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RESEARCH ARTICLE

Amino Acids Profile of Some Economically Important Marine and Freshwater Fish from Sudan

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Abstract

Amino acids profile of Sudanese marine and freshwater commercial fish species was estimated. The freshwater fish species studied here were: *Oreochromis niloticus*, *Bagrus bayad* and *Lates niloticus* and the marine fish species were: *Plectropomus maculates*, *Lethrinus harak* and *Mugil cephalus*. Flesh of each sample was isolated and freeze dried, hydrolyzed by 6N HCl and amino acids profile determined using the amino acid analyzer model (SYKAM 57130). A total of 14 amino acids were reported in each of the marine and freshwater fish samples. The sum of essential amino acids percentage was 43.04% in marine species and 40.41% in freshwater species. Seven essential amino acids were detected. No significant variation was observed between marine and freshwater fish species except for histidine and isolucine which were found significantly higher in marine fishes. Among the nonessential amino acids, only alanine was found significantly higher in marine fish and specifically in *P. maculates*. Aspartic acid and glutamic acid were highest in the fresh water fish *L. niloticus*. Serine was highest in *M. cephalus*. Conditional essential amino acids revealed significantly high percentages of arginine in the marine fish species, especially *R. canadum* as well as tyrosine. Marine species *L. harak* showed also the highest percentage of essential amino acids except for histidine and lysine. Glysine was found highest though in the freshwater species *O. niloticus*. To conclude, both marine and freshwater species possess high quality protein. Nonetheless, *L. harak* and *L. niloticus* species are highly recommended as a dietary supplement since they contain essential amino acids in quantities sufficient for human health.

INTRODUCTION

Fish are considered as a potential source of animal protein and essential nutrients in human diets. Besides being nutritious fish are tasty and easily digested. It is estimated that around 60% of people in many developing countries depend on fish for over 30% of their animal protein supplies (Osibona *et al*., 2009); thus fish plays an important role in food security.

Amino acids, the building blocks of protein, act as a precursor of many enzymes, hormones, neurotransmitters, nucleic acids and other molecules essential for life. They are classically divided into three categories: essential, nonessential and conditional essential amino acids.

Amino acids play important roles in cell signaling and act as regulators of gene expression and protein phosphorylation cascade, nutrient transport and metabolism in animal cells, and innate and cell-mediated immune responses (Mohanty *et al*., 2014). The amino acid histadine for example, plays multiple roles in protein interaction (liao *et al*., 2013) and it is also a precursor of histamine (Mohanty *et al*., 2014) whereas leucine increases the synthesis of muscle proteins (Etzel, 2004) and has important therapeutic role in stress conditions like burn, trauma, and sepsis (De Bandt and Cynober, 2006;) methionine is used as a treatment for liver disorders, wounds, depression, alcoholism, allergies and Parkinson's disease (Mischoulon and Fava, 2002) and lysine is required for optimal growth and its deficiency leads to immunodeficiency (Chen *et al*., 2003). Threonine is important in treating various nervous system disorders (Hyland, 2007). Phenylalanine serves as a precursor for synthesis of tyrosine (Fernstrom and Fernstrom 2007). The nonessential amino acid alanine is highly beneficial for supporting gluconeogensis and leucocyte metabolism (Kudsk, 2006). Glutamic and aspartic acid are vital in the synthesis of glutathione and precursor for essential amino acids (Mohanty *et al*., 2014). Serine is the precursor of glycine, cysteine, and tryptophan and plays many important roles in cell signaling. Arginine plays an important role in cell division, wound healing, immune function blood clotting, and maintenance of blood pressure (Mohanty *et al*.,. 2014). Glycine plays an important role in metabolic regulation, enhancing anti-antioxidant activity, promoting protein synthesis and wound healing. Tyrosine is a precursor for several biologically active substances including catecholamine, neurotransmitters, hormones and melanin skin pigments.

Fish protein can thus be used as complement for amino acid pattern and improve the overall protein quality of mixed diet. It also contains significant amounts of all essential amino acids, particularly lysine which is relatively poor in cereal (Osibona *et al*., 2009). Therefore, better knowledge of fish nutritional constituents, which is expected to be closely associated with fish species, could contribute to the understanding of variability in meat quality of different species of marine and freshwater fish species. In this study, we provide basic information about amino acid profiles of commercial marine and freshwater fish species in order to support their consumption and enhance their utility in clinical nutrition field.

Materials and methods:

Samples Collection:

Three samples of each of the following freshwater fish species: *Oreochromis niloticus* (Bulti), *Lates niloticus* (Ejil) and *Bagrus bayad* (Bayad) were purchased from local fish markets in Khartoum state. The same number was obtained for marine fish species: *Plectropomus maculates* (Najil) *Lethrinus harak* (Shour) and *Mugil cephalus* (Arabi) were purchased from local fish markets in Port-Sudan (Red Sea state). Fish samples were transferred to the laboratory in an ice box where they were cleaned and flesh was isolated. Freeze dried flesh of each sample was powdered and kept till used for detection of amino acids.

Samples preparation:

0.2g of each sample was digested in 5ml of 6N HCl for 24hours and then filtered. 200µg of filtrate was evaporated and dried in a 140^{o}C oven for 1hour. 1ml of diluting buffer (11.2g lithium citrate+ 6g citric acid+ 20 ml thiodiethanol 25%, pH 2.2) was added to each sample. Finally samples were injected to amino acid analyzer model (SYKAM 57130) and profile of each sample determined.

Statistical analysis:

Arithmetical means ± standard deviation was computed. Analysis of variance (ANOVA) and student t-test were conducted using the Statistical Packages of Social Science (SPSS). Significant alpha was set as < 0.05.

Results:

In the present study a total of 14 amino acids were detected; 7 essential, 4 nonessential and 3 conditional essential amino acids. The percentage of essential amino acids was 43.04% in marine fishes and 40.41% in freshwater fishes. The nonessential and conditional essential amino acids collective percentage was 48.27% in marine fish and 54.17% in freshwater fish. The essential amino acids / nonessential amino acid ratio (E/N) was 0.89 for marine and 0.74 for freshwater fish samples.

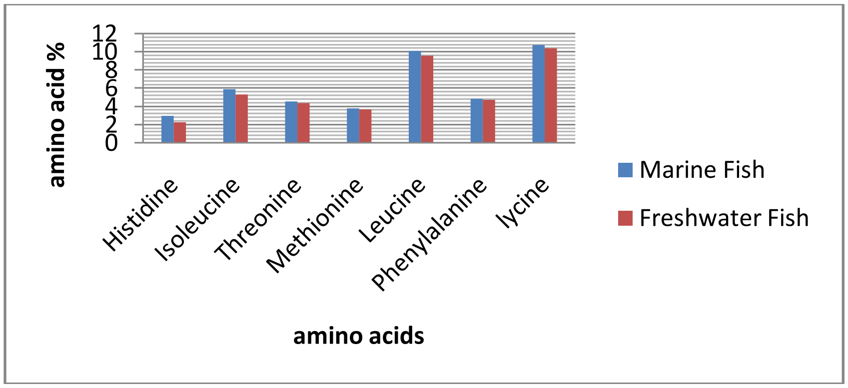

Fig (1): The mean percentages of Essential amino acids in Marine and Fresh water fish

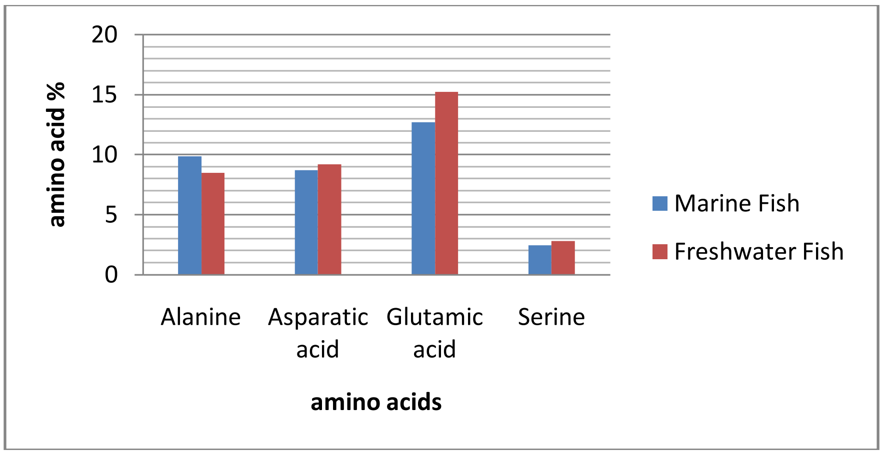

Fig (2): The mean percentages of Non essential amino acids in Marine and Fresh water fish

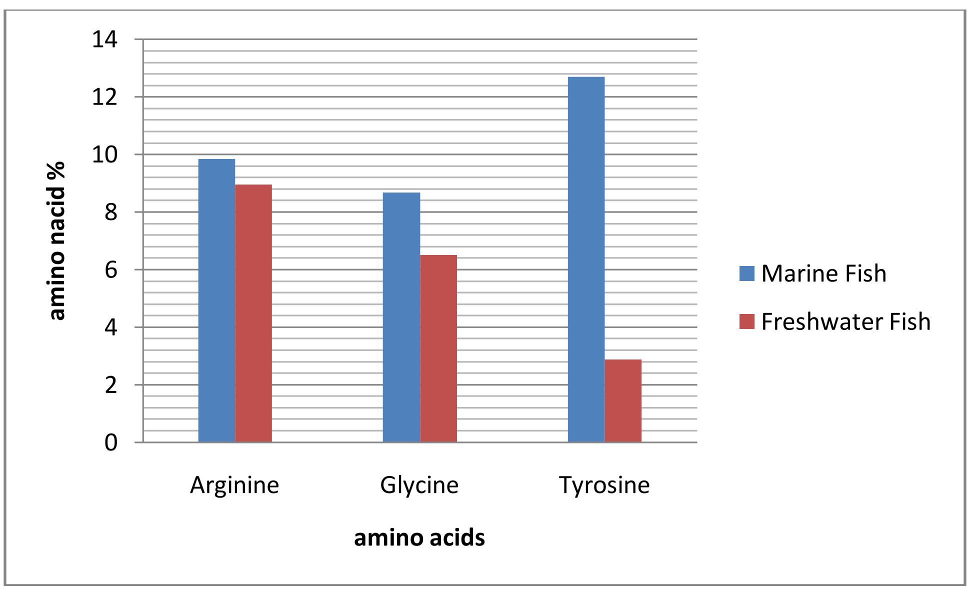

Fig (3): The mean percentages of Conditional essential amino acids in Marine and Fresh water fish

Table (1): Amino acids mean percentages± St.D. of different marine and freshwater fish samples.

Essential Amino Acids									
No.	Amino acid name	Marine Fish Samples				Fresh water Fish Samples			
		M. cephalus	*P. maculates*	*L. harak*	Total Mean%	*O. niloticus*	*B. bayad*	*L. niloticus*	Total Mean%
1	Histidine	3.87 ± 0.21*	2.40 ± 0.10	2.70 ± 0.26	2.99 ± 0.69*	2.37 ± 0.06	2.30 ± 0.20	2.20 ± 0.00	2.29 ± 0.13
2	Isoleucine	5.67 ± 0.06	5.93 ± 0.32	6.23 ± 0.87	5.94 ± 0.52*	5.20 ± 0.35	5.36 ± 0.46	5.47 ± 0.06	5.32 ± 0.31
3	Threonine	4.46 ± 0.00	4.40 ± 0.17	4.73 ± 0.40*	4.58 ± 0.26	4.40 ± 0.10	4.40 ± 0.50	4.43 ± 0.06	4.41 ± 0.26
4	Methionine	2.97 ± 0.64	4.10 ± 0.26	4.30 ± 0.44	3.79 ± 0.74	3.50 ± 0.20	3.50 ± 0.06	4.00 ± 0.10	3.68 ± 0.27
5	Leucine	9.53 ± 0.12	10.33 ± 0.49	10.57 ± 1.27	10.14 ± 0.83	9.37 ± 0.49	9.63 ± 0.51	9.73 ± 0.12	9.58 ± 0.40
6	Phenylalanine	4.63 ± 0.15	4.83 ± 0.06	5.07 ± 0.35	4.84 ± 0.27	4.63 ± 0.15	4.70 ± 0.26	4.87 ± 0.06	4.73 ± 0.19
7	lycine	10.10 ± 0.10	11.27 ± 0.46	11.00 ± 0.28	10.76 ± .062	9.73 ± 0.55	10.93 ± 0.55	10.53 ± 0.06	10.40 ± 0.66
Non-essential Amino Acids									
		M. cephalus	*P. maculates*	*L. harak*	Total Mean%	*O. niloticus*	*B. bayad*	*L. niloticus*	Total Mean%
1	Alanine	8.27 ± 0.15*	10.70 ± 0.61	10.60 ± 1.91	9.86 ± 1.55*	7.93 ± 0.46	9.30 ± 1.56	8.30 ± 0.10	8.51 ± 1.02
2	Asparatic acid	9.40 ± 0.10	8.27 ± 1.02	8.40 ± 0.44	8.69 ± 0.77	9.67 ± 0.25	8.03 ± 1.86	9.93 ± 0.06	9.21 ± 1.29
3	Glutamic acid	14.97 ± 0.40	11.10 ± 1.39	12.03 ± 1.80	12.70 ± 2.09	16.43 ± 0.25	12.47 ± 4.43	16.97 ± 0.12	15.25 ± 3.07*
4	Serine	3.10 ± 0.10	1.97 ± 0.06	2.27 ± 0.57	2.44 ± 0.59	2.97 ± 0.12	2.43 ± 1.14	2.97 ± 0.06	2.79 ± 0.63
Conditional Amino Acids									
		M. cephalus	*P. maculates*	*L. harak*	Total Mean%	*O. niloticus*	*B. bayad*	*L. niloticus*	Total Mean%
1	Arginine	9.00 ± 0.40	9.80 ± 0.10	10.43 ± 1.11	9.86 ± 1.55*	9.82 ± 0.23	9.27 ± 0.72	8.70 ± 0.00	8.97 ± 0.45
2	Glycine	6.70 ± 0.46	7.17 ± 0.67*	6.87 ± 0.51	8.69 ± 0.77	8.20 ± 1.93*	6.53 ± 0.85	4.83 ± 0.51	6.52 ± 1.82
3	Tyrosine	2.87 ± 0.31	2.73 ± 0.32	3.20 ± 0.17	12.70 ± 2.09	2.63 ± 0.15	2.87 ± 0.38	3.13 ± 0.15	2.88 ± 0.31

*= significant (P ≥ 0.05).

Essential amino acids:

Seven essential amino acids were reported in each of marine and freshwater fish samples (Table 1). The total percentages of histidine and isoleucine were significantly high in marine fish samples compared to freshwater samples. However, no significant ($P < 0.05$) variations were reported in total percentages of therionine, methionine, leucine, phenylalanine, and lysine among marine and freshwater fish samples as shown in fig (1).

Histidine and threonine were significantly high in *M. cephalus* and *L. harak* ($P < 0.05$) respectively, while no significant variations were observed in the rest of essential amino acids within and between the other specimens. The highest percentages of isoleucine, therionine, methionine, leucine and phenylalanine were reported in *L. harak* (marine fish) and *L. niloticus* (freshwater fish). The highest percentage of lysine was reported in *B. bayad* (freshwater fish) and *P. maculates* (marine fish).

Nonessential amino acids:

Four nonessential amino acids were detected (Table 1). The total percentages of alanine and glutamic acid content were significantly ($P < 0.05$) high in marine and freshwater fish respectively. However, no significant variation was detected for asparatic and serine acids content fig (2).

The highest percentages of alanine were reported in *B. bayad* (freshwater spp) and *P. maculates* (marine spp) whereas it was found significantly low in the marine species *M. cephalus*. Other than this, no significant variations were reported within and between the groups of the present study samples (Table 1). The highest serine percentages were reported in *M. cephalus* (marine spp), *O. niloticus* and *L. niloticus* (freshwater spp). In addition, the highest percentages of aspartic and glutamic acids were reported in *M. cephalus* and *L. niloticus*. In summary, species *M. cephalus* and *L. niloticus* presented with the highest percentages of amino acids.

Conditional essential amino acids:

Three conditional essential amino acids were detected in both marine and freshwater fish samples fig (3): arginine, tyrosine and glycine. The total arginine percentages were found to be significantly higher in marine fishes compared to that of freshwater samples. Whereas no significant variations were observed in the total percentages of tyrosine and glycine in both marine and freshwater fish samples (Table 1).

The highest percentages of arginine were detected in *L. harak* (marine fish) and *O. niloticus* (freshwater fish), whereas tyrosine was found to be highest in *L. harak* (marine fish) and *L. niloticus* (freshwater fish). Glycine percentages were found to be significantly ($P < 0.05$) high in P. *maculates* (marine spp) and O. *niloticus* (freshwater fish).

The amount of nonessential amino acids was higher than that of essential amino acids and the ratios of E/N were 0.89 and 0.74 for marine and freshwater fish samples respectively

Discussion:

The investigated marine and freshwater fish species are among the popular commercial fish in Sudan. They were chosen according to consumer preference. The traditional classification of amino acids into essential (not synthesized *de novo* and must be provided in diets), nonessential (synthesized *de novo*) and conditional essential (their utilization is greater than rates of their synthesis under certain conditions) was considered in comparing the nutritional value of the species studied.

Protein quality is determined by 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 (Mohanty *et al*., 2014).

In the present study a total of 14 amino acids were reported, including: 7 essential, 4 nonessential and 3 conditional essential amino acids.

This indicates high protein quality for marine as well as freshwater fishes. However, some amino acids were not detected in our samples. This can be explained either by acid hydrolysis or oxidation (Gam *et al*,. 2005, Diniz *et al*.,2013, James and Kumar, 2013) or by the mere absence of these amino acids. The amount of nonessential amino acids was higher than that of essential amino acids and the ratios of E/N were 0.89 and 0.74 for marine and freshwater fish samples respectively. Sabetian *et al* (2012) reported nearly similar amino acid percentages and E/N ratios in Rainbow Trout.

The amino acids detected in this study were similar to those obtained by Kumaran *et al* (2012), and provide the daily requirement of amino acids for healthy living human. Limited variations were observed in the total percentages of amino acid composition between marine and freshwater fish samples. This is in agreement with Osibona (2011) and Mohanty *et al*., (2014). These minor variations may be attributed to differences in species and/or catch locality. The total percentages of essential amino acids histidine and isoleucine were significantly higher in marine spp making them a suitable source for histidine, isoleucine, alanine and argnine, whereas, freshwater species may be a good source for glutamic acid.

The marine fish *M. cephalus* was found to contain the highest percentage of histidine. Other essential amino acids were detected including insolucine, leucine, phenylalanine, methionine, threonine and lysine. Unlike the findings of Mohanty *et al*., (2014) who found leucine in large amounts in marine species, this study showed no significant variations among freshwater and marine fish in leucine percentages. The highest percentages of essential amino acids isolucine, leucine, phenylalanine, methionine and threonine were reported in *L. canadum* and *O. niloticus* within marine and freshwater species respectively. *P. maculates* (marine) and *L. niloticus* (freshwater) were rich source for lysine since they reported the highest percentages.

Nonessential amino acids alanine, glutamic acid, aspartic acid and serine were reported in both groups. The highest percentages of both glutamic and aspartic acid were reported in the Nile perch *L. niloticus*. ; the highest percentages of serine were observed in *M. cephalus* (marine) and *O. niloticus*(freshwater).

The highest percentages of glycine were reported in freshwater fish *O. niloticus*.. This is in agreement with Mohanty *et al*., (2014) who found that the amount of glycine was highest in freshwater fishes.

Conclusion:

In conclusion, both marine and freshwater fish samples possess high protein quality, since they contain most of the essential and nonessential amino acids required for human health. Furthermore, most of these amino acids are present in quantities sufficient to satisfy metabolic needs for maintenance, normal growth and other functions of adequate protein uptake. Marine species could be recommended as a dietary supplement for essential amino acids, especially *L. harak*; which is highly recommended as a dietary supplement since it contains sufficient quantities of essential amino acids followed by the freshwater species *L. niloticus*. These findings provide basic information for developing nutritionally balanced diets especially for individual with specific nutritional needs.

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