SEASONAL VARIATION IN THE AMINO ACID COMPOSITION OF THREE AIR BREATHING FISHES OF LOKTAK LAKE OF MANIPUR, INDIA

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Abstract. *The proximate composition and amino acid profile of three important air breathing fishes Anabas testudineus, Clarias batrachus and Channa punctata of Loktak lake were determined for different seasons. Major components like moisture, protein and ash were determined using AOAC (2000) and lipid by Singh et al, (1990). Amino acids were analyzed following the methods of Ishida et al. (1981). Moisture content showed no significant variation in Clarias batrachus and Channa punctata. All the three fishes showed variation in the Protein value in all the seasons. Lipid values were recorded higher in Winter season in Clarias batrachus and Channa punctata. Higher Ash values were recorded in all the three fishes. All the three fishes had recorded higher content of histidine, lysine, serine and glutamic acid in post-monsoon season. Asparagine and Hydroxyproline were not detected. The most abundant amino acids in all the three air-breathing fishes throughout the year were Lysine, Alanine, Glycine and Phenylalanine. Essential Amino acids like Isoleucine, Leucine, Threonine and Non-essential amino acids like Aspartic acid, Arginine, Serine, Glutamine and Tyrosine are detected in lesser amount in all the three fish samples. Therefore, Anabas testudineus, Clarias batrachus and Channa punctata of Loktak lake is a good sources of nutrients.*

Keywords*: air breathing fishes, amino acids, Loktak lake, nutrients, proximate composition, seasonal variations.*

1. INTRODUCTION

Fish is an important food source globally consumed by majority of the populace. Fish plays an important role in food security in underdeveloped countries in both rural and urban areas. Fish is rich in protein, lipids, minerals, vitamins, fatty acids and amino acids, etc. The analysis of the major constituents (i.e., proximate composition) of fishes is necessary for providing information of the concentrations of protein, lipid, ash and moisture of the particular species. And, the contents of proximate composition are traditionally used as indicators of the nutritional value of fish [41].The taste of fish meat is closely related to the protein and fat content, and also the seasonal variations of these components are important determinant of both consumer choice and quality of the processed product [11]. Among the fish protein, 85-95% is digestible part which contains all dietary essential amino acid [20].

Amino acids are the major protein constituents responsible for the synthesis of most body tissues, enzymes, hormones and other metabolic molecules [28]. Fish muscle tissue is the main element for human food containing important amino acids necessary in human diet having an essential impact on growth, maintenances process, inflammation and wound healing and a unique source of physiological beneficial amino acids [14, 44, 31]. Certain amino acids like aspartic acid, glycine and glutamic acid are also known to play a key role in the process of wound healing [42]. 50-80% of the non-protein nitrogenous compounds in fish are amino acids and significant amounts of these are proline, arginine, lysine, alanine, histidine, glutamic acid and taurine [11].

Many workers has reported that nutrient composition of fish often appear to vary from season to season and the variation in the chemical composition of fish is related with their age, sex, maturity, seasons, environmental changes, etc. [20, 8, 10]. There are reports on biochemical composition of freshwater fishes from different parts of India [21, 17, 30, 32, 31] but no reports so far on seasonal variation of nutritional properties of air breathing fishes of Loktak lake of Manipur. The Present study is on the seasonal variation in the proximate and amino acid composition of three air breathing fishes; *Anabas testudineus*, *Clarias batrachus* and *Channa punctata* of Loktak lake and the findings could be helpful to nutritionists, dieticians, researchers, fish farmer, etc for future references.

2. MATERIALS & METHODS

2.1 STUDY SITE AND SAMPLE COLLECTION

The live fish samples were collected from the Loktak lake with the help of local fisherman. The samples were collected during the Pre-monsoon (March–May) Monsoon (May – August), Post-monsoon (September – November) and Winter (December – February) seasons of 2017 and 2018. The sample fish were brought to the Fishery Laboratory, Life Sciences Department (Zoology), Manipur University. Six numbers of *Anabas testudineus*, *Clarias batrachus* and *Channa punctata* of similar weight of about 70-80g, 125-155g and 80-90g and standard length of about 16-18cm, 24.5-27cm and 16-18.5cm respectively were used for different seasons. The fishes were washed thoroughly with running tap water, beheaded, eviscerated and the edible muscle parts were taken for various analyses.

2.2 PROXIMATE COMPOSITION ANALYSIS

Moisture content was determined by hot air oven method [5] at 60˚C till a constant weight is obtained. Total Nitrogen content was determined by using modified Micro-Kjeldahl's method [5]. The samples were subjected to digestion,

nesslerization and finally absorbance were measured in 440 nm by using Eppendorf BioSpectrometer. Total protein was obtained by multiplying the nitrogen value with 6.25 [29]. Total lipid content was determined as per the modified method of [39] by extraction with chloroform and Methanol in the ratio of 2:1. Ash content was determined by igniting the moisture free sample at 550˚C in a Muffle furnace for about 2-3 hours to obtained carbon free white ash as described by [5].

2.3 AMINO ACID ANALYSIS

Amino acid analysis was done following the methods of [19]. 100mg of sample was taken in a test tube and 6N HCl was added to it. The tube was filled with nitrogen gas and sealed and allowed to digest at 110˚C for 24 hours. The test tubes were cooled and then digested samples were filtered. The filtrates were evaporated to dryness by using vacuum evaporator. 10ml of Millipore water was added and evaporation was continued until the samples were acid free. Then, the acid free samples, containing free amino acids were dissolved in 10 ml of 0.05M HCl.

The digested samples were filtered by passing through Whatman filter paper no. 42 (0.45µm pore size). 20µl of this filtrate was injected through the sample loop of HPLC, fitted with a packed column (C18 reverse phase; ISC-07/51504-Na) of length 19 cm and diameter 5 mm. oven temperatutre was adjusted for 60˚C. The amino acids were detected by Spectroflurometer after post column derivatization with ophthaldehyde at the wavelength of 338 nm.

2.4 STATISTICAL ANALYSIS

The samples were analyzed using one way-ANOVA and the significant mean were compared by Duncan's multiple range tests ($P<0.05$). Data were analzed using SPSS package (version 16.0) [40].

3. RESULTS AND DISCUSSIONS

The proximate composition of three air breathing fishes *Anabas testudineus*, *Clarias batrachus* and *Channa punctata* are shown in Fig 1, 2 and 3.

In *Anabas testudineus*, moisture content ranges from 77.60±0.13−78.48±0.11% and showed no significant variation among Pre-monsoon, Monsoon and Winter season (Fig.1). In *Clarias batrachus*, moisture values ranges from 78.88±0.32−79.15±0.23% and no significant variation in moisture content was observed in all the season (Fig.2).

In *Channa punctata*, moisture content showed no significant variation in all the seasons and moisture value ranges from 80.26±0.16−80.71±0.23% (Fig.3). The moisture content in the fish muscle of all the three air-breathing fishes were within the acceptable range (60−80%). The reason might be due to the stable water levels in the environment from where the fishes were collected. [33], reported that the moisture content of some freshwater fishes of Manipur were in the range of 71.00−80.00%. [21] also reported that the moisture content of 25 different freshwater fishes were in the range of 73−82%. Among the three fish sample *Channa punctata* was recorded with highest moisture content which implies the flesh of *Channa punctata* has high water holding capacity. [7] stated that high moisture content could play important roles in metabolic reactions and also help in easily solubilize certain elements. The difference in moisture value of three air-breathing fishes might be due to difference in species, sex, feeding habits, spawning period, metabolic activities, etc.

In *Anabas testudineus*, protein content was recorded in the range of 6.43±0.45% to 12.86±0.57% and higher protein content was found in Post-monsoon season followed by Winter season. In *Clarias batrachus*, the protein content ranges from 8.06±1.24% to 15.83±0.14% and was recorded higher in Pre-monsoon season and lower in Winter season. In *Channa punctata*, the protein content ranges from 5.31±0.30% to 11.16±1.07% and was observed higher in Post-monsoon season and lower in Monsoon season. The difference in the value of protein might be attributed to difference in food

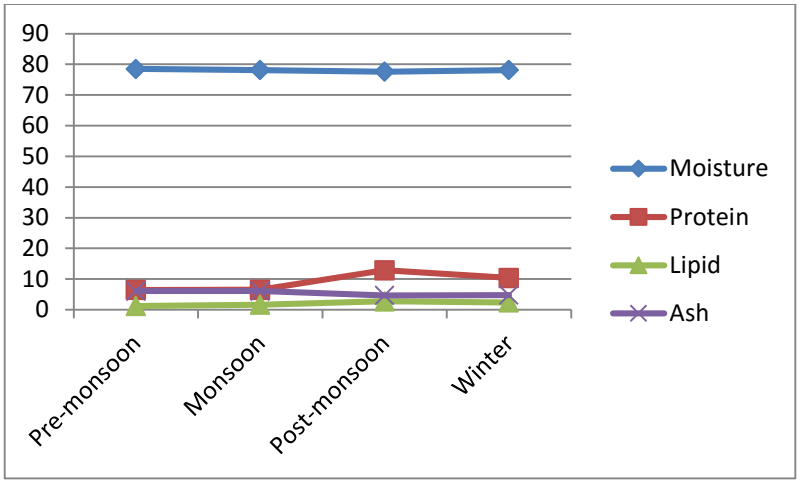

Fig:1: Moisture, Protein, Lipid and Ash content (%) of *Anabas testudineus* for four different seasons.

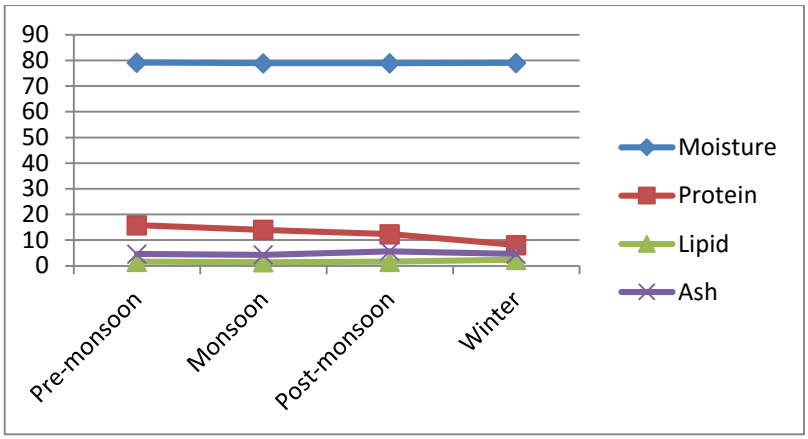

Fig.2: Moisture, Protein, Lipid and Ash content (%) of *Clarias batrachus* for four different seasons

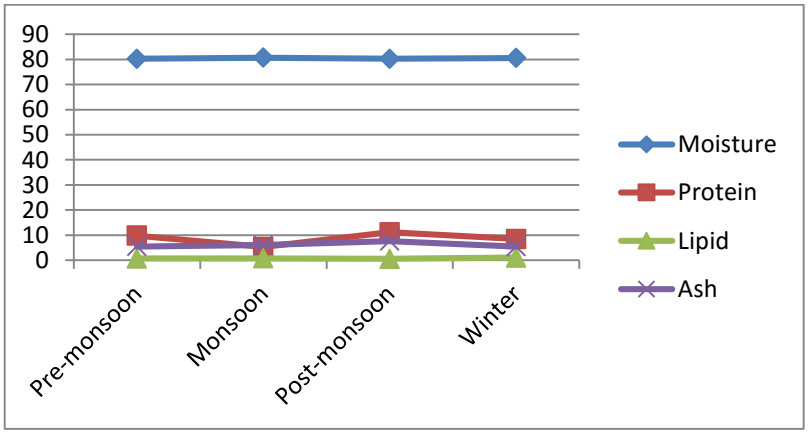

Fig.3: Moisture, Protein, Lipid and Ash content (%) of *Channa punctata* for four different seasons.

intake and availability of food, temperature and maturity. [16] also stated that, the variability in the content of protein in fish muscle depends on the abundance and availability of fish food and there is an opposite relationship among protein and moisture content. According to [43]; [37], the decrease in the muscle protein during Winter season might be due to cold climatic condition of the study area and less food intake due to shortening of the daytime.

In *Anabas testudineus*, lipid value was recorded in the ranges from 1.21±0.20% to 2.75±0.15% and higher lipid content was recorded in Post-monsoon followed by Winter

season. In *Clarias batrachus,* the lipid content showed no significant variation among Pre-monsoon, Monsoon season and Post-monsoon season, and higher lipid content was found in Winter season (Fig 2). In *Channa punctata*, the lipid content showed no significant variation among Pre-monsoon, Monsoon season and Post-monsoon season and higher lipid content was found in Winter season (Fig 3). Variation in the lipid values might be due to poor storage mechanism and the used of the fat reserves during spawning activities. According to the classification given by [1], *Anabas testudineus* and *Clarias batrachus* can be grouped into low fat fish (2-4%) and *Channa punctata* into lean fish (<2%).

In *Anabas testudineus*, ash values ranges from 4.7±0.28% to 6.1±0.07% and higher ash content was recorded in Monsoon season. In *Clarias batrachus*, ash values ranges from 4.3±0.42% to 5.65±0.35% and higher value was observed in Post-monsoon season. The ash content of *Channa punctata* showed significant variation among Monsoon, Post-monsoon and Winter, and higher ash content was observed in Post-monsoon season (Fig 3). Higher ash content in the three fishes shows that they are a good source of minerals like Na, K, Ca, Zn, Fe, etc. Higher ash content observed during Monsoon and Post-monsoon season of the year might attribute towards a higher mineral metabolism during this period.

Amino acid content of the three air breathing fish *Anabas testudineus*, *Clarias batrachus* and *Channa punctata* are shown in Table 1, 2 and 3 respectively. Significant variations were observed in all the seasons among the three samples and within the same species also.

In *Anabas testudineus*, out of 21 amino acids analyzed, 7 Essential amino acids and 8 Non-essential amino acids were detected (Table 1) and amino acids were abundant in Post-monsoon and less in Pre-monsoon season. In *Clarias batrachus*, out of 21 amino acid analyzed, 6 Essential amino acids and 8 Non-essential amino acids were detected (Table 2) and amino acids were abundant in Post-monsoon and less in Pre-monsoon season and in *Channa punctata*, out of 21 amino acids analyzed 6 Essential amino acids and 8 Non-essential amino acids were detected (Table 3) and amino acids were abundant in Winter and less in Post-monsoon season. Most of the EAAs and NAAs of the three fishes were found higher in the Post-monsoon season than in the other three seasons which is in agreement with the study of [12]. However, it was not similar with that of [32] in *Anabas testudineus* and *Clarias batrachus* for Pre-monsoon and Post-monsoon seasons.

Amino acids content in all the three fishes were detected in small amount as compare to the amino acids content reported by other workers: [38, 13, 22, 12].

Minimal quantity of amino acids were also detected by [25 in the muscle tissues of *L. niloticus, B. bayad, O. niloticus, S. schall and Tetraodon lineatus*; [23]; [32] in *Monopterus cuchia* ; [11].

All the three fishes had recorded higher content of histidine, lysine, serine and glutamic acid in post-monsoon season. Presence of high level of histidine will contribute to better taste [17]. Lysine helps the body to absorb calcium and plays an important role in the formation of collagen. Lysine is an essential amino acid which is extensively required for optimal growth and its deficiency leads to immunodeficiency [9]. Serine is important in metabolism and participates in the biosynthesis of proteins, cysteine, glycine, purines and pyrimidines. It is also being used for the treatment of schizophrenia [27]. Glutamic acid plays an important role in amino acid metabolism because of its role in transamination reactions and is necessary for the synthesis of glutathione which are required for removal of highly toxic peroxides and the polyglutamate folate cofactors [27]. Freshwater species may be a good source of glutamic acid [34].

The most abundant amino acids in all the three air breathing fishes throughout the year were lysine, alanine, glycine and phenylalanine. Some amino acids like glutamic acid, glycine and alanine are related to flavor of fish [11]. Alanine is involved in sugar and acid metabolism, increase immunity and provides energy for muscles tissue, brain and the central nervous system. Glycine is an important component of the human skin collagen that combines with aspartic and glutamic acids to form a

Table 1. Amino acids profile (mg/100g) of *Anabas testudineus* for different seasons.

Particular	Pre-monsoon	Monsoon	Post-monsoon	Winter
Essential Amino Acids				
Histidine	0.020±0.000[a]	0.046±0.002[b]	**0.132±0.001[d]**	0.082±0.000[c]
Isoleucine	0.039±0.000[b]	**0.040±0.002[b]**	0.038±0.000	0.035±0.000[a]
Leucine	0.189±0.000[c]	0.181±0.002[b]	**0.201±0.000[d]**	0.146±0.002[a]
Lysine	0.130±0.000[a]	0.168±0.002[b]	**0.336±0.001[d]**	0.207±0.000[c]
Metheonine	ND	ND	ND	ND
Phenylalanine	**0.519±0.001[d]**	0.033±0.001[a]	0.054±0.000[c]	0.038±0.000[b]
Threonine	0.099±0.000[b]	0.100±0.001[b]	0.082±0.000[a]	**0.142±0.002[c]**
Valine	0.092±0.000[a]	ND	**0.570±0.001[b]**	ND
Tryptophan	ND	ND	ND	ND

Non-essential amino acids				
Alanine	0.761±0.000[a]	0.973±0.002[c]	**1.038±0.001[d]**	0.924±0.000[b]
Aspartic acid	0.212±0.00[a]	0.222±0.002[b]	**0.334±0.000[d]**	0.256±0.000[c]
Asparagine	ND	ND	ND	ND
Arginine	0.146±0.002[a]	0.218±0.000[c]	**0.289±0.000[d]**	0.176±0.000[b]
Serine	0.147±0.000[a]	0.219±0.002[b]	**0.296±0.000[d]**	0.237±0.001[c]
Glutamic acid	0.396±0.002[c]	0.374±0.001[b]	**0.512±0.000[d]**	0.369±0.000[a]
Glutamine	0.072±0.000[b]	0.051±0.000[a]	**0.116±0.002[d]**	0.097±0.001[c]
Glycine	0.341±0.001[a]	0.428±0.002[b]	**0.798±0.000[d]**	0.630±0.000[c]
Tyrosine	0.112±0.000[a]	0.111±0.000[a]	**0.313±0.002[c]**	0.131±0.001[b]
Cysteine	ND	ND	ND	ND
Hydroxyproloine	ND	ND	ND	ND

ND- Not Detected
Values are mean of three replicates.
Means (±SD) followed the same letter are not significantly different (P≤0.05).

polypeptide, which is responsible for tissue growth and the healing of wounds [3]. Phenylalanine is the precursor of some hormones and the pigment melanin in hair, eyes and tanned skin [6]. [11], reported that the most abundant amino acids in his investigation in *Upeneus moluccensis* were lysine, leucine, aspartic acid, glutamic acid, alanine and glycine. [2] reported that lysine, arginine, leucine, glutamic acid, aspartic acid and glycine were the most abundant amino acid in his study in smoke fishes. [30], reported that lysine, leucine, threonine, phenylalanine, aspartic acid, glutamic acid and alanine were predominant in his investigation in *Tenualosa ilisha.* In the study conducted by [22] in *Mugil cephalus*, lysine, leucine, arginine, leucine, aspartic acid, glutamic acid and alanine were reported as the most abundant amino acids. [26], reported that the most abundant amino acids in four commercial Niles fishes in Sudan were glutamic acid, leucine, aspartic acid, alanine and glycine. As reported by [36, 11], fish body composition especially of fatty acids and amino acids were varied among the fishes and within the same species and the variability may depend on such factors as food availability, fishing location, fish size, maturity stage and biological variations, seasonal conditions, age and spawning season.

Asparagine and hydroxyproline were not detected in the present investigation. Absence of some amino acids like asparagines, glutamine and tryptophan could be as a result of acid hydrolysis [4] or oxidation as it destroys or chemically modifies asparagines, glutamine and tryptophan residues in protein while asparagines and glutamines are converted to their corresponding acids (aspartic and glutamic acids) and are quantified with them, tryptophan is completely destroyed or by the mere absence of these amino acids [34]. Protein

Table 2. Amino acids profile (mg/100g) of *Clarias batrachus* for different seasons.

Particular	Pre-monsoon	Monsoon	Post-monsoon	Winter
Essential Amino Acids				
Histidine	0.008±0.000[a]	0.097±0.002[c]	**0.122±0.002[d]**	0.091±0.002[b]
Isoleucine	ND	0.022±0.001[b]	0.017±0.002[a]	**0.029±0.002[c]**
Leucine	0.066±0.001[a]	0.111±0.002[b]	**0.148±0.002[d]**	0.121±0.000[c]
Lysine	0.021±0.000[a]	0.263±0.002[b]	**0.397±0.002[d]**	0.377±0.001[c]
Metheonine	ND	ND	ND	ND
Phenylalanine	ND	0.028±0.002[a]	**0.054±0.001[c]**	0.048±0.002[b]
Threonine	0.004±0.001[a]	**0.173±0.002[d]**	0.163±0.001[c]	0.131±0.002[b]
Valine	ND	ND	ND	ND
Tryptophan	ND	ND	ND	ND
Non-essential amino acids				
Alanine	0.038± 0.002[a]	**6.676±0.000[d]**	0.581±0.000[b]	0.622±0.001[c]
Aspartic acid	0.047±0.000[a]	0.270±0.000[c]	**0.291±0.001[d]**	0.201±0.000[b]
Asparagine	ND	ND	ND	ND
Arginine	0.016±0.000[a]	0.240±0.002[c]	0.224±0.001[b]	**0.260±0.000[d]**

Serine	0.017±0.000[a]	0.226±0.002[c]	**0.287±0.001[d]**	0.182±0.000[b]
Glutamic acid	0.033±0.000[a]	0.285± 0.002[b]	**0.379±0.001[d]**	0.307±0.000[c]
Glutamine	0.011±0.000[a]	0.097±0.001[c]	**0.122±0.002[d]**	0.084±0.000[b]
Glycine	0.026±0.000[a]	0.501±0.001[b]	**1.570±0.000[d]**	0.529±0.002[c]
Tyrosine	0.008±0.000[a]	0.111±0.000[b]	0.170±0.002[c]	**0.225±0.001[d]**
Cysteine	ND	ND	ND	ND
Hydroxyproline	ND	ND	ND	ND

ND- Not Detected
Values are mean of three replicates.
Means (±SD) followed the same letter are not significantly different (P≤0.05).

quality is determined by the assessment of the amino acids content and hence knowledge of the amino acid composition of foods serves as a basis for establishing their potential nutritive value [27]. Essential and non-essential amino acids ration in dietary protein has an important effect on protein utilization by fish [15]. Amino acids are associated with health issues and amino acid deficiencies lead to a number of diseases.

Essential amino acids like isoleucine, leucine, threonine and non-essential amino acids like aspartic acid, arginine, serine, glutamine and tyrosine are detected in lesser amount in all the three fish samples. Valine was detected only in *Anabas testudineus* in Pre-monsoon and Post-monsoon season. Leucine is the only dietary amino acid that can stimulate muscle protein synthesis and has important therapeutic role in stress conditions like burn, trauma and sepsis [27]. Threonine is used for treating various nervous system disorders including spinal spacticity, multiple sclerosis, familial spastic paraparesis and amyotrophic lateral sclerosis [18]. Valine is needed for the synthesis of proteins and also used as an energy fuel [24]. Arginine is essential for children's growth [2]. Aspartic acid, glutamine, proline, glycine and leucine have strong cytotoxic activity against cancer cells [35]. Tyrosine is an essential component for the production of several important brain chemicals called neurotransmitters, including epinephrine, norepinephrine and dopamine and also helps to produce melanin.

4. CONCLUSIONS

The present study shows the seasonal variations in the proximate composition and amino acids content of the three air breathing fishes *Anabas testudineus*, *Clarias batrachus* and *Channa punctata* of Loktak lake. The variation in the values might be influenced

Table 3. Amino acids profile (mg/100g) of *Channa punctata* for different seasons.

Particular	Pre-monsoon	Monsoon	Post-monsoon	Winter
Essential Amino Acids				
Histidine	0.051±0.000[b]	0.039±0.001[a]	**0.113±0.000[d]**	0.074±0.000[c]
Isoleucine	0.017±0.000[ab]	0.017±0.000[ab]	**0.019±0.002[b]**	0.016±0.001[a]
Leucine	0.051±0.000[a]	**0.108±0.002[d]**	0.100±0.001[c]	0.061±0.000[b]
Lysine	0.156±0.002[c]	0.133±0.001[b]	**0.345±0.005[d]**	0.101±0.000[a]
Metheonine	ND	ND	ND	ND
Phenylalanine	0.031±0.000[b]	0.039±0.002[c]	**0.042±0.001[d]**	0.029±0.000[a]
Threonine	0.092±0.000[a]	0.058±0.020[c]	**0.120±0.000[b]**	0.087±0.000[a]
Valine	ND	ND	ND	ND
Tryptophan	ND	ND	ND	ND
Non-essential amino acids				
Alanine	0.986±0.002[c]	0.858±0.000[b]	**1.019±0.000[d]**	0.774±0.000[a]
Aspartic acid	0.184±0.000[b]	0.178±0.001[a]	0.256±0.002[c]	**0.272±0.000[d]**
Asparagine	ND	ND	ND	ND
Arginine	0.161±0.000[b]	**0.288±0.002[d]**	0.258±0.001[c]	0.157±0.001[a]
Serine	0.168±0.002[a]	0.196±0.001[b]	**0.245±0.000[d]**	0.219±0.000[c]
Glutamic acid	0.296±0.002[b]	0.324±0.000[c]	**0.352±0.001[d]**	0.273±0.000[a]
Glutamine	0.056±0.002[b]	0.058±0.001[a]	**0.117±0.002[c]**	0.101±0.000[b]
Glycine	0.586±0.000[b]	0.484±0.002[a]	0.649±0.000[c]	**0.782±0.000[d]**
Tyrosine	**0.149±0.001[c]**	0.089±0.002[a]	ND	0.101±0.001[b]
Cysteine	ND	ND	ND	ND

Hydroxyproline	ND	ND	ND	ND

ND- Not Detected
Values are mean of three replicates.
Means (±SD) followed the same letter are not significantly different (P≤0.05).

by many factors such as seasons, species, maturity, age, sex, availability of food, environmental condition, pH, turbidity, etc. It may be concluded that these air breathing fishes are important food source of basic nutrients, protein, lipids and amino acids in all the seasons and is also able to compete with more commercially utilized species in terms of nutritional value and taste.

Moreover, further action is needed for conservation of such air breathing fishes. Unaware of their possible extinction, many habitats and feeding ground have been disturbed. Due to their unique taste, nutritive value and high demand, these air breathing fishes and their fingerlings have been sold in high price in the market. Therefore, specific government policies and research programmes are required for conservation of these air breathing fishes.

5.ACKNOWLEDGEMENT

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6. ABBREVIATION

L. niloticus: Labeo niloticus

B. bayad: Bagrus bayad

O. niloticus: Oreochromis niloticus

S. schall: Synodontis schall

7. REFERENCES

[1] Ackman R.G. (1989). *Nutritional composition of fats in seafood*. Progress in food & nutrition science. 13 (3-4),161-241.

[2] Adeyeye S. A. O., Fayemi O. E. and Adebayo-Oyetoro A. O. (2019). *Amino acid, vitamin and mineral profiles of smoked fish as affected by smoking methods and fish types.* Journal of Culinary Science & Technology. 17(3), 195-208.

[3] Aliyu-paiko M., Hashim R. and Amuzat A. O. (2012). *Comparison of the Whole body composition of fatty acids and amino acids between reared and wild snakehead fish Channa striata (Bloch 1793) Juveniles.* Asian Fisheries Science 25, 330-342.

[4] AOAC. (1990). *Official Methods of Analysis.* Association of Official Analytical Chemists.15th Edition. Arlington.

[5] AOAC (2000). *Official methods of Analysis*. 12th Edn. Assocoiation of Official Analytical Chemists, Washington D.C.

[6] Aremu M.O., Namo S.B., Salau R.B. Agbo C.O. and Ibrahim H. (2013). *Smoking Methods and Their Effects on Nutritional Value of African Catfish (Clarias gariepinus)*. The Open Nutraceuticals Journal. 6, 105-112.

[7] Ayanda I.O., Ekhator U.I., Bello O.A. (2019). *Determination of selected heavy metal and analysis of proximate composition in some fish species from Ogun River,* Southwestern Nigeria. Heliyon. 5 e02512.

[8] Boran G. and Karacam H. (2011). *Seasonal changes in proximate composition of some fish species from black sea*. Turk J. Fish Aquatic Soc. 11, 1-5.

[9] Chen C., Sander J.E. and Dale N.M.(2003). *The effect of dietary lysine deficiency on the immune response to Newcastle disease vaccination in Chickens.* Avians Diseases. 47(4), 1346-1351.

[10] Deka K.B., Mahanta R. and Goswami U. (2012). *Seasonal variation of protein and essential amino acid contents in Labeo gonius from Lotic and Lentic water bodies*. World J. Sci. Med. Res. 2, 71.

[11] Dogan G. and Ertan O. O. (2017). *Determination of amino acid and fatty acid composition of goldband goatfish [Upeneus moluccensis (Bleeker, 1855)] fishing from Gulf of Antalya (Turkey).* Int Aquat Res. 9, 313-327.

[12] Effiong B.N. and Mohammed I. (2008). *Effect of Seasonal variation on the nutrient composition in selected fish species in Lake Kainji Nigeria*. Nature and Science 6(2), 1-5.

[13] El Oudiani Guizani Salma and Mojahed Nizar (2015). *Atlantic Mackerel amino acids and minerals contents from the Tunisian Middle eastern coast.* International Journal of Agricultural policy and Research. 3(2), 77-83.

[14] Erkan N., Selcuk A. and Ozden O. (2010). *Amino acid and vitamin composition of raw and cooked Horse mackerel.* Food. Anal. Methods. 3, 269-275.

[15] Green J.A., Hardy R.W. and Brannon EL (2002). *The optimum dietary essential: nonessential amino acid ratio for rainbow trout (Oncorhynchus mykiss), which maximizes nitrogen retention and minimizes nitrogen excretion.* Fish. Phys. Biochem., 27, 1-2.

[16] Gulsun O. and Abdurrahman P. (2006). *Amino acid and fatty acid composition of wild sea bass (Dicentrarchus labrax): a seasonal differentiation.* European food research & technology. 222(3), 316-320.

[17] Hei A. and Sarojnalini Ch. (2012). *Proximate composition, Macro and Micro mineral elements of some smoke-dried hill stream fishes from Manipur, India.* Nature and Science. 10(1), 59-65.

[18] Hyland K. (2007). *Inherited disorders affecting dopamine and serotonin: critical neurotransmitters derived from aromatic amino acids.* Journal of Nutrition. 137(6), 1568-1572.

[19] Ishida Y., Fujita T. and Asai K. (1971). *New detection and separation method for amino acids by high-performance liquid chromatography*. Journal of chromatography. 204, 143-8.

[20] Islam M. N. and Joadder M. A. R. (2005). *Seasonal variation of the proximate composition of freshwater Gobi, Glossogobius guiris (Hamilton) from the River Padma.* Pakistan Journal of Biological Sciences. 8(4), 532-536.

[21] Jafri, A.K., D.K. Khawaja and S.Z. Qasim (1964). *Studies on the Biochemical Composition of some Freshwater fishes*.149-157.

[22] Kumaran R., Ravi V., Gunalan B., Murugan S. and Sundramanickam A. (2012). *Estimation of proximate, amino acids, fatty acids and mineral composition of mullet (Mugil cephalus) of Parangipettai, Southeast Coast of India.* Adv. Appl. Sci. Res., 3(4), 2015-2019.

[23] Lim L., Chor W. Firdaus R. F., Malitam L., Ransangan J. and Shapawi R. (2015). *Proximate and amino acid compositions of the pond-cultured spotted barb, Puntius binotatus.* Malaysian Journal of Science. 34(2), 168-171.

[24] Martin Kohlmeier (2003). *Nutrient metabolism.* Food Science and Technology, 370-377.

[25] Mohamed H. A. E., Al-Maqbaly R. and Mansour H. M. (2010). *Proximate composition, amino acid and mineral contents of five commercial Nile fishes in Sudan. African Journal of Food Science.* 4(10), 650-654.

[26] Mohammed M.O. and Alim D.I. (2012). *Amino acids contents of four commercial Nile fishes in Sudan.* African Journal of Environmental Science and Technology. 6(2), 142-145.

[27] Mohanty B., Arabinda Mahanty, Satabdi Ganguly, T.V. Sankar, kajal Chakraborty, Anandan rangasamy, Baidyanath Paul, Debajit sarma, Suseela Mathew, Kurukkan Kunnath Asha, Bijay Behera, Md. Aftabuddin, Dipesh Debnath, P. Vijayagopal, N. Sridhar, M.S. Akhtar, Neetu Sahi, Tandrima Mitra, Sudeshna banerjee, Prasenjit Paria, Debajeet Das, Pushpita Das, K.K. Vijayan, P.T. Laxmanan, and A.P. Sharma (2014). *Amino Acid composition of 27 Food Fishes and their Importance in Clinical Nutrition.* Journal of Amino Acids. 7 pages.

[28] Oluwaniyi O.O., Dosumu O.O. and Awolola GV (2010). *Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishescommonly consumed in Nigeria*. Food Chemistry.

[29] Osborne D.R. and Voogt T.P. (1978). *Analysis of nutrients in foods*. Academic Press, New York.

[30] Paul B.N., Bhowmick S., Singh P., Chanda S., Sridhar N. and Giri S.S. (2019). *Seasonal variations in proximate composition of nine freshwater fish.* Indian J. Anim. Nutr. 36(1), 65-72.

[31] Rahman M. (2021). *Estimation of Amino acids profile of Hilsa, Tenualosa ilisha in upper and lower reaches of Brahmaputra river during migration*. Journal of Global Biosciences. 10(1), 8266-8275.

[32] Rana S., Faruque Md. H., Eshik Md. M. E., Hasan Md. R. and Rahman M. S. (2019). *Seasonal variation in nutritional profile of the freshwater mud eel, Monopterus cuchia (Hamilton, 1822)*. Journal of Fisheries. 7(1), 671-680.

[33] Sarojnalini Ch. and Vishwanath W. (1988). *Nutritive value of some fishes endemic in Manipur*. Indian Journal of Fisheries. 35(2), 115-117.

[34] Saad H.A. and Alim D.I. (2014). *Amino Acids Profile of Some Economically Important Marine and Freshwater Fish From Sudan.* International Journal of Advanced Research. 3(2), 838-844.

[35] Sarma D., Das P.D., Das P., Bisht H.C.S., Akhtar M.S. and Ciji A. (2015). *Fatty acid, amino acid and mineral composition of rainbow trout (Oncorhynchus mykiss) of Indian Himalya.* Indian J. Anim. Res., 49(3), 399-404.

[36] Shearer K.D. (1994). *Factors affecting the proximate composition of cultured fishes with emphasis on salmonids.* Aquaculture, 119, 63-88.

[37] Shekhar C. (2004*). Changes in muscle biochemical composition of Labeo rohita (Ham) in relation to season.* Indian Journal of Fisheries 51(3), 319-323.

[38] SHI P. S., Wang Q., Zhu Y. T., Gu Q. H. and Xiong B. X. (2013). *Comparative study on muscle nutritional composition of juvenile bighead carp (Aristichthys nobilis) and paddlefish (Polyodon spathula) fed live feed*. Turkish Journal of Zoology. 37(3), 321-328.

[39] Singh M.B., Sarojnalini C. and Vishwanath W. (1990). *Nutritive values of sundried Esomus danricus and smoked Lepidocephalus guntea*. Food Chemistry. 36, 89-96.

[40] SPSS. (2008) *Statistical Package for Social Sciences Program*, Version 16.0 for Windows. Chicago, III, USA, SPSS Inc.

[41] Stansby, M.E. (1962). *Proximate composition of fish.* In Heen, R. and Kreuzer, R. (Eds): *Fish in Nutrition.* London Publ. News (Books) Ltd., 55.

[42] Tenyang N., Womeni H.M., Linder M., Tiencheu B., Villeneuve P. and Mbiapo F.T. (2014). *The chemical composition, fatty acid, amino acid profiles and mineral content of six fish species commercialize on the Wouri river coast in Cameroon.* La Rivista Italiana Delle Sostanze Grasse Grasse. 129-138.

[43] Yahya Bakhtiyar and Seema langer (2018). *Seasonal variation in the proximate body composition of Labeo rohita (Hamilton) from Gho-Manhasa Fish ponds.* Journal of Research & Deve;lopment. 18, 24-36.

[44] Zuraini A., Somchit M.N., Solihah M.H., Goh Y.M., Afrifah A.K., Zakaria M.S., Somchit N., Rajion M.A., Zakaria Z.A. and Mat Jais A.M. (2006). *Fatty acid and amino acid composition of three local Malaysian Channa Spp. Fish*. Food. Chem. 97, 674-678.