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Full Length Research Paper

Proximate composition, amino acid and mineral contents of five commercial Nile fishes in Sudan

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The objective of this study was to determine the meat quality of the Nile fishes: *Lates niloticus*, *Bagrus bayad*, *Oreochromis niloticus*, *Synodontis schall* and *Tetraodon lineatus*, which represent different grades of preference to the Sudanese consumers. Lipid content was 1.8 to 17.3% and moisture was 73 to 80%. Protein content was 59.8% in *S. schall* and 77 to 79.1% in the remaining species. The caloric value was 357 to 425 Kj/100 g, which is high in *B. bayad* and least *in T. lineatus*. Minerals included potassium (33 to 41%), phosphorous (25 to 36%), selenium (12 to 16%), calcium (4 to 19%), sodium (2 to 10%), and magnesium (2 to 3%); while zinc, iron, aluminum and copper were present in trace amounts. Eight essential amino acids with total amount of 961 to 2279 µg/g were identified, and lysine formed the highest value in all the species, followed by leucine. Essential amino acids (EAA) formed 38 to 46% of the total amino acids, high in *L. niloticus* and low in *S. schall*. The data showed that the Nile fishes are of high nutritional value and good source of proteins, minerals as well as essential amino acids. It is recommended to assess the meat quality of other species, especially presently unused ones prior to processing and storage, because the contents of moisture, fats and other components in the tissues could affect the post-harvest processing and storage of the fish.

Key words: Essential amino acids, lipids, minerals, moisture, Nile fishes, proteins, proximate composition, Sudan.

INTRODUCTION

Fish received increased attention as a potential source of animal protein and essential nutrients for human diets (Kromhout et al., 1995; Zenebe et al., 1998a; Arts et al., 2001; Fawole et al., 2007). Fish meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meats (Neil, 1996; Nestel, 2000). The nutritional value of fish meat comprises the contents of moisture, dry matter, pro-tein, lipids, vitamins and minerals plus the caloric value of the fish (Evangelos et al., 1989; Chandrashekar and Deosthale, 1993; Steffens, 2006). Minerals are essential nutrients, they are components of many enzymes and metabolism, and contributes also to the growth of the fish (Glover and Hogstrand, 2002). The human body usually contains small amount of these minerals and the deficiency in these principal nutritional elements induces a lot of malfunctioning; as it reduces productivity and causes diseases (Mills, 1980). Besides being used as food, fish is also increasingly demanded for use as feed. However, information concerning the chemical composition of freshwater fishes in general is valuable to nutritionists concerned with readily available sources of low-fat, high-protein foods such as most freshwater fishes (Sadiku and Oladimeji, 1991; Mozaffarian et al., 2003; Foran et al., 2005) and to the food scientist who is interested in developing them into high-protein foods, while ensuring the finest quality flavor, color, odor, texture, and safety obtainable with maximum nutritive value. It is also useful to the ecologists and environmentalists who are interested in determining the effects of changing biological/environmental conditions on the composition, survival, and population changes within fish species. The nutritional component of the freshwater fish was found to differ between species, sexes, sizes,

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Table 1. Proximate composition (g/ 100g, dry weight) and caloric values of five commercial Nile fishes.

Parameters	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Total lipid (TL)	6.8	13.2	5.3	17.3	1.8
Total protein (TP)	77.9	77	78.4	59.8	79.1
Moisture (M)	75	76	76	73	80
TL: M *	9.1	13.6	6.6	23.7	2.3
TL: TP**	8.8	13.4	6.4	28.8	2.3
Caloric value (Kj/100 g)	396.9	424.8	382.6	413.7	356.5

*TL: M = Percentage of total lipid concentration (TL) to Total moisture concentration (M). **TL: TP = The ratio of total lipid concentration to total protein concentration in 100g of dry tissues.

seasons, and geographical localities (Zenebe et al., 1998b). It was also found to influence post-harvest processing and affect the shelf-life of the fish (Clement and Lovelli, 1994). Changes in fatty acid and amino acid concentrations were found to be useful as an index of freshness and decomposition of marinated fish in storage (Özkan, 2005). Likewise, different cooking methods affect the quality of fish meat (Prapasri, 1999).

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan, but little is known about the nutritional value of the Nile fishes that are normally utilized either fresh or preserved dried, salted or smoked. Better knowledge of their nutritional value, which is expected to be closely associated with fish species, could contribute to the understanding of variability in meat quality of different species of the Nile fish.

Moreover, the measurement of some proximate profiles such as protein contents, lipids and moisture contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000).

Therefore, in view of these facts, the present study was carried out on the commercial and most preferred species of the Nile fishes: *Lates niloticus* L., *Bagrus bayad* F., *Oreochromis niloticus* T., *Synodontis schall* Bl-Sch. and *Tetraodon lineatus* L., in order to assess their proximate compositions, minerals and amino acid contents prior to their consumption.

MATERIALS AND METHODS

Samples collection

The fish samples used for this study include *L. niloticus* (L. 1964), B. bayad (F. 1975), *O. niloticus* (T. 1982), *S. schall* (Bl- Sch. 1801), and *T. lineatus* (L. 1964); they were purchased from the fish market in Khartoum. Their length range was SL: 151 ± 5.4 to 351.7 ± 7.7 mm and body weight was 135.2 ± 14.8 to 585.5 ± 25.5 g. All the samples of the flesh were collected fresh and refrigerated below 4℃ prior to use. Two grams for each species were weighed and freeze dried by Freeze Dryer model 230 to -40℃. The surrounding pressure was reduced and enough heat were added to remove frozen water from the flesh, until the samples had constant weights.

Chemical analysis

The percentage proximate composition was determined chemically according to the method of analysis described by the Association of Official Analytical Chemists (AOAC, 2000). Moisture was expressed as percentage of wet weight according to the standard methods. Total lipids were determined following the method of Folch et al. (1957) and the concentration of mineral elements was determined using Atomic Absorption Spectrophotometer (AAS) and calculated in ppm (µg/g dry weight). The relationship between total lipids and moisture, and total lipids and total protein contents were determined and the caloric value of each species was calculated. Amino acids composition was determined with an automatic amino acid analyzer (LKB 4151 plus, Biochrom Ltd., Cambridge, UK) according to Bidlingmeyer et al. (1987). The degree of variability in different groups of amino acids (according to type of side chain) was expressed as percentages of total amino acids in each species and the ratio of essential amino acid was determined.

RESULTS

Table 1 represents the concentration and percentage of proximate composition (that is, protein, moisture and lipid contents) and the caloric value of the selected species analyzed. The varied values of their presence in the body tissues of the fishes analyzed were recorded. The fish samples analyzed presented highest to lowest amounts of total lipid (TL) in the order: *S. shall* > *B. bayad* > *L. niloticus* > *O. niloticus* > *T. lineatus;* and highest to lowest amounts of total protein (TP) in the order: *T. lineatus* > *O. niloticus* > *L. niloticus* > *B. bayad* >*S. schall*. The results showed that *T. lineatus* is a 'low lipid-high protein' fish with the highest amount of moisture (M), while *S. schall* is a 'high lipid-low protein' fish and contains the least amount of moisture. The lowest ratios of (TL: M) and (TL: TP) were found in *T. lineatus* and the highest in *S. schall*. The highest caloric value was obtained for *B. bayad* followed by *S. schall*, *L. niloticus* and *O. niloticus*, and *T. lineatus* has the least value. The concentrations of mineral elements are given in Table 2.

The mineral contents from high to low value were present in the species analyzed in the order: *T. lineatus*, *B. bayad*, *L. niloticus*, *S. schall* and *O. niloticus*. Potassium (K+) was the highest followed by phosphorus, selenium, sodium and calcium, while magnesium showed

Table 2. The mineral constituents (ppm, µg/g dry weight) and ratios (%) for five commercial Nile fishes.

Minerals	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Potassium	11550 (40)	12100 (41)	9545 (37)	10175 (36)	9990 (33)
Phosphorous	7270 (25)	7730 (26)	9350 (36)	7370 (26)	7885 (26)
Selenium	4565 (16)	3610 (12)	3610 (14)	4328 (15)	3925 (13)
Calcium	2305 (8)	2920 (10)	1075 (4)	3113 (11)	5880 (19)
Sodium	2395 (8)	2360 (8)	1800 (7)	2805 (10)	2035(6.6)
Magnesium	705 (2)	748 (3)	687 (3)	696 (2)	751 (2)
Zinc	62	51	46	53	88
Iron	26	17	26	60	61
Aluminum	18	17	21	40	48
Copper	0.9	1.0	1.0	1.4	1.3
Total minerals	28870	29537	26161	28641.4	30664.3

Table 3. The concentrations (µg/g dry weight) and ratios (%) of different groups of amino acids and total ammonia for five commercial Nile fishes.

Amino acids	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Non-polar amino acids	1023 (35)	1681 (33)	1433 (32)	1141.5 (37.3)	780.8 (32.4)
Acidic amino acids	518.2(17.6)	980.8(19.2)	935 (21)	716 (19)	517.8 (21.5)
Basic amino acids	573.2(19.5)	1022.7(20)	914.1(20)	655.3(17.3)	433.3(18)
Amino acids with OH- group	333.3 (11.3)	622 (12.2)	553.3 (12.2)	438.4 (11.6)	297.4(12.4)
Amino acids with SH- group	143.8(4.9)	266.8(5.2)	215.1(4.8)	173.3 (4.6)	120.5 (5)
Amino acids with aromatic ring	353.7 (12)	531.7 (10.4)	501.6 (11)	385.8 (10.2)	256.3 (10.7)
Total amino acids	2945.3	5105.4	4552.3	3780.3	2406.1
Total ammonia (µg/g)	40	67	53	54	44

Table 4. Essential amino acids (EAA) profile (µg/g dry weight) in muscle tissues of five commercial Nile fishes.

Amino acids	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Leucine	244.1	422.1	357.8	260.5	177.6
Isoleucine	151.1	250.9	210.1	141.6	97.0
Valine	167.3	266.8	222.3	158.3	110.4
Threonine	153.9	246.6	219.9	171.6	114.5
Lysine	281.1	486.4	423.6	300.3	202.3
Histidine	105.3	173.6	142.6	106.3	78.9
Methionine	106.9	189.9	156.3	124.6	88.3
Phenylalanine	139.1	243.1	205.1	156.8	91.6
Total EAA	1348.8	2279.4	1937.7	1420.0	960.5

medium concentration in all species and zinc, iron, aluminum and copper were found in trace amounts.

Sixteen amino acids (aa) were identified and the degree of variability in different groups of amino acids (according to type of side chain) was expressed as percentages of total amino acids in each species (Table 3). *S. schall* contained the highest value of non- polar amino acids and the least value of basic amino acids, while *L. niloticus* contained the least value of acidic amino acids and amino acids with OH- group. *B. bayad* contained the highest and *L. niloticus* the least ammonia concentration. Non - polar amino acids formed 31.5 to 37.3%, highest in *S. schall* and least in *O. niloticus*; acidic amino acids 17.6 to 21.5%; basic amino acids 17.3 to 20 %, high in *B. bayad* and *O. niloticus* and least in *S. schall*; amino acids with OH- group 11.3 to 12.41%; amino acids with SH-group 4.6 to 5.2%; and amino acid with aromatic ring 10.2 to 12%. Essential amino acids (Table 4) formed 38 to 46% of the total amino acids, high in *L. niloticus* and low in *S. schall*.

DISCUSSION

The species investigated in the present study: *L. niloticus*, *B. bayad*, *O. niloticus*, *S. schall* and *T. lineatus*, are the popular market fishes in rural and urban areas, and belong economically to the different traditional grades, according to consumer and fishermen preference in Sudan. Proteins, lipids and moisture contents as well as the caloric values were the major constituents, which had been considered in evaluating the nutritional value of the species studied. The nutritional elements showed variable values in the species analyzed; with crude protein recording the highest values and lipid recording the lowest. This makes the Nile fishes important living resources of dietary protein as other sea and freshwater fish (Vlieg and Murray, 1988; Zuraini et al., 2006). High-lipid fishes had less water and more protein than low-lipid fishes. This is in-line with the report of Steffens (2006), that protein forms the largest quantity of dry matter in fish. Likewise, the species examined also contained appreciable concentrations of potassium, phosphorus, selenium, sodium and calcium suggesting that these species could be used as good sources of minerals. Potassium was observed to dominate other minerals in all species. Few heavy metals analyzed were present, but within tolerable limits. The variations recorded in the concentration of the different nutritional components in the fish examined could have been as a result of the rate in which these components are available in the water body (Yeannes and Almandos, 2003), and the ability of the fish to absorb and convert the essential nutrients from the diet or the water bodies where they live. This is supported by the findings of Window et al. (1987), Adewoye and Omotosho (1997), Prapasri et al. (1999), Ricardo et al. (2002), Adewoye et al. (2003) and Fawole et al. (2007). The richness in phosphorus level in the five species can also be attributed to the fact that phosphorous is a component of protein. Other elements (such as zinc, iron, aluminum and copper) varied in concentration among the studied species. Most of these microelements are equally important in trace amounts as observed, but they tend to become harmful when their concentrations in the tissues exceed the metabolic demands (Hogstrand and Wood, 1996; Ako and Salihu, 2004). High amount of non-polar amino acids with aliphatic side chains and amino acids with a sulfur group and those with aromatic ring on the side chains, which together formed 37.4 to 52 % of the total amino acids, is a good indicator of stability of protein in these fish. Amino acids with aromatic side chains are also highly hydrophobic. Non-polar amino acids are hydrophobic, that is, they have an aversion to water and like to cluster (Stryer, 1995), while SH-containing side chains are hydrophilic (soluble in water). The present work has elucidated more on the importance of Nile fish as good sources of protein and minerals and has also broadened our knowledge on the nutritional value of some freshwater fish species that had been previously neglected. A majority of consumers do eat fish because of its availability, flavor and palatability, while few do so because of its nutritional value. Therefore, it can be suggested that taste, size, freshness and other related external appearances should not be the only factors to be considered in making choice for marketing and consumption of the Nile fishes. Likewise, since the interest in commercial culture of fish has increased to fill the gaps between supply and demand, therefore, this information is useful in developing nutrient-balanced, cost-effective diets and practical feeds for cultured fish. In addition, since the chemical composition of fish meat was found to vary with sex, seasons, size, age and geographical locality of catch (Zenebe et al., 1998b), therefore, it is essential to be determined and evaluated for different species of the Nile fish in relation to these factors. The chemical composition could influence the post-harvest processing and storage and could assist in determining the suitability of the different species to specific processing and storage techniques.

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