishes, we analyzed the proximate composition of this fish without removing skin to cross-check the low value for crude fat. Crude fat content of this fish meat with skin was found to be 1.69 ± 0.49 % which is slightly higher than the deskinned meat, as expected. However, it reconfirmed the low fat content of this catfish.

The high protein and low fat content of *S. seenghala* indicates that this catfish can be exploited as a good source of lean meat, which has a good demand. The importance of fish in providing easily digested protein of high biological value is well documented. In comparison to the sources of dietary proteins of other animal origin the unit cost of production of fish is much cheaper. Fish also come in a wide range of prices making it affordable to the poor. A common man can afford to meet the family's dietary requirement of animal proteins because he has the option to choose from large number of fish species available [7]. A portion of fish provides with one-third to one half of one's daily protein requirement. On a fresh weight basis, fish contains a good quantity of protein, about 18–20 %. This explains how fish plays an important role in protein-calorie malnutrition. In the past this has served as a justification for promoting fisheries and aquaculture activities in several countries.

Table 1 Proximate composition of edible muscle tissue of *S. seenghala* (Sykes)

Proximate composition	Content (g 100 g^{-1} wet tissue)
Moisture	79.4 ± 0.09
Crude protein	20.06 ± 1.13
Crude fat	1.40 ± 0.79
Ash	0.90 ± 0.08

Values are shown as means ± standard deviation ($n = 20$)

Amino Acids

The amino acid profile of *S. seenghala* is presented (Table 2). All the data have been expressed in percentage of total area of amino acids. The predominant amino acids

Table 2 Amino acid composition (% of total area) of *S. seenghala*

Amino acids	% of total area
Essential	
Thr	9.21 ± 0.26
Val	6.07 ± 0.33
Iso	6.37 ± 0.46
Leu	9.12 ± 0.61
Phe	4.31 ± 0.30
His	9.34 ± 4.12
Lys	0.93 ± 0.08
Met	1.74 ± 0.30
Trp	1.30 ± 0.27[a]
∑EAA	47.09 ± 1.49
Non-essential	
Asp	12.98 ± 0.13
Ser	7.17 ± 1.16
Glu	16.90 ± 0.26
Pro	1.98 ± 0.12
Gly	6.70 ± 0.68
Ala	4.44 ± 0.29
Cys	nd#
Arg	1.38 ± 0.04
Tyr	1.36 ± 0.27
∑NEAA	52.91 ± 0.61
EAA/NEAA	0.89

Values are shown as means ± standard deviation ($n = 6$)

Due to very low concentration not detected by HPLC

EAA Essential amino acids, *NEAA* non-essential amino acids

[a] Value is expressed as mg 100 g^{-1} of wet sample and not included in ΣEAA

found in *S. seenghala* flesh are glutamic acid (16.90 ± 0.26 %) followed by aspartic acid (12.98 ± 0.13 %), histidine (9.34 ± 4.12 %), threonine (9.21 ± 0.26 %) and leucine (9.12 ± 0.61 %). Amino acids like lysine (0.93 ± 0.08 %), proline (1.98 ± 0.12 %), tyrosine (1.36 ± 0.27 %), arginine (1.38 ± 0.04 %) and methionine (1.74 ± 0.30 %) were low with respect to other amino acids. *Sperata seenghala* contains higher amount of essential amino acids (EAA) histidine, threonine, isoleucine, valine and leucine than *C. striatus*, the important murrel known for its therapeutic values owing to its richness in many important amino acids and bioactive substances[21, 22]. Tryptophan content was estimated as 13.0 ± 0.27 mg kg^{-1} of freshly minced meat which is higher than that of *C. carpio* [23]. Among the EAA, histidine, threonine and leucine are predominant and the non-essential amino acids (NEAA) like glutamic acid, aspartic acid and serine are present in higher concentration.

Amino acids are the building blocks of body proteins that are responsible for growth, repair and maintenance of cell [24]. The primary purpose of dietary protein is to provide amino acids for the biosynthesis of the body proteins. For optimal protein synthesis, all essential amino acids should be supplied to the tissues in an appropriate amount. Fish proteins contain all the essential amino acids as required for human nutrition and thus, improve the overall protein quality of a diet [23].

EAA to NEAA ratio is an index to determine the quality of the protein [25]. Optimal EAA to NEAA ratio has been reported in gilthead seabream (*Sparus aurata*) which is 0.71 and signify a high quality protein; on the other hand a very high ratio was recorded in squid roe (0.93) and a low value was reported in sea urchin roe (0.65) [26]. Studies in mature and immature salmon showed that mature salmon roe exhibits a moderately higher ratio of EAA and NEAA (0.84) as compared to immature one (0.78) [27]. We calculated the essential to nonessential-amino acids (EAA/NEAA) of *S. seenghala*, from the river Ganga, to be 0.89. The higher value is indicative of the superior protein quality of this important member of the bagridae family.

Fatty Acids

Fatty acid compositions of muscle tissues of *S. seenghala* are presented (Table 3). The data have been expressed in percentage of total area of fatty acids. Thirty-one different fatty acids have been identified in edible portion of *S. seenghala.* The total saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and PUFAs were 36.08 ± 2.17, 28.36 ± 1.75 and 35.53 ± 1.51 %, respectively. The principal fatty acids content of SFA, MUFA, ω-3 PUFA and ω-6 PUFA were palmitic acid 21.10 ± 6.93 %, oleic acid 20.46 ± 4.61 %, docosahexaenoic acid 6.19 ± 1.94 % and arachidonic acid 9.82 ± 3.01 % respectively**.** These four fatty acids represent 57.57 ± 2.63 % of total area. SFA content was lesser in *S. seenghala* than *C*. punctatus [22]. Fish serves as a health food for the affluent world owing to rich content of unsaturated fatty acids in the fish oils. Clinically important fatty acid eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)

Table 3 Fatty acid composition (% of total area) of *S. seenghala*

Fatty acids	% of total area
SFA	
8:0	0.08 ± 0.02
10:0	0.04 ± 0.01
12:0	0.59 ± 0.35
13:0	0.14 ± 0.01
14:0	7.09 ± 2.85
15:0	2.61 ± 0.49
16:0	21.10 ± 6.93
17:0	2.75 ± 0.09
18:0	0.17 ± 0.08
20:0	0.75 ± 0.26
22:0	0.37 ± 0.31
24:0	0.39 ± 0.19
∑SFA	36.08 ± 2.17
MUFA	
14:1	0.31 ± 0.13
15:1	0.11 ± 0.04
16:1	1.32 ± 0.43
17:1	1.86 ± 0.65
18:1	20.46 ± 4.61
20:1	1.98 ± 1.35
22:1	1.80 ± 0.96
24:1	0.52 ± 0.04
∑MUFA	28.36 ± 1.75
PUFA	
18:2 ω-3	3.72 ± 0.86
18:3 ω-3	4.75 ± 1.63
20:3 ω-3	0.98 ± 0.67
20:5 ω-3	4.37 ± 2.58
22:6 ω-3	6.19 ± 1.94
18:2 ω-6	0.74 ± 0.38
18:3 ω-6	1.38 ± 0.47
20:2 ω-6	1.33 ± 0.94
20:3 ω-6	2.21 ± 0.62
22:2 ω-6	0.04 ± 0.00
20:4 ω-6	9.82 ± 3.01
∑PUFA	35.53 ± 1.51
Σ ω-3 PUFA	20.01 ± 1.69
Σ ω-6 PUFA	15.52 ± 1.33
ω-3:ω-6 PUFA	1. 29:1
EPA + DHA	10.56 ± 2.28

Values are shown as means ± standard deviation ($n = 6$)

were present (4.37 ± 2.58 % and 6.19 ± 1.94 %, respectively). EPA plus DHA, the important ω-3 PUFAs content of *S. seenghala* is 10.56 ± 2.28 % (Table 3).

Minerals

The mineral profiles of *S. seenghala* are presented in Table 4. Data has also been compared with other important fish species available from other studies. The macro minerals sodium, potassium and calcium contents of raw edible fish were recorded to be 1983.11 ± 12.91, 13780.01 ± 65.99 and 4581.15 ± 34.76 mg kg^{-1} wet flesh, respectively. The potassium content *S. seenghala* (13780.01 mg kg^{-1}) is almost two times higher than that of nutrient-dense small indigenous fish *Puntius stigma* (male 7190.0 mg kg^{-1}, female 6550.0 mg kg^{-1}) [20].

The calcium content of *S. seenghala* is 4581.15 ± 34.76 mg kg^{-1} which is higher than that of the major carps *Labeo rohita* (862.8 mg kg^{-1}), *C. mrigala* (3521.0 mg kg^{-1}), and *L. calbasu* (3185.0 mg kg^{-1}) [28], respectively. Calcium level is even higher than the micronutrient rich murrel *C. punctatus* [28]. It is well known that the calcium is very much necessary for normal functioning of muscle, nervous system and strong bones (formation and mineralization). The intake of calcium, phosphorous and fluorine is higher when small fish are eaten with their bones rather than when the fish bones are discarded [5]. Deficiency of calcium is associated with rickets in young children and osteomalacia (softening of bones) in adults and older people. So richness of *S. seenghala* in calcium is a boon to poor and landless fisher folks whose livelihood and nutrition fully depend on the riverine catch.

Micro minerals like iron, zinc, magnesium, manganese and copper were found to be 45.1 ± 5.17, 29.4 ± 3.64, 1200 ± 11.87, 2.36 ± 1.06 and 5.29 ± 2.03 mg kg^{-1}, respectively. Zinc is an important micronutrient that is required for growth and development as well as the proper functioning of immune system, cell growth and healthy skin. Zn content was found to be higher as compared to that of the major carps *L. rohita* (0.84 ± 0.22 mg kg^{-1}) [29], *C. cirrhosus* (15.0 ± 0.1 mg kg^{-1}) and *Channa punctatus* (15.0 ± 0.2 mg kg^{-1}) [30]. Zn content of *S. seenghala* is comparable with the nutrient-dense *Amblypharyngodon mola* (32.0 ± 0.4 mg kg^{-1}) [6] and other SIF *Puntius sophore* (31.0 ± 0.5 mg kg^{-1}) [30]. Zn is required for most body processes as it occurs together with proteins in essential enzymes required for metabolism. It also has a role in cell division, cell growth, wound healing and the breakdown of carbohydrates and is needed for the senses of smell and taste. Zn deficiency is associated with poor growth, skin problems and loss of hair among other problems.

Iron content of *S. seenghala* is 45.1 ± 5.17 mg kg^{-1}. This is very high in comparison to Indian major carps *L. rohita* (14.0 mg kg^{-1}), *C. mrigala* (11.0 mg kg^{-1}), *L. calbasu* (09.0 mg kg^{-1}) and *C. catla* (10.0 mg kg^{-1}) [28] and even higher than that of the murrel *C. punctatus* (20.0 mg kg^{-1}) which is an important species known for its richness in micronutrients [28]. Thus the high iron content makes this species nutritionally superior as such consumers have a strong perception that this fish is highly nutritious and thus is market demand for this fish. This fish fetches 2–3 times as compared to the major carps. Iron is essential for synthesis of hemoglobin in red blood cells which is important for transporting oxygen to all parts of the body. Iron deficiency is associated with anemia, impaired brain function and in infants is associated with poor learning ability and poor behavior. Due to its role in the immune system, its deficiency may also be associated with increased risk of infection [31]. Compared to other animal sources, although fish contains less iron than the amount found in red meat, iron in white fish is well absorbed and so is a useful source of iron. However, on a wet weight basis, shellfish contains as much iron as lean meat. The minerals profile of catfish *S. seenghala* indicates that the fish is richer in zinc, iron and calcium in comparison to many carps and catfishes (Table 4).

Arsenic is a toxic environmental contaminant and a potential human carcinogen [32]. Similarly, mercury is a heavy metal which causes mercury toxicity [33]. We found arsenic content in *S. seenghala* to be 0.08 ± 0.03 mg kg^{-1}, which is much below the prescribed permissible level according to the Joint FAO/WHO Expert Committee [34] of arsenic in fish flesh (0.1 mg kg^{-1}) [35]. The WHO prescribed permissible level of mercury content in fish is 0.50 mg kg^{-1} [36]. The mercury content in *S. seenghala* was determined to be 0.03 ± 0.02 mg kg^{-1}, which is well within the safety limits.

Table 4 Mineral composition of *S. seenghala*

Minerals	Content (mg kg^{-1})
Na	1983.11 ± 12.91
K	13780.01 ± 65.99
Fe	45.1 ± 5.17
Zn	29.4 ± 3.64
Ca	4581.15 ± 34.76
Mg	1200 ± 11.87
Mn	2.36 ± 1.06
Cu	5.29 ± 0.03
As	0.08 ± 0.03
Hg	0.03 ± 0.02

Values are shown as means ± standard deviation ($n = 6$)

Vitamins

Fat soluble vitamin profiles of *S. seenghala* are presented in Table 5. Fish is a good source of vitamins likes A, D, E and K. The vitamin profile shows that vitamin A, D, E, K in *S. seenghala* was 1687.35, 18737.51, 8654.25 and 16670 μg kg^{-1}, respectively. The vitamin A content of *S. seenghala* is higher than that of *Anabas testudineus* (281.7 μg kg^{-1}) [37]. Vitamin A from fish is more readily available to the body than from plant source [38]. It is well known that vitamin A is required for normal vision and for bone growth. Vitamin A derivative retinoic acid regulates gene expression in the development of epithelial tissue [30]. The vitamin E content of *S. seenghala* is also higher than that of *A. testudineus* (6363.63 μg kg^{-1}) [37]. Vitamin E is an indispensable nutrient required to maintain flesh quality, immunity, normal resistance of red blood corpuscles to haemolysis, permeability of capillaries and heart muscle [39]. Vitamin E functions as lipid soluble antioxidants and protects biological membranes, lipoproteins and lipid stores against oxidation. Its main function is to protect unsaturated fatty acids against free radical-mediated oxidation [40].

Bagridae family, comprising of 27 genera (six in Indian region), is widely distributed in Asia and Africa [9]. Some species of this family are kept as aquarium fishes, while others like *S. seenghala* and *S. aor* are very large and important as food fishes. These are among the well marketable freshwater fishes in South-East Asia, because of their tasty flesh and lesser bones. Catfishes are in great demand in domestic markets, but catfish aquaculture has not yet been developed in India [41] and entire demand of these fishes is met through natural riverine resources. Riverine fisheries of the plains in India support the fisheries of several fishes like IMCs *L. rohita*, *C. catla* [42] and among bagrid catfishes, *S. seenghala* and *S. aor* are the major ones. *S. seenghala* and *S. aor* are among the potential species of catfishes for future aquaculture plans as they fetch higher price as compared to carps [41, 42].

Under nutrition, malnutrition and starvation and resultant mortality are the major problems of developing and under-developed countries. Fish, being one of the cheapest sources of animal proteins, is playing an important role in preventing the protein-calorie malnutrition. *S. seenghala* is a highly preferred food fish; because of its tasty flesh and less number of intramuscular bones [41], it has the potential to be used in fast food industry. Moreover, low fat and high protein content along with high zinc, iron, potassium and calcium makes this species nutritious. The information on nutrient profile of *S. seenghala* generated indicates if this species is domesticated and brought into aquaculture, it can play an important role in preventing protein-calorie malnutrition prevalent in the underprivileged population, including fisherman community.

Table 5 Fat-soluble vitamin profiles of *Sperata seenghala*

Vitamin	Content (μg kg^{-1})
A	1687.35
D	18737.51
E	8654.25
K	16670.12

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