International Journal of Fisheries and Aquatic Studies 2016; 4(1): 160-164

ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2016; 4(1): 160-164

www.fisheriesjournal.com
Received: 13-11-2015
Accepted: 15-12-2015

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Proximate and mineral composition of some commercially important fish species of tekeze reservoir and lake Hashenge, Ethiopia

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Abstract
The aim of the present study was to estimate the chemical composition (crude protein, crude fat, ash, moisture and carbohydrate) and mineral contents (K, Ca, Na, Mg, P, Zn, Fe, Cu and Mn) in five fish species from the Tekeze reservoir and Lake Hashenge. Samples of fishes were collected from Tekeze reservoir and Lake Hashenge between December 2014 and March 2015 from the landing sites of the two water bodies. The samples were immediately and fish fillets were stored in refrigerator to determine the proximate and mineral contents of the fillet using the standard procedures of AOAC (2000). The result of the proximate composition analysis showed that the content of the crude protein of *Cyprinus carpio, Clarias gariepinus, Bagrus docmak, Labeobarbus intermedius* and *Labeobarbus nedgia* was 17.25%, 15.44%, 15.35%, 14.98% and 15.09% of the wet weight, respectively. The analyzed result showed that the content of moisture, Crude protein, crude fat and carbohydrate value of the different fish species were significantly different (P<0.05). The percentage of ash between the sampled fish species were not significantly different (P>0.05). The content of crude fat and ash were ranged from 1.26 to 5.74% and 0.83 to 0.94% of the wet weight, correspondingly. The crude fat content of the different fish species were significantly different (P<0.05) and *C.gariepinus* was showed the highest crude fat content (5.74±0.27%). The concentration of K was highest in muscle of *C. carpio* (17276.21±25.54 mg/kg). The highest concentrations of K, Ca, P, Mg and Mn were found in the *C. carpio* among the five species. Iron and Zinc value were highest in the *C. gariepinus*, whereas Copper was highest in muscle of the *L. intermedius.* The analyzed mineral content found in each fish species was in the order K>Na>Ca>Mg>P>Fe>Zn>Cu>Mn. The present study revealed that all fish species are good sources of proteins and fats, there is need to investigate in detail the types of amino acids and fatty acids of the sampled fishes.

Keywords: Fillets composition, Hashenge, Mineral content, Tekeze Reservoir

1. Introduction
About 148 million tons of fish were supplied by the capture and aquaculture sector to the world population in 2010, of which about 128 million tons was utilized as food for people (FAO 2012). In Africa, fishery sector supported about 200 million people with food and nutritional security and also provides income for 10 million people engaged in fish production, processing, and trade (FAO 2003). The lack of sufficient protein is one of the most widespread nutritional deficiencies in many tropical countries (Ozkan, 2005) [21]. All of the essential amino acids needed for good health are present in fish meat. Fisheries and aquaculture can play a significant role to fight against food insecurity of the regions in Ethiopia where there is huge potential of water resource. In addition to this fish is a cheap source of high protein; so there is a need to produce it as an alternative way of fulfilling animal protein requirement for the poor rural communities of Ethiopia (Abebe & Stiassny, 1998) [1]. The water surface areas of Ethiopia are estimated about 7,334 km^2 of major lakes and reservoirs, and 275 km^2 of small water bodies with 7,185 km length of rivers within the country (FAO, 2011). In these water bodies, there are about 200 fish species (Dereje, 2014) [12] and the major commercially important fish species of the country include *Oreochromis niloticus, Labeobarbus spp, Lates niloticus, Clarias gariepinus, Bagrus docmak* and *Cyprinus carpio* (Abebe & Eshete, 2012) [1]. The country has huge potential for fish production. According to Bernard & Maes (2003) [9] report the estimation of fish production of the country is reaches up to 23,342 tons per year from major lakes, 4,399 tons per year from major reservoirs, 1,952 tons per year from small

water bodies and 21,788 tons per year from rivers.

The proximate composition of fish species is different among the fish species. The food type of the fish is important for the quality and quantity of the fillet nutrients. Estimation of proximate composition such as protein, fats and ash is often necessary to ensure that they meet the dietary requirements and commercial specifications (Watchman, 2000) [30].

Sutharshiny and Sivashanthini (2011) [28] reported that fish received increased attention from time to time as a potential source of animal protein and some minerals for human diets. The fillet of a fish contains lower lipids and higher water content than beef or chicken (Sidhu, 2003) [26]. Fish is also very important for health since it comprises good contents of moisture, protein, lipids, vitamins, minerals and energy source (Steffens, 2006) [27].

In addition to nutritional value, fish is also a good source of income. 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. Generally, composition of live-weight, whole fish is 70 to 80% water, 20 to 30% protein and 2 to 12% lipid (Das & Sahu, 2001) [11]. Estimation of the some proximate profiles of a fish such as protein, lipids and moisture contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications. This knowledge of the biochemical composition of fishes is essential to estimate their energy value and to plan the most appropriate industrial and commercial processing.

Even though Ethiopia has many fish species, only few are commercially important and deserves to be investigated on their biochemical composition. Currently the knowledge of proximate composition and mineral contents of fish species from Ethiopia water bodies is inadequate. There are many reports on the proximate and mineral composition of *C. carpio* and *C.gariepinus* in different parts of the worlds. But none of the researchers reported on the other three fish species (B. *docmak*, *L. intermidius* and *L. nedgia).* The present study evaluated that the proximate and mineral composition in *C. carpio, C. gariepinus, B. docmak*, *L. intermidius* and *L. nedgia,* fishes of economic importance.

2. Materials and methods

Description of study areas

Tekeze Reservoir

Tekeze reservoir is a hydropower reservoir constructed on 2009 over the Tekeze River, the major river in Ethiopia and is a tributary of Nile River. Tekeze reservoir has maximum length of 75 km and maximum width of 6 km, and covering an area of about 160.4 km^2. According to National Statistics of Agency (NSA) (2008) Tekeze River is 608 kilometers long. Mana, Tsilare, Seletsa, Avera and Ariqua rivers are the main tributaries of the Tekeze River joined in to the reservoir. The origin of Tekeze River is the central Ethiopian Highlands near Mount Qachen within Lasta, at 14°11N 37°31.7E and 14.18.3°N 37.52 83°E. The reservoir is situated at an elevation of 1107 m asl. The capacity of the reservoir is estimated 9.293 billion m^3 (9.293 km^2) of water. The main aim of constructing of the reservoir was to produce electricity, but the reservoir fisheries were later recognized as a significant socio-economic importance to Tigray and Amhara people.

Lake Hashenge

In addition to Tekeze reservoir, the study was extended to Lake Hashenge, which is one of the natural highland lakes of Ethiopia found in Tigray region. It is situated in Ofla district, Southern Tigray, about 628 km North of Addis Ababa in the coordinates of 12°34′50″N and 39°30′00″E and at an elevation of 2440 m asl. It is one of the crater lakes in the country and is not associated with the East African rift system; instead it is the result of volcanism. This lake has no outlet to drain its water. Hashenge Lake is five kilometers long and four kilometers wide, with a surface area of 20 square kilometers and maximum depth of 25 m and the mean depth 14 m. Its drainage area is 129 Km^2.

Methods

Proximate Analysis

A total of 25 fishes from both sex were examined. 5 *C. gariepinus,* 5 *B.docmak,* 5 *L. intermidius* and 5 *L. nedgia* were collected from Tekeze reservoir and 5 *C. caprio* collected from Lake Hashenge landing sites. The proximate composition and mineral content were analyzed based on standard procedures of AOAC (2000) [7]. The moisture content of the fillet of the fish was determined by oven drying at 105 ºC overnight, ash by incineration of 2g of each sample in a muffle furnace at 600 ºC for 2 hours, crude protein by the Micro-Kjeldahl method then (N x 6.25), crude fat was extracted with n-hexane in a soxhlet extractor, while available carbohydrate was calculated by difference. The result of the proximate composition were analyzed in triplicate and reported as mean on percentage wet weight basis.

Mineral Analysis

The mineral content (Calcium, Potassium and Sodium) were determined using Flame photometric method (Jenway Digital Flame Photometer: PFP7 model). Phosphorus was estimated using Vanadomolybdate colorimetric method while other mineral elements such as Iron, Zinc, Manganese, Magnesium and Copper were determined using Atomic Absorption Spectrophotometric method. The content of the mineral were done in triplicate and reported as mean mineral content in mg/kg of dry matter.

Data Analysis

The data collected were stored in a database created in MS Excel, a variety of subjects were analyzed by combining quantitative and qualitative social scientific methods. One-way ANOVA model was used to evaluate the association of proximate composition and mineral contents with the fish species using SAS software (SAS version 9.0).

3. Results

The analysis result of proximate composition of all sampled fish species showed variation among the fish species. There was a significant difference ($P<0.05$) in moisture, crude fat crude protein and carbohydrate between the fish species. The percentage of ash between the sampled fish species were not significant different ($P>0.05$). Moisture analysis of the sampled fish species revealed that from all the fish samples, *L. intermidius* from Tekeze reservoir had the highest percentage of moisture content (78.18%) while, *C. gariepinus* had the lowest moisture content (75.92) (Table 1). The content of crude protein of sampled fish species were ranged between 14.98 and 17.25%, which was in the range of permissible limit (15-28%) for fish and fisheries products (USDA, 2010) [29], and the crude protein content of *C. carpio* was higher (17.25%) and *L. intermidius* showed lower protein content (14.98%). The crude protein content for all the fish species followed a decreasing order *C. carpio* > *C. gariepinus* > *B.docmak* > *L. nedgia* > *L. intermidius.*

Analysis result of crude fat content showed difference among the fish species with *C. gariepinus* having the highest value (5.74%) and *C. carpio* had the lowest (1.27%). The fish species has different crude fat contents.

The ash content ranged between 0.83% and 0.94 % in all sampled fishes. The present results revealed that, the species are a good source of minerals like calcium, potassium, zinc, iron and magnesium. The highest ash content was recorded from *C.carpio* (0.94±0.09%) and lowest value from *C. gariepinus* (0.83±0.07%).

The carbohydrate content ranged between 2.07% for *C. gariepinus* and 3.76% for *L. intermidius.* The results observed for carbohydrate showed difference among the fish species. The highest carbohydrate content was discernible in *L. nedgia* (3.76±0.22%) and lowest was observed in the muscle of *C. gariepinus* (2.07±0.08%).

Table 1: Mean values in wet percentage of the proximal composition of fishes analyzed in Ethiopia

Fish species	Moisture	Ash	Crude_Fat	Crude Protein	Carbohydrate
B. docmak	76.81±0.77^{bc}	0.88±0.08	4.32±0.16^{b}	15.35±0.22^{b}	2.64±0.15^{bc}
C. carpio	77.24±0.32^{ab}	0.94±0.09	1.26±0.14^{d}	17.25±0.47^{a}	3.30±0.37^{ab}
C. gariepinus	75.92±0.34^{c}	0.83±0.07	5.74±0.27^{a}	15.44±0.31^{b}	2.07±0.08^{c}
L. intermidus	78.18±0.13^{a}	0.92±0.09	2.32±0.15^{c}	14.98±0.15^{b}	3.60±0.32^{a}
L. nedgia	77.98±0.60^{ab}	0.89±0.06	2.28±0.14^{c}	15.09±0.28^{b}	3.76±0.22^{a}

Data is expressed as mean ± SD of three separated determinations.

a-d Value in the same columns with different superscript letters within a same strain are significantly different (p<0.05).

Concentrations of mineral contents of fish species studied are presented in Table 2. A total of 9 macro and micro elements were considered for the investigation and they are Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Phosphorus (P), Zinc (Zn), Copper (Cu), Iron (Fe), and Manganese (Mn) and the contents observed between fish species were different.

Elemental concentration in the muscle of the sampled fishes were in the order of K>Na>Ca>Mg>P>Fe>Zn>Cu>Mn. The concentration of K was highest from the elements analyzed from fish species and Mn was found in lowest concentration.

The mineral content of the fish species were significant different (P<0.05) between the sampled fishes. The levels of potassium in all sampled fish species were in the range from 11209.85 to 17276.21 mg/kg of dry weight. The lowest content was observed from *B. docmak* (11209.85±18.98 mg.kg) and highest from *C. carpio* (17276.21±25.54 mg/kg). Mn was detected in lower concentration in all the fish species. The lowest Mn was observed from the muscle of *C. gariepinus* (0.16±0.01 mg/kg) and highest recorded in *C. carpio* (0.52±0.04 mg/kg). The Mn concentration levels in the five fish species did not exceed the WHO limit of 2.50 mg/kg for fish and fish products in the present study was found to be (0.16-0.52mg/kg) (FAO/WHO, 1984).

Table 2: Mean values of mineral contents (mg/kg dry wet) in fishes analyzed in Ethiopia.

Minerals	Fish species				
	B. docmak	***C. gariepinus***	***C. carpio***	***L. intermidius***	***L. nedgia***
Ca	244.69±10.39^{c}	123.55±4.47^{d}	981.24±8.49^{a}	878.03±7.68^{b}	864.92±8.88^{b}
Mg	613.56±10.25^{c}	599.59±2.26^{c}	808.17±4.75^{a}	645.78±3.76^{b}	637.66±2.66^{b}
Na	1880.62±9.08^{d}	2101.97±9.93^{a}	1629.69±5.23^{e}	1989.39±4.55^{b}	2019.43±7.48^{c}
K	11209.85±18.98^{c}	11223.22±7.85^{c}	17276.21±25.54^{a}	12397.34±8.93^{b}	12403.02±19.8^{b}
P	398.05±16.15^{b}	351.41±7.17^{c}	555.64±11.20^{a}	265.98±7.68^{d}	247.65±5.27^{d}
Zn	4.34±0.43^{c}	38.52±1.49^{a}	13.22±0.98^{b}	14.47±0.97^{b}	12.78±0.67^{b}
Cu	0.70±0.19^{c}	2.28±0.31^{b}	2.37±0.23^{b}	3.49±0.34^{a}	2.08±0.34^{b}
Fe	19.27±1.10^{bc}	25.89±1.85^{a}	18.58±1.24^{bc}	16.04±1.29^{c}	21.69±1.14^{b}
Mn	0.22±0.04^{c}	0.16±0.01^{c}	0.52±0.04^{a}	0.42±0.03^{b}	0.47±0.02^{ab}

Data is expressed as mean ± SD of three separated determinations.

a-e Value in the same columns with different superscript letters within a same strain are significantly different (p<0.05).

4. Discussion

The percentage range of the moisture contents of fish muscle was within the acceptable level (60-80%) in all of the sampled fish species. Adewumi *et al.* (2014) [4] reported that the stable water level in the fillet of fish species were due to the stable water in the water body where the fish lives. Zmijewski *et al.* (2006) [33] found a reverse correlation between the fat and water content to be common among fish species, and it was in line with the present result. Similar moisture content of *C. gariepinus* (75.65%) has also been reported by Nwali *et al.* (2015) [21] and Osibona *et al. (*2009) [20].

The proximate composition of *L. intermidius, L. nedgia, B. docmak, C.gariepinus* and *C. carpio* showed high crude protein contents of 14.98%, 15.09%, 15.35%, 15.44% and 17.25% respectively (Table 1). The analysis result showed that all the analyzed fish species were good sources of protein, but the recorded value differences observed, could be as a result of fish consumption or absorption capability and conversion potentials of essential nutrients from their diets or their local environment (Adewoye & Omotosho, 1997) [3]. Effiong and Tofa (2006) [13] reported 18.60% crude protein for *C. gariepinus* which was higher than the obtained result in the present study. The values of crude protein were highest in *C.carpio* collected from Lake Hashenge than other fish species collected from Tekeze reservoir. This may be due to the diet composition of the fish (Zenebe, 2010) [32].

Different types of fatty acids which are nutritionally important for human body were found in the fish meat. The difference in the value of crude fat level in the fish species could be due to water temperature difference, stage of life, environmental salinity, food type, and species (Fabiola & Martha, 2012) [15] and diet of the fish (Zenebe, 2010) [32]. Beyza and Akif (2009) [10] reported that *C. gariepinus* contained 5.02% crude fat and according to Rosa *et al.* (2007) [23] the mean crude fat content of *C. gariepinus* was 5.70 which were similar to the present study. Samy *et al.* (2012) [25] have reported that feed composition has a major influence on the proximate composition of salmonids. Based on the fat content *B.docmak, L. intermidius, L.nedgia* and *C. carpio* were distinguished as lean fish as fat contents of these fishes were lower than 5% by weight while, *C. gariepinus* was classified as fat fish (>5% fat content) (Bennion and Scheule, 2003) [8].

The variation observed in the content of minerals in the fish fillets could be due to the different in amount of the minerals in the water bodies (Ali *et al.,* 2001) [6], the physiological state of the fish or the ability of the fish to absorb the elements from the diets and the water bodies (Ako and Salihu, 2004) [5]. This study indicates that mineral content of omnivorous fish species is higher than that of carnivorous species. This agrees with the report of Farkas *et al.* (2003) [16] that the concentrations of element in fish body could be related primarily to their feeding habits. Adewumi *et al.* (2014) [4] reported that microbiological activities in the aquatic environment, feeding habits and age of fish have also been found to determine elemental concentrations in fish and even within a species of fish, mineral retention depends mainly on the feed and the feeding rate and interaction with the water environment. Pirestani *et al.* (2009) [22] reported that amount of several elements analyzed from different fish species collected from different areas were significantly different.

Mineral analysis in the present study showed highest values of K and Ca in all of the samples; and Fe, Zn and Cu were the most dominant micro elements. Saadettin *et al*. (1999) [24] reported that, the most abundant micro element in fish were Zn and Fe followed by Cu. All the fishes were good sources of different minerals. However, the microelement (Manganese) recorded were of low values; this may be due to the fact that the body needs it in trace amounts.

5. Conclusion

The result of the present study showed that the different examined fish species are good sources of protein, fat, moisture and minerals. It was also revealed that the superiority of *C. capio* in crude protein content, *C. gariepinus* in crude fat and *L. intermidius* in moisture content while the five fish species are good source of minerals. The fish species examined from Tekeze reservoir and Lake Hashenge (*B. docmak, L. intermidius, L. nedgia, C. gariepinus* and *C. carpio)* are rich in sources of crude protein, moisture, crude fat, ash and minerals. In addition to this the result revealed the proximate composition values obtained would be useful to help the consumers in choosing fish based on their nutritional values. It also providing update information in fish fillets composition and mineral contents to food composition database and consumers can have sufficient knowledge in the biochemical contents of each examined fish species and they can eat what they want based on their need.

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