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A study on the proximate composition and mineral distribution in tissues of Nile tilapia (*Oreochromis niloticus*) from Gilgel Gibe Reservoir, south-west Ethiopia

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Abstract

Fish is the most important food valued for its nutritional qualities. It is rich in protein, vitamins, polyunsaturated fatty acids and minerals. Nile tilapia (Oreochromis niloticus) is the most abundant and commercially important fish species in Ethiopia. The present study was aimed at analyzing tissue proximate composition, mineral distributions in tissues and analysis the fatty acid profile and amino acid of Nile tilapia. Deneba and Bore sites were selected based on the accessibility of the Reservoir. From each site, ten fish samples were collected. Then blood samples and targeted tissues (muscle, gill, skin, stomach and liver) were collected from all fish samples. Finally, all the samples were processed for further analysis of proximate composition and minerals following the procedure in Association of Official Analytical Chemists. Data were analyzed both qualitatively and quantitatively. Variations were observed between the tissues both in terms of proximate composition and mineral distribution. Accordingly, lowest (69.39 ± 1.99%) and highest (81.44 ± 0.102%) moisture content were recorded in skin and muscle, lowest (7.49 ± 0.36%) and highest (21.89 ± 121%) crude protein were recorded in stomach and skin, lowest (0.71 ± 0.003%) and highest (7.92 ± 0.24%) crude fat were recorded in muscle and gill, lowest (1.12 ± 0.023%) and highest (7.24 ± 0.09%) ash content were recorded in muscle and stomach tissues respectively. High levels of saturated fatty acid were obtained from the blood analyzed and followed by monounsaturated fatty acid and then polyunsaturated fatty acid. Amino Acid profile indicated the fish was rich source essential amino acid. The minerals were accumulated specifically within each tissue. Relatively stomach accumulated higher concentration of minerals and followed by liver and gill. While skin and muscle store less amounts minerals compared to the other tissues. The value recorded for some toxic minerals were above the recommended uptake limit that needs concerns. Gill, liver and stomach could be the preferable tissues that used as a bioindicators of aquatic pollution.

Keywords: Nile tilapia, proximate composition, minerals, Gilgel Gibe.

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List of Acronyms

SFA	Saturated fatty acid
MUFA	Monounsaturated fatty acid
PUFA	Polyunsaturated fatty acid
n-3 PUFA	Omega 3 polyunsaturated fatty acid
n-3 LC PUFA	Omega 3 long chain polyunsaturated fatty acid
AOAC	Association of official analytical chemists
AAS	Atomic absorption spectrophotometer
SPSS	Statistical package for social science
FAO	Food and agricultural organization
EAA	Essential amino acid
WHO	World health organization
APHA	American public health association
NGO	Non-governmental organization

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1. Introduction

1.1 Background

About 71% of earth's surface is covered by water, of which 97.5% is salty water and 2.5% is fresh-water. About 98.8% of freshwater is found in ice and as ground water, and less than 0.3% is in river, lakes and atmosphere (Janko, 2014). These water bodies are a home for aquatic life and fishes are one of the species that are fully dependent on the presence of water for their survival and reproduction.

Though, landlocked Ethiopia is endowed with a variety of freshwater ecosystems including a number of lakes, large and medium perennial rivers, streams, reservoirs and wetlands that are of great scientific and economic importance. The total surface area of lentic water bodies of Ethiopia is about 8,800 km^2 (Grebovai *et al*., 1994) while the major rivers are about 7,400 km long. These water bodies are home for nearly 200 fish species (Golbtsov & Darkov, 2004). From these source Ethiopia is estimated to have 51,500 tons of fish production per year but currently only 30-38% is used (Tesfahun, 2018). From these small reservoirs and ponds have 1000 tons fishery potentials per year and 150 tons catch (Janko, 2014). Fish is one of the known aquatic animals used for human consumption as food.

In Ethiopia people consume large amount of fish during the fasting time around production area, big city and town specially Ziway, Bahirdar, Addis Ababa and Arbaminch. Outside of these areas the habit of fish consumption is very low for several factors including lack of integration of fish and diet of the population, lack of culture of small scale fish farming, religious influence on consumption patterns and limited supply of the product and high prices (Janko, 2014).

Additionally, fish is one of the most important foods and is valued for its nutritional qualities. Globally, over a billion people rely up on fish as protein source food. It is also the cheapest source of animal protein for some communities including those who don't consume red meat, the malnourished, pregnant women, immunocompromised, and nursing mothers (Jim *et al.*, 2017). Fish is rich in protein, vitamins, polyunsaturated fatty acids (PUFAs) and mineral salts. It is widely acceptable because of its high palatability, low cholesterol, tender flesh, cheap and its aroma cooking (Eyo, 2001).

Furthermore, fish diets are rich in fatty acid which has different advantages regarding health benefits, nervous system development, photoreception and reproductive system developments (Skonberg & Perkins, 2002). Fish lipid are rich in long chain of n-3 polyunsaturated fatty acid (PUFA) that can't synthesized by human and obtained only through fish diet. Connor, (2000) reported the consumption of fish oil containing n-3 PUFAs reduces the risk of coronary heart disease, decreases mild hypertension, prevents certain cardiac arrhythmias and sudden death, lowers the incidence of diabetes, and appears to alleviate symptoms of rheumatoid arthritis.

Study conducted on chemical composition of wild and cultured Tilapia by Job *et al.,* (2015) revealed that the percentage of moisture content was 80.8% in the cultured species and 80.9% in the wild groups; crude protein was 17.6% in the wild species with 17.1% in the cultured species. Ash content had a percentage composition of 1.2% in the wild species and 1.3% in the cultured.

Additionally, the results for the mineral analysis revealed that calcium (wild individuals: 28.3 mg/100 g, cultured: 27.0 mg/100 g), magnesium (wild individuals: 11.9mg/100 g, cultured: 2.7 mg/100 g), potassium (wild individuals: 17.1 mg/100 g, cultured: 11.90 mg/100 g), iron (wild individuals: 151.0 mg/100 g, cultured: 146.0 mg/100 g), zinc (wild individuals: 67.1 mg/100 g, cultured: 66.9 mg/100 g and sodium (wild individuals: 13.0 mg/100 g, cultured: 12.7 mg/100 g).

On the other hand, research conducted by Anthony *et al*., (2016) on different five fish species (*Clarotes laticeps; Distichodus rostratus; Synodontis schall; Schilbe mystus and Hyperopisus bebe*) indicated that the value for protein content is 11.2%; 23.5%; 11.79%; 12.9%, and 14.1%, while the value for moisture content is 68.81%; 64.83%; 67.76%; 69.00%; and 70.5%, while the value for fat content is 5.4%; 6.8%; 8.8%; 5.6% and 6.2%, and the ash content is 4.9%; 3.7%; 5.1%; 4.2%; 5.4% for *C. laticeps; D. rostratus; S. schall; S. mystus and H. bebe* respectively.

Moreover, Uysal, (2011) reported the mean concentration of heavy metals in different tissues (gill, liver, muscle, skin and intestine) of fishes. In all tissues of fish species (*Rutilus rutilus, Carassius carassius and Cyprinus carpio*) the highest concentration were recorded for Mg (95.8 to 903.2 mg/kg) and followed by Ca. While the lowest concentration for Fe (4.4–137.1 mg/kg) was recorded in muscle and skin compare to other tissues. Mn and Co were not detectable in muscle of all species. Generally their findings revealed the accumulation of Cu, Zn, Mn, Fe, and Co in muscle of the analyzed fish is lower than other tissues. While the concentration of Mg level in muscle of all species is higher than other tissues except gill. On the other hands, the basic knowledge on biochemical composition of different fish species were inadequate in Ethiopia.

1.2 Statement of the problem

Ethiopia has considerable number of commercially important fish species. However, the knowledge of biochemical composition of fish species is inadequate. Often only fish muscle is consumed while the other tissues such as gill, stomach, skin and liver that account for 50% fish part are discarded as a residue and there may be important nutrients are missing with discarded parts, which has great contribution to environmental pollution (Kristinsson & Rasco, 2000).

In Ethiopia, there are a few reports on the proximate composition of Nile tilapia (Emire & Gebermariam 2010; Alemu *et al.*, 2013; Team *et al.*, 2016) all for muscle tissue. Particularly there is no report on biochemical composition of Nile tilapia from Gibe watershed, southwest Ethiopia. It becomes imperative to undertake an assessment on the relatively more comprehensive biochemical composition (i.e. proximate and mineral composition) of this commercially important fish species in its various tissues.

1.3 Objectives

1.3.1 General objective of the study

- The general objective of the study was to analysis of proximate composition and distribution of minerals in the targeted tissues (liver, gill, muscle, skin and gut) of Nile tilapia from Gilgel gibe reservoir I.

1.3.2 Specific objectives of the study

- To determine the proximate composition of the targeted tissues of Nile tilapia.
- To compare and evaluate the correlation of the biochemical composition among the targeted tissues.
- To determine the distribution of selected minerals within targeted tissues.
- To identify profile of amino acid and fatty acid in the blood of Nile tilapia

1.4. Significance of the study

The study result has several roles both in scientific and local communities. Certainly, this study outcome provided baseline information on the proximate composition and mineral sequestration of tissues of Nile tilapia, the dominant fish both in terms of consumer preference and market outlet in the country. Furthermore, these study result might give the end users clue toward which particular minerals are available for human consumption at which particular tissues. In addition to this, it also came up with types of essential nutrients that humans missed upon feeding only muscle part of the fish.

2. Literature Review

2.1 Habit as feeding habit of Nile tilapia.

The Nile tilapia is an African fresh water Cichlid and one of the world's most important food fishes. In Ethiopia Nile tilapia is locally called koroso and it is the most dominant and economically valuable. It adapts to a wide range of environmental conditions. For this reason, the species has been introduced into many tropical and subtropical inland waters and culture systems. It has been introduced mostly for the purpose of farming in more than 50 countries in all continents except Antarctica (Pullin *et al.,* 1997) and is found in virtually every country within the tropics.

Knowing food and feeding habit of freshwater fish are a basis for the development of successful management program on fish capture and culture and enable to identify the trophic relationships present in aquatic ecosystems, identifying feeding composition, structure and stability of food webs in the ecosystem. Additionally, Tsegay *et al,* (2016) reported that feeding conditions has association with proximate composition content of the fish.

Different researchers reported Nile tilapia is omnivorous, that feeds on a variety of food items including phytoplankton, zooplankton, insects, detritus, macrophytes, fish parts and nematodes (Wakjira, 2013; Teame *et al.,* 2016; Tesfahun & Temesgen, 2018). Review by Tesfahun and Temesgen, (2018) revealed that Nile tilapia found in different Ethiopian fresh water bodies feed on different types of food based on the environment in which they live. The study of Wakjira, (2013) on the present study site Gilgel Gibe reservoir showed aquatic insects (Coleoptera and Diptera) were the most dominant and phytoplankton were the most dominant in the diet of *O. niloticus* followed by detritus. Additionally, the seasonal feeding habit of *O .niloticus* were more or less uniform during dry and wet season while aquatic insects and phytoplankton were the most dominant prey items.

2.2 Biochemical composition and nutritional values of fishes

Fisheries and aquaculture play an important role in providing food and income in many developing countries, either as a stand-alone activity or in association with other income generating activities, such as crop agriculture and livestock rearing (FAO, 2016). But the world facing great challenges of how to feed more than nine billion people in the coming feature. Food security and nutrition represent a global challenge, as hunger and malnutrition remain among the most devastating problems facing the world. Fish is one of the most important foods and is valued for its nutritional qualities.

Fish and seafood products have a high nutritional value consisting of protein, lipids as well as essential micronutrients. Fish protein is a good source of high quality protein containing essential amino acids in the amount and proportion required for good nutrition. It also provides a good source of vitamins and minerals (Onyia *et al.,* 2013). Moreover it has been considered as excellent source of food and preferred in the diet for centuries not only due to its excellent taste and high digestibility but also due to higher proportions of unsaturated fatty acids, essential amino acids and minerals for the formation of functional and structural proteins (Massresha *et al.,* 2018).

Comparing with land living animals aquatic animals foods are rich source of protein, low caloric density and have a high content of omega 3 long chain polyunsaturated fatty acids (n-3 LC PUFA) (Tacon & Metian, 2013). Also during pregnancy and the neonatal period an optimal diet containing an appropriate amount of the essential LC n-3 PUFA is necessary for neural development of children. Different researchers recommend consuming fish have positive health effects especially with the decreasing risk of coronary heart and cardiovascular diseases, decreasing inflammatory disease as arthritis and preventing of cancer (Calder, 2004; Tilami & Sample, 2017).

Furthermore, the protein compounds in fish are made up of all the essential amino acids, with an abundant amount of lysine and tryptophan (a like milk protein, eggs and meat of mammals), and this confirms a high biological value of the fish meat (Calder, 2004). Water is the elemental that found in greatest amounts in the composition of fish species and its presence is inverse with fat contents. Additionally, mineral is the components of fish composition and important mineral elements of fish are calcium, magnesium, potassium, phosphorus, iron and chlorine while many others are important in trace amounts. Their deficiencies cause a lot of malfunctioning, such as it reduces productivity, and causes disorders such as inability of blood to clot, osteoporosis and anemia.

The measurement of some proximate profiles of fish such as protein contents, carbohydrates, lipids, moisture contents and ash percentage is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000). Chemical composition of fresh fish varies greatly from one species to other species and between individuals depending on age, sex, environmental conditions and seasons (FAO, 2016). Additionally, nutrient content of most fish species are not constant in their fatty acid profile contents due to environmental factors, such as feeds, temperature and salinity. On the other hand, fatty acid of fish are rich in omega-3 polyunsaturated fatty acid (n-3 PUFA), which has great advantageous in prevention of disease such as hypertension, inflammation, psoriasis, aggression, depression and cancer (Massresha *et al.*, 2018).

Furthermore, in many studies, fishes are the subject of investigations on heavy metal accumulations and monitoring programs in seas, due to their importance in human nutrition (Turkmen et al., 2009). Assessing mineral contents of fish has different advantageous which can serve as bioindicators because (i) they have long life spans; (ii) they develop and live in- water allowing continuous monitoring of pollutants and simultaneous spatial integration of pollutant data; and (iii) they are relatively easy to sample (Silva *et al.,* 2016). Fish incorporates trace elements by ingestion of suspended particulate matter in the water column and food, by ion exchange of dissolved elements across lipophilic membranes (e.g., the gills) and by adsorption of elements on tissue and membrane surfaces. The measurement of this distribution can serve as a pollution indicator.

Different studies aimed to asses contamination of trace mineral using fish focused on soft tissues like muscle, gill, liver and kidney, specially muscle is commonly analyzed to determine contaminant concentrations and to assess health risks because it is the main fish tissue consumed by humans (Kebede & Wondimu, 2004; Silva *et al*., 2016). Several researchers have monitored the water quality by fish analysis because higher and relatively stable concentrations would be obtained for fish samples compared with the water itself and water quality monitoring by fish analysis could be selected since some trace elements show organ specific accumulation (Kebede & Wondimu, 2004).

2.3. Proximate composition of fish

Proximate composition of the fish involves the determination of moisture, fat, protein, ash and carbohydrate and is determined by the difference of the sum total of the others parameters from hundred (Massresha *et al.,* 2018). The proximate composition of fish is affected by exogenous factors (temperature, pH, salinity, oxygen concentration, diet) and endogenous factors (life stage, age, size, sex and anatomical position of the fishes) (Shearer, 1994; Alemu *et al*., 2013). When compare with endogenous factors exogenous have very limited effects while endogenous factors governs the majority of principles that determines the composition of fish. The protein content is usually in the range of 15–20%, whereas the fat content varies widely from species to species and from season to season; it can be as low as 0.5% in lean and starved fatty fish and can reach over 20% in some species (Shimeles & Mekonnen, 2009).

2.3.1. Moisture Contents of fish

Moisture contents are the amounts of water contents in different tissues of fish. The moisture content in the tissue of fish varies due to biological and physiological factors. The acceptable value for moisture content is ranged from 60%-80%. Additionally, moisture contents varied from species to species and from one water bodies to the other (Massresha *et al*., 2018). Ahmed *et al.*, (2016) investigated that, the moisture contents in *O. niloticus* range between 75.33±1.15 and 79.30±1.15 for *Synodontis schall.*

Review of Massresha *et al.,* (2018) show that moisture content of Ethiopian commercial important fish have different percentage with *O. niloticus* from Lake Zeway having the highest percentage of moisture (80.80%.) content than *C. carpio* from Lake Hashenge (77.24%). The work of Alemu *et al.*, (2013) on proximate composition of Nile tilapia revealed that the highest moisture content (80.8 %) was recorded from five years fish and lowest (79.6 %) being from four years old fish. He also found that the moisture showed tendency to increase with advance in age of fish but nearly no variation between sexes. Moreover different researchers have reported that moisture content of male fish were higher than female fish (Bhavan *et al.*, 2010; Cornelia, 2012). This is due to muscles of female Nile tilapia fish contain more organic materials and less water than male (Amer *et al.*, 1991).

On the other hands, the reports of moisture contents on different tissues of Nile tilapia from lake ziway and Awassa shows significant difference that varied from 78.2–79.3% in muscle, 76.7–80.3% in gill, and 76.0–79.8% in liver (Kebede & Wendimu, 2004). Tsegaye *et al.*, (2016) reported that the results obtained for *O. niloticus* that collected from Tekeze reservoir showed the highest percentage of moisture content (79.83 ±0.34 for male and 79.11 ± 0.14% for female) than *O. niloticus* from Lake Hashenge that had the lowest moisture content (77.55 ± 0.22% for female and 77.69 ± 0.39% for male). They conclude that the reason for the result variation is *O. niloticus* from lake Hashenge have concentrated nutrients than *O. niloticus* from Tekeze reservoir. Different reports founds it is common among fish species that fat and water contents have inverse correlations (Tsegaye *et al*., 2016; Zmijewski *et al.*, 2006). Comparing with other species reports by Hantoush, (2015) on commercially important fish from Iraq water shows (79.4%) for *Ilisha melagoptera*, (78.5%) for *Cypirnus carpio*, (73.74%) for *Chirocentrus dorab* and (71.23%) for *Liza abu*. The result indicates their moisture content found within the same ranges with Nile tilapia and the today’s study result also confirmed with the above reports.

2.3.2. Crude Proteins

Crude protein is one of the parameters that used to determine the amount of protein in the proximate analysis of food. The permissible limit of crude protein for the fish and fisheries products are ranged from (15% to 28 %) (Massresha *et al*., 2018). The protein compounds in fish are made up of all the essential amino acis, with an abundant amount of lysine and tryptophan (like milk protein, eggs and meat of mammals), and this confirms a high biological value of the fish meat (Effiong & Fakunle, 2011). Emire & Gebremariam, (2009) reported that storing sample fish for 90 days has significant effects on the percentage protein contents. Their results revealed that the highest protein content (18.52 ± 0.08 g/100 g) was recorded for fresh fish sample and the least protein content (17.25 ± 0.09 g/100 g) was recorded for fish sample stored for 90 days and the decrease in protein content may be attributed to its denaturation of fish protein, i.e., due to the changes in the proportion of chemical composition and protein breakdown.

The works of Olopade *et al*., (2016) on the proximate composition of Nile tilapia and Tilapia hybrid from Oyan lake of Nigeria revealed that the crude protein content of hybrid Tilapia was higher than the crude protein content of *O. niloticus*, irrespective of the fish sexes. Additionally, genetically modified *O. niloticus* was significantly higher in protein and fat contents when compared with the other non-transgenic genotypes of tilapia. The crude protein contents for the fish collected from Ethiopian fresh water lake Ziway and lake Ashenge ranged between 15.32 and 16.32%, which was in the range of permissible limit (15-28%) for fish and fisheries products, and the protein content of female *O. niloticus* from Hashenge was higher (16.32 ± 0.30%) and male *O. niloticus* from Tekeze reservoir showed relatively lower protein content (15.32 ± 0.28%) (Tsegaye *et al*., 2016).

The other reports from lake Ziway by Alemu *et al.*,(2013) reported that the protein content of male and female *O. niloticus* was 14.5 and 14.6% respectively which was lower than the result reported by Tsegay *et al*., (2016). Ahmed *et al.* (2016) reported that the crude protein contents of *O. niloticus* is less when compared with other fish species. Reports of Anthony, (2016) on different five species shows the value for protein ranges from 11.29% to 23.59% and the results of the today's study for crude protein was confirmed with the literature reports.

2.3.3. Crude Fat

Crude fat is the amounts of fat in the food and it involves dissolving the material in a solvent such as ether or hexane and then evaporates the solvent. Fish can be grouped into four categories according to their fat content lean fish (<2%), low (2-4%), medium (4-8%) and high fat (>8%) (Ackman, 1989). The normal fat content for fat is 2.75 ± 0.16% (Gabre, 2000). Moreover, crude fat content varies widely from species to species and from season to season; it can be as low as 0.5% in lean and starved fatty fish and can reach over 20% in some species (Emire & Gebermariam, 2009). Additionally, they reported that the fat content for tilapia that stored under frozen for three months increased significantly from 0.37% to 0.56%. This was due to the fact that there was an inverse relationship between the moisture and lipid contents of fish flesh.

Jim, (2017) reported that the value of fat contents and moisture contents are inversely related and also at some site the results shows inverse correlation with protein contents. In Lake Chivero, fish had 3.17% fat against a protein content of 16.45% whereas Lake Kariba fish had 1.74% fat value against a protein content of 17.12%.

Lipid content of fish flesh, on the other hand, is directly related to the nutrition of the fish. When comparing wild and farmed fish, higher lipid contents are found in farmed fish mostly because of the accessible and well formulated diets (Orban *et al.,* 2003). Ahmed *et al.,* (2016) reported the crude fat contents for *Oreochromis niloticus* by comparing with other five fish species such as *Synodontis schall, Lates niloticus, Labeo niloticus, Bagrus bayad* and *Hydrocynus froskalii* And it was ranked on the fifth by its crude fat contents.

Massresha *et al.,* (2018) reviewed the crude fat contents for Ethiopian fresh water that crude fat for the fish collected from Lake Zeway and Lake Hashenge ranged from 0.37% to 2.45%. Additionally, the results for fat from Lake Ashenge were greater than the results from Lake Ziway for *O. niloticus* which may be due to water temperature and food diet difference between the two lakes. Alemu *et al.,* (2013) reported that the fat content of fish at any stage is dependent upon age; the higher the amount of fat is the older the fish, the amount of fat for the fish at four ages is 0.4 ± 0.02 and for the fish at five ages is 0.7 ± 0.02. Lipid content was increased with increase of fish age, however, the average lipid content shown no significant difference between male and female fish. Larger (older) fish have higher levels of lipid than smaller fish (Toppe *et al.,* 2006).

2.3.4. Ash Content

Ash content is a measure of the total amount of minerals present within a food. The normal ash content of *O. niloticus* meat is 2.6±0.2% (Gebre, 2000). Emire and Gebiremariam , (2009) reported the ash contents for the tilapia fillet stored at -18±2C̊ revealed significant decrease from 0.98% to 0.89%. The works of Teame *et al.,* (2016) shows the results of Ash contents for different fish species ranged between 0.83% and 0.94 % in all sampled fishes and it represents the species are a good source of minerals like calcium, potassium, zinc, iron and magnesium. Massresha*et al.,* (2018) reviewed also for the Ash from Ethiopian fresh water Lake Ziway and Lake Ashenge and explained that ash content ranged between 0.81% and 1.20% from the two lakes. The highest ash contents were recorded for *O. niloticus* collected from Lake Ziway (1.20%) and less for Lake Ashenge (0.81%).

2.4. Mineral distributions in different tissues of fishes

Minerals occurring in considerable amounts are called macro elements and those found in minute amounts are called trace elements or microelements. Calcium, phosphorus, sodium, potassium, Sulphur, chlorine, Magnesium and Iron are found in appreciable amounts; coppers, iodine, manganese, cobalt, zinc, fluorine, selenium are found in smaller quantities whereas cadmium, boron, arsenic, aluminum, lead, nickel are found in trace quantities in different group of fishes. Mineral elements are basic requirement of all living organisms. Some minerals are essential elements but these essential metals may be toxic at their high concentration in body of animals (Tyrrell *et al*., 2005).

Knowledge about mineral concentration in fish is important with respect to nature management and human consumption. Those mineral such as Mg, Ca, Na, P and K are essential since they have great role in biological system structurally and functionally (Rivas, 2014).

Both macro and micro mineral could inter and incorporates into different tissues of fish via different ways. Reports by Kebede & Wondimu, (2004) on lake Ziway and lake Awassa for the distribution of trace minerals in different tissues of Nile tilapia shows that the concentrations of copper varied from 1.68–4.95 in muscle, 6.65–7.58 in bone, 7.08–9.73 in gill and 601–797 mg/kg dry mass in liver. The concentration for iron ranged from 13.7–53.9 in muscle, 81.9–94.3 in bone, 120–196 in gill and 635–7139 mg/kg dry mass in liver. Moreover they reported both Cd and Pb were concentrated more in bone followed by gill and they were known for their toxicity in organisms. Generally their reports revealed that each minerals show organic specific accumulation and there are two factors that affecting mineral distribution: one is the physiological role of each element, and the other is the preference of an element to bind to or replace some elements in the tissue.

The study of Team *et al.*, (2016) on five different fish species from Lake Ashenge and Tekeze reservoir shows that there was significant elemental concentration difference between sampled species and water bodies. Elemental concentration in the muscle of the sampled fishes were in the order of K > Na >Ca> Mg > P > Fe > Zn > Cu >Mn. The variation of minerals concentration observed in the fish fillets from the two water bodies could be due to the different in amount of the minerals in the water bodies (Ali *et al.,* 2001), 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).

The results of Team *et al.,* (2016) from the two water bodies showed highest values of K and Ca in all of the samples; and Fe, Zn and Cu were the most dominant micro elements. Iron has an active part in oxidation/reduction reactions and electron transport associated with cellular respiration. The iron content of fish is very low compared to that of mammals (Watanbe, 1997). Zinc and Manganese are used in the human physiology that in the metabolism of carbohydrate, lipid and bone.

According to Bashir and Alhemmali, (2015) the concentration of heavy metals in tissue gill of fish is depends on absorption of metals onto the gill surface, as well as by formation of complexes between the metals and the mucous, which is often impossible to remove them from lamellae prior to the analysis. Additionally their reports on analysis of heavy metals in different tissues of fish show that accumulation of heavy metal is higher in liver and gill than muscle. Moreover, the concentration of Zinc shows significant difference between each tissue of the fish.

Silva *et al.,* (2016) reports revealed that concentration of trace elements in the muscle and gonad tissue of fish is lower while gill, liver and kidney contain the highest concentration. Muscle doesn’t actively accumulated trace mineral because of it metabolic rate. On the other hand, gill and liver accumulates high concentration of trace mineral due to their low metabolic rates.

Uysal, (2011) determined heavy metal concentration in five different tissues (gill, liver, skin, intestine and skin) of three fresh water fish’s species (*Rutilus rutilus, Carassius carassius,* and *Cyprinus carpio*). In his results Ni, Pb, Cr, and B were not detected in all tissues of the fish. The average concentration of metals in each tissues species found within the range of the following that Cu, below detection limit (BDL) - 17.15; Zn, 9.08–699.60; Mn, BDL-8.23; Fe, 4.42–137.17; Co, BDL-1.49; Ca, 144.40–14376.60 and Mg, 95.81–903.23. Moreover, highest concentration of Zn, Mn, Ca, and Mg is observed in the gill while skin contains higher concentration of Co and Cu, Liver is rich in Fe for species *R. rutilus*. On the other hand the highest concentration for Zn, Mn and Fe is observed in intestine of *C. carassius* while gill accumulated more Ca and Mg and Cu is accumulated in liver. Additionally, Uysal, (2011) reported *C. carpio* accumulates more Mg, Mn and Ca in gill; Fe, Cu and Co in liver and Zn in intestine.

2.5 Amino acid and fatty acid of fishes

Amino acids are a building block of protein that plays a vital role both as building blocks of proteins and as intermediates in metabolism. The presence of essential amino acids such as Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, tryptophan, and Valine in the protein of fishes that are not synthesized by animal made fish an important source for human beings (Bruke *et al*., 1997). The major constituent's amino acids are responsible for the synthesis of most body tissues, hormones, as well as enzymes and other metabolic molecules (Oluwaniyi *et al.,* 2010).

Fish because of high nutritional quality and easily digestibility are the most important nourishments in human Diet (Gladyshev *et al*., 2006). lipids are well known as a rich source of long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) which cannot be synthesized by humans and commonly obtained from the diet (Alasalvar *et al*., 2002). And also it is scientifically demonstrated to have functional effects on human diet (Saoud *et al*., 2008; Rafflenbeul, 2001). Fatty acid profile of the fish can be categorized as saturated fatty acid and unsaturated fatty acid that contain mono unsaturated fatty acid (MUFA) and poly unsaturated fatty acid (PUFA) (Rodrigues *etal.,*2017). From these *n*-3 PUFA's, mainly EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acids), have been widely reported to promote several benefits on human health, especially regarding the prevention of cardiovascular disorders (Harris *et al*., 2008;Baum *et al*., 2012). Additionally, recent studies have also suggested that the *n*-6 family and its metabolites show beneficial effects on cardiovascular system health (Mozaffarian *et al*., 2011; Baum *et al*., 2012).

Reports of Rodrigues *et al.*, (2017) on profile of fatty acid of five different species revealed Oleic acid (C18:1) was the predominant fatty acid in all species, ranging from 36.47% to 52.72% of total MUFA. All fish species demonstrated high PUFA content, ranging from 50.91% to 58.70%. Additionally, they founds that *n*-3 FA represented a large proportion (43.78–58.41%) of total

PUFA values while DHA accounted for 30.70 to 45.04% whereas EPA represented 10.54–13.89% of total PUFA contents.

3. Materials and Methods

3.1 Description of study area

The fish samples were collected from Gilgel Gibe Reservoir, constructed on Gilgel Gibe River, a tributary of a major Gibe River, located within the Omo-Turkana drainage basin in the southwestern part of the country (Fig. 1). It was commissioned in 2004 as a hydropower dam and located at an altitude of 1640 m above sea level at geographic coordinates of 07.4253-07.55580 N and 37.1153-37.20330 E. Its maximum and minimum water levels during wet and dry seasons respectively are 1671 m^3 and 1653 m^3 ASL. It has a total surface area of 51 $Km^2$and max volume of 900 million m^3 (Ethiopian Electric Power Corporation, 1997). Its depth ranges between 2 m and 35 m with a mean depth of about 17.6 m. It drains a total catchment area of 4225 Km^2. The mean annual atmospheric temperature is 19.2℃. The mean annual rainfall ranges between 1300 mm and 1800 mm in the catchment areas (Wakjira, 2013).

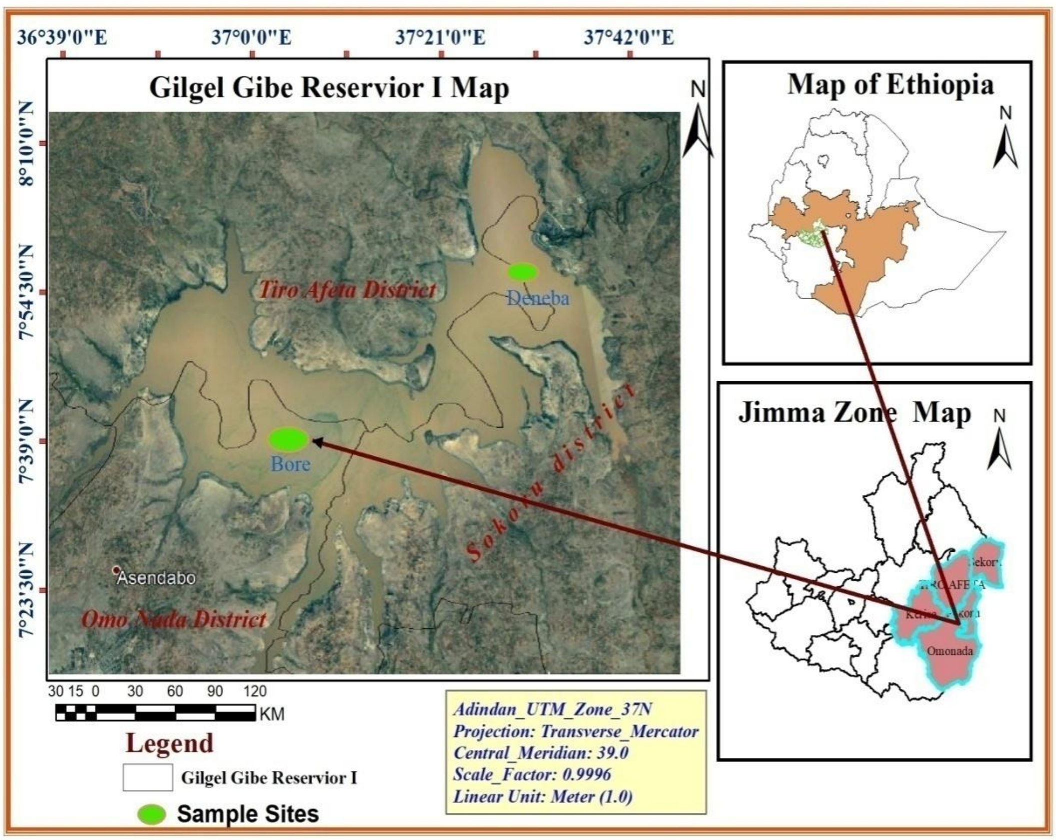

Figure 1. Map of the study area (Self sketched).

3.2 Sample collection and preparation

Two sampling sites were selected based on the accessibility of the Reservoir. From each site, ten fish samples were collected. Consequently, morphometric measurement like weight and length of the fish was measured using appropriate measuring board and sensitive balance. Similarly, sex was identified by genital papillae observation and gonad dissection. Then after, all fish samples were dissected for the collection of the five targeted tissues (muscle, gill, skin, stomach and liver). The weight of each tissue sample was measured. Tissue samples were put in ice box and transported to the Zoological Sciences laboratory of Jimma University, Jimma , Ethiopia. Plate 2-5 shows length, weight measurement, dissection and collected tissues in ice box respectively.

Plate 1: collection of data for length.

Plate 2: collection of data for their weight.

Plate 3: Dissection of fish to collect targeted tissues.

Plate 4: Collected tissues in ice box.

3.3 Apparatus and Reagents used

3.3.1 Apparatus

Ice box SB1-B600, Oven N50C, Muffle furnace LV 3/11 - LVT 15/11, Atomic absorption spectrophotometer, Kjeldhal machine UDK 159, Gas chromatography–mass spectrometry, Whatman paper. Soxhlet extraction apparatus.

3.3.2 Reagents

$CuSO_4$**,** 98% (H_2SO_4)**,** K_2SO_4, 30% (H_2O_2), 40% (NaOH), 0.2 N HCl**,** Methyl blue**,** Bromocrosel green**,** 1N HCl

3.4 Blood sample collection and preparation

Based on the materials on the hand the fish were washed by water and their tail was cut to collect the blood from abdominal arteries. Then the fish were erected in slanted position and one drop of blood was collected on each spot of whatman paper. Whatman paper with collected blood kept on a nonabsorbent surface and allowed to dry at room temperature. Dried bloods on whatman paper were sent to Belgium for fatty acid and amino acid profile analysis by using Gas chromatography–mass spectrometry (GC–MS) (Bieber, 1997).

Plate 5: Blood sample collected on whatman paper.

3.5 Proximate composition analysis

Determination of the proximate composition of the samples was carried out following the procedure presented by Association of Official Analytical Chemists (AOAC, 1975, 1990, 1995, 2005) as described below in sections 3.3.1-3.3.6.

3.5.1 Moisture content determination

To determine the moisture content of the sampled tissue, weight of both the container (Petrdish) and the sample was recorded separately. Then the tissue in the container was placed in the oven adjusted at 105 ℃ for 12 hrs. A repeated measurement has been taken until no more weight change was recorded. The weight difference before and after heating was taken as estimation for moisture content of the fresh sample (AOAC, 1990). Plate 5-6 shows wet samples of tissue in the oven to dry and dried and grinded sample,

The moisture % was calculated as follow:-

$$\% \text{ moisture} = \frac{\text{Weight of fresh wet sample with petirdish} - \text{Dry weight with petirdish} \times 100}{\text{Fresh weig ht}}$$

Plate 6: Wet sample in the oven to drying

Plate 7: Dried and grinded sample of each tissue

3.5.2 Protein content determination

Protein content in each sample was determined using Kjeldhal method (AOAC, 2005). For protein analysis 1 gm of the oven dried and ground sample was taken and added to flask of protein analysis. 0.2 gm of $CuSO_4$ and 20 ml of 98% (H_2SO_4) were added to each flask. Then 7 gm of K_2SO_4 and 5 ml of 30% (H_2O_2) were added to each flask to facilitate the digestion process. The digestion occurs at three different temperatures (AOAC, 2005).

- 1^{st} round at 250 ℃ for 30 minutes.
- 2^{nd} round at 350 ℃ for 30 minutes.
- 3^{rd} round at 420 ℃ for 1hrs.

For the distillation 10 ml of 40% NaOH and 40% of boric acid with two indicators 7 ml of methyl and 10 ml of bromocrosel green were used while for the titration analysis chambers 0.2 N HCl were used. Finally, the results for the crude protein were displayed on the screen boards of Kjeldhal machine. Plate 7 shows the samples with different reagents added those used for digestion.

Plate 8: Digestion of samples

3.5.3 Determination of total Ash

A 3 g powder of dried fish sample of each tissue was weighed into an empty pre-weighed crucible and placed in a muffle furnace which has been ignited for 6 hours at 550 ℃. The furnace was turned off to cool to 250 ℃ before sample removal. Sample was desiccated prior to weighing (AOAC, 1990). Plate 8 shows the ashed sample of each tissue after ashing process. The ash content was calculated as follows:

$$\text{Ash \%} = \frac{(\text{weight of crucible plus sample after ashing} - \text{empty weight of crucible})}{\text{weight of sample before ashing}}$$

Plate 9: ashed sample

3.5.4 Crude fat determination

Crude fat content in each sample was determined by using non-polar solvent (petroleum ether), and a Soxhlet extraction apparatus. A 3 gm powder of dried fish sample was added to extraction thimble and put in extraction chamber. Weight of empty round bottom flask was recorded before extraction. 250 ml of petroleum ether was added to the round bottom flask through extraction chamber. Then the extraction process was continued for 8 hrs. After extraction, the solvent was evaporated and weight of round bottom flask with extracted materials was recorded. Percentage of crude fat was calculated as followed (AOAC, 1990):

% fat = (weight of extract/weight of sample) x 100.

Plate 10: Extracted fat

3.5.5 Carbohydrate content determination

Carbohydrate content was computed by taking the sum of values for moisture, protein, fat and ash contents and subtracted this from 100 (AOAC, 1995).

CHO % = 100 – (A + B + C + D)

Where:

A = moisture, C = fat

B = protein, D = ash

3.5.6 Determination of mineral elements

Ash sample of each tissue was sent to Belgium for the analysis of Mineral content which was determined from the ashed sample using an atomic absorption spectrophotometer (AOAC, 1975). To determine the mineral concentration of each samples, ash were treated with 2 ml of HNO_3 to obtain clean, practically carbon-free ash. Then 10 ml of 1N HCl was added and ash was dissolved by heating cautiously on a hot plate. The mixture was left to cool down and the contents were transferred to 100 ml volumetric flasks and the volumes of the contents were made to 100 ml with distilled water. The minerals analyzed were Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn, Mg, Na, S, K, P and Ca. All the samples was carried out in triplicate and reported as mean mineral content in mg/Kg (AOAC, 1990).

3.6 Statistical analysis

Descriptive statistics were used to analyze the mean and standard deviation of parameters used for different measurements, one- way ANOVA used to test significance difference for proximate composition, independent sample t-test were used to test significance of parameters between sex and site for fatty acid and Pearson correlation were used to test the relation of parameters between parameters used to measure proximate composition of each tissue by using the statistical software – SPSS (version 22). A significant difference was established at $p < 0.05$.

4. Results

4.1 Body characteristics of the fish

Morph-metric measurements (weight and length) of the fish samples from Bore and Deneba were presented in Table.1 Accordingly, the average weight of male and female Nile Tilapia from Bore and Deneba were (132.5 ± 24.69 gm), (139.0 ± 14.31gm) and (114.6 ± 20.69 gm), (113.4 ± 33.48 gm) respectively. While the average length of male and female from Bore and Deneba were (19.42 ± 1.78 cm), (19.0 ± 2.37 cm) and (18.1 ± 1.64 cm), (18.88 ± 1.27 cm) respectively.

Table.1: Mean weight and total length of Nile tilapia.

Trait	sex	location	
		Bore	Deneba
Average weight (g)	Male	132.5 ± 24.69	139.0 ± 14.31
	female	114.6 ± 20.69	113.4 ± 33.48
Average length (cm)	male	19.42 ± 1.78	19.0 ± 2.37
	female	18.1 ± 1.64	18.88 ± 1.27
Average of Weight to length ratio	male	8.722 ± 3.6	6.5 ± 2.19
	female	7.398 ± 2.95	7.9 ± 0.99

4.3 Proximate composition of each tissue

The percentage of moisture content, crude protein, crude fat, ash content and carbohydrate of male and female were analyzed for each tissue which was grouped as a size (small and medium) of the fish and presented in Table 2 and 3 respectively. Based on the recorded length those fishes with greater than 18 cm were grouped as medium size while those with less than 18 cm were grouped as small size (Santos *et al.*, 2012).

Remarkable mean variations were observed in between the tissues in its proximate composition. However, there is no pronounced mean variation in proximate composition among size and sex. In both sex and size group, the maximum moisture content, crude protein, crude fat and ash were observed in muscle (81.44 ± 0.102%), skin (21.89 ± 1.42%), gill (7.92 ± 0.24%) and stomach (7.24 ± 0.09%) respectively. The minimum moisture content, crude protein, crude fat and ash were observed in skin (69.39 ± 2), stomach (7.49 ± 0.36%), muscle (0.71 ± 0.01%) and again muscle (1.12 ± 0.006%) respectively.

Table. 2: The mean and standard deviation (M ± SD) of proximate composition of tissues from small size Nile tilapia (n = 2).

Tissue	sex	MC (%)	CP (%)	CF (%)	Ash (%)	CHO (%)
Muscle	Male	81.44 ± 0.10	15.7 ± 0.087	0.71 ± 0.003	1.12 ± 0.01	1.01 ± 0.01
	Female	78.88 ± 0.99	17.87 ± 0.84	0.82 ± 0.038	1.28 ± 0.06	1.14 ± 0.05
skin	Male	69.86 ± 0.60	21.56 ± 0.43	2.20 ± 0.048	3.95 ± 0.08	2.41 ± 0.05
	Female	69.65± 0.36	21.7 ± 0.26	2.22 ± 0.026	3.97 ± 0.04	2.43 ± 0.03
Gill	Male	77.8 ± 1.17	10.34 ± 0.5	7.13 ± 0.376	3.37 ± 0.17	1.3 ± 0.07
	Female	76.84 ± 2.4	10.8 ±1 .14	7.46 ± 0.79	3.52 ± 0.37	1.36 ± 0.14
Liver	Male	79.37 ± 0.61	12.65 ± 0.37	3.13 ± 0.09	3.28 ± 0.09	1.55 ± 0.04
	Female	79.68 ± 0.12	12.46 ± 0.06	3.08 ± 0.01	3.23 ± 0.02	1.52 ± 0.01
stomach	Male	80.26 ± 0.64	7.96 ± 0.26	3.48 ± 0.11	7.21 ± 0.23	1.07 ± 0.04
	Female	81.41 ± 0.90	7.49 ± 0.36	3.27±0.15	6.79±0.32	1.07 ± 0.03

Table. 3: The mean and standard deviation (M ± SD) of proximate composition of tissues from medium size Nile tilapia (n = 2)

Tissue	sex	MC (%)	CP (%)	CF (%)	Ash (%)	CHO (%)
Muscle	Male	80.39 ± 0.61	16.59 ± 0.51	0.75 ± 0.02	1.19 ± 0.04	1.06 ± 0.03
	Female	81.24 ± 0.18	15.65 ± 0.32	0.71 ± 0.01	1.12 ± 0.02	0.86 ± 0.18
skin	Male	69.77 ± 3.84	21.62 ± 2.75	2.21 ± 0.28	3.96 ± 0.50	2.42 ± 0.30
	Female	69.39 ± 2.0	21.8 ± 1.42	2.24 ± 0.146	4.01 ± 0.26	2.45 ± 0.16
Gill	Male	77.75 ± 1.47	10.38 ± 0.68	7.16 ± 0.47	3.38 ± 0.22	1.36 ± 0.14
	Female	75.39 ± 0.77	11.48 ± 0.36	7.92 ± 0.24	3.74 ± 0.11	1.45 ± 0.04
Liver	Male	79.26 ± 0.37	12.70 ± 0.23	3.14 ± 0.06	3.30 ± 0.06	1.55 ± 0.02
	Female	79.92 ± 0.62	12.31 ± 0.38	3.04 ± 0.09	3.20 ± 0.09	1.50 ± 0.04
stomach	Male	80.23 ± 0.25	7.97 ± 0.10	3.48 ± 0.04	7.24 ± 0.09	1.07 ± 0.01
	Female	80.72 ± 3.05	7.77 ± 1.23	3.40 ± 0.53	7.04 ± 1.11	1.05 ± 0.16

4.4 Fatty acid and amino acid profile

4.4.1 Fatty acid

From the analyzed blood of the fish both saturated and unsaturated fatty acid were identified and presented in Table 5 and 8. Among identified UFAs Tetradecenoylcarnitine (C14:2) and Linoleic acid (C18:2) were PUFA while the rest were MUFAs. From monounsaturated fatty acid Decenoylcarnitine (C10:1) were the predominated and followed by Oleic acid (C18:1). In their value there were no remarkable variations observed in between both sex and site. Accordingly highest MUFA (0.096) recorded for female from bore site and highest PUFA from Deneba female (0.0175).

Table. 4: profiles of unsaturated fatty acid (M ± SD) (n=5 for each sex from both site) analyzed from each blood of fishes by GC-MS were reported by µmol/l.

Unsaturated fatty acid		Bore		Deneba	
Lipid number	Systemic name	Male	Female	Male	Female
C5:1	Tiglylcarnitine	0.024 ± 0.001	0.022 ± 0.001	0.021 ± 0.001	0.017 ± 0.002
C14:1	Myristoleic acid	0.006 ± 0.001	0.018 ± 0.002	0.015 ± 0.002	0.015 ± 0.001
C14:2	Tetradecenoylcarnitine	0.012 ± 0.001	0.010 ± 0.00	0.005 ± 0.0004	0.01 ± 0.004
C10:1	Decenoylcarnitine	0.028 ± 0.004	0.02 ± 0.001	0.016 ± 0.003	0.01 ± 0.00
C16:1	Palmitoleic acid	0.012 ± 0.004	0.018 ± 0.003	0.008 ± 0.0005	0.012 ± 0.001
C18:2	Linoleic acid	0.004 ± 0.001	0.01 ± 0.00	0.01 ± 0.0006	0.0075 ± 0.002
C18:1	Oleic acid	0.012 ± 0.001	0.018 ± 0.003	0.02 ± 0.0008	0.017 ± 0.003
∑MUFA		0.082	0.096	0.08	0.071
∑PUFA		0.016	0.02	0.015	0.0175
	∑PUFA:∑MUFA	0.195	0.235	0.1875	0.2464

The ratio for summation of polyunsaturated fatty acid to monounsaturated fatty acid revealed there was more amount of MUFAs available in the blood of Nile tilapia than PUFAs.

Totally eleven SFA were identified in which no remarkable variations were observed in between both sex and site groups of fishes. Among identified SFA Butanoic acid were the predominate and followed by pentanoic acid from short chain of fatty acid. Hexadecanoic acid (C16:0) was the predominate and followed by Octadecanoic acid (C18:0). The total saturated fatty acids were ranged from (1.78 µmol/l to 2.57 µmol/l).

Table. 5: Profiles of saturated fatty acid. The (M ± SD) (n = 5 for each sex from both site) of recorded value were reported in µmol/l.

Saturated fatty acid		Bore		Deneba	
Number of lipid	Systemic name	Male	Female	Male	Female
C4:0	Butanoic acid	0.99 ± 0.07	1.088 ± 0.06	1.09 ± 0.06	0.71 ± 0.04
C5:0	Pentanoic acid	0.54 ± 0.07	0.712 ± 0.04	0.43 ± 0.04	0.41 ± 0.01
C6:0	Hexanoic acid	0.35 ± 0.06	0.324 ± 0.007	0.32 ± 0.07	0.277 ± 0.02
C8:0	Octanoic acid	0.12 ± 0.01	0.112 ± 0.008	0.08 ± 0.036	0.07 ± 0.001
C10:0	Decanoic acid	0.03 ± 0.01	0.068 ± 0.00	0.041±0.002	0.028±0.003
C12:0	Dodecanoic acid	0.028 ± 0.002	0.054 ± 0.002	0.031 ± 0.011	0.03 ± 0.007
C14:0	Tetradecanoic acid	0.022 ± 0.001	0.034 ± 0.001	0.035 ± 0.009	0.03 ± 0.002
C16:0	Hexadecanoic acid	0.058 ± 0.01	0.1 ± 0.009	0.065 ± 0.006	0.085 ± 0.004
C18:0	Octadecanoic acid	0.128 ± 0.01	0.064 ± 0.003	0.038 ± 0.007	0.06 ± 0.005
C24:0	Tetracosanoic acid	0.01 ± 0.00	0.014 ± 0.001	0.011 ± 0.009	0.007 ± 0.00
C26:0	Hexacosanoic acid	0.006 ± 0.00	0.014 ± 0.002	0.013 ± 0.01	0.012 ± 0.001
∑ SFA		2.282	2.584	2.154	1.719

4.4.2 Amino Acid

Nine amino acid were detected from the blood of fish analyzed. Among identified leucine, methionine, phenylalanine and valine are essential amino acid while Glycine and Tyrosine are conditionally essential. The values recorded have no remarkable difference in between sex and site. However, concentration of glycine were the highest followed by alanine while the lowest value was recorded for ornithine.

Table. 6: Amino acid profile of Nile tilapia. The (M ± SD, n = 5) of the recorded value were reported in μmol/l.

Amino acid	Bore		Deneba	
	male	female	male	female
Glycine	1055.28 ± 58.69	1334.4 ± 47.97	1616.3 ± 90.4	1605.26 ± 71.99
Alanine	536.34 ± 28.71	530.95 ± 93.81	547.23 ± 14.57	510.58 ± 15.672
Valine	292.16 ± 76.33	322.92 ± 15.46	290.58 ± 10.42	250.702 ± 16.98
Leucine	417.65 ± 12.11	377.39 ± 15.96	443.57 ± 16.82	436.57 ± 18.64
Ornithine	7.98 ± 1.691	10.792 ± 3.38	8.341 ± 3.13	8.25 ± 1.36
Methionine	42.07 ± 7.27	32.67 ± 14.2	35.19 ± 2.32	35.83 ± 3.37
phenylalanine	107.92 ± 13.32	98.41 ± 5.21	90.95 ± 3.91	86.69 ± 2.41
Citruline	16.57 ± 2.3	15.23 ± 2.5	12.23 ± 1.07	11.72 ± 5.94
Tyrosine	104.15 ± 4.96	69.91 ± 15.35	74.57 ± 9.1	66.11 ± 5.45
∑AA	2580.12	2792.67	3118.9	3011.712

Though, no remarkable variation between sex and site highest values for total amino acid were observed in male fishes from deneba site and followed by female fishes from bore site.

4.5 Mineral Distribution

The concentrations of all minerals in each tissue of fish were summarized in Table. 14. Their concentration was determined from ash sample by using AAS. To solve the challenges with sample insufficiency sample of ash were pooled randomly to represent for each tissues irrespective of sex and size. Values of analyzed minerals in each tissue were determined in triplicates and reported as mean and standard deviation.

Table. 7: The distribution of selected minerals in different tissues of Nile tilapia. The value were determined and reported in mg/kg (Al, Cu, Fe, and Mn), in µg/Kg (Cd, Cr, Co, Ni and Pb) and for Zn, Mg, Na, S, P, K and Ca (mg/g). (M ± SD, n = 3).

Minerals	Tissues				
	Muscle	Gill	Skin	Stomach	Liver
Al	188.66±49.3	745 ± 38.38	217.33 ± 13.3	31739.6 ± 275.11	2939 ± 285.7
Cd	<2.5	<2.5	<2.5	<2.5	<2.5
Co	<10	<10	<10	21.2 ± 3.935	75.5 ± 33.37
Cr	13.43 ± 0.057	9.79 ± 2.57	15.5 ± 2.02	31.93 ± 1.95	99.05 ± 8.36
Cu	36.1 ± 10.97	13.16 ± 1.059	9.043 ± 1.91	83.93 ± 8.26	9529.4 ± 134.1
Fe	483.6 ± 99.14	3214 ± 35.9	405.66 ± 55.7	44096.3 ± 1299	16438.5± 505.5
Mn	23.96 ± 6.4	132.16±50.4	79.5 ± 2.306	3896 ± 13.3	367.5 ± 29.6
Ni	<20	<20	<20	60.76 ± 5.94	38.8 ± 2.68
Pb	<50	<50	<50	<50	<50
Zn	267 ± 43.03	346.66 ± 18.5	421 ± 48.5	486 ± 58.64	1152 ± 44.46
Mg	24.63 ± 1.33	7.96 ± 0.24	8.78 ± 0.475	486 ± 58.64	11.1 ± 1.272
Na	18.19 ± 1.42	33.13 ± 3.074	9.89 ± 1.6	70.53 ± 17.26	75.8 ± 23.75
S	1.065 ± 0.41	4.61±1.89	0.811 ± 0.038	4.08 ± 0.68	0.827 ± 0.45
P	184.6 ± 9.29	180.6±11.06	197.33 ± 2.08	65.76 ± 10.78	165 ± 9.89
Ca	36.8 ± 6.73	327.0 ± 10.81	349.0 ± 5.56	35.9 ± 4.71	20.65 ± 1.47
K	316.0 ± 6.84	34.53 ± 5.7	46.7 ± 7.27	77.63 ± 14.68	172.5 ± 26.16

The mineral content of each tissue were analyzed and thee were great difference between each tissues in their mineral concentration.

5. Discussion

5.1 Proximate composition of tissue Nile tilapia.

The knowledge of chemical composition of any edible organism is extremely important since the nutritive value is reflected in its biochemical contents. As fish of different species don't provide the same nutrient profile to their consumer, different tissues of the fish also don't provide the same nutrient profile to their consumer (Takama *et al.*, 1999). The biochemical composition of the fish muscle generally indicates the fish quality and also it is varies from one species to other species (FAO, 2012).

In present finding, moisture content of muscle tissue was in the range of previously reported values. Masresha (*et al.,* 2018), reported that the acceptable range of fish muscle moisture content in between 60 - 80%. This indicated the stable water levels in the environmental location, where the fish were collected. Similarly, Ahmed (*et al*., 2016) reported that the moisture content of Nile tilapia ranges (75.33 ± 1.15% to 79.30 ± 1.15%) which is comparable with the present report. Additionally, reports from Lake Ziway for *O. niloticus* were found within the same ranges with the present reports (Massresha *et al.,* 2018).

Although, there were no pronounced mean differences within the tissues both in the group of size and sex, the highest moisture content was recorded in the small size group compared to medium size. This finding is in agreement with the work of Alemu (*et al*., 2013), who reported that increase in size of the fish directly related with accumulation fat, but inversely related with moisture content. This could be explained that the bigger the fish the more it accumulate the fat, which is insoluble in water this which intern reduce the moisture content.

Comparing with other tissues muscle was rich in moisture content and ranked on the second next to stomach, but the moisture of the stomach is not fixed in which it depends on feeding types of fish. The percentage of moisture in muscle tissue is a good indicator of the relative energy, protein and fat contents (Barua *et al.,* 2012). The existence of an inverse relationship between moisture and fat contents that has been reported by several scholars (Barua *et al*.,2012; Alemu *et al*., 2013; Massresha *et al*., 2018) in which low moisture content is usually associated with the relatively high-fat content and vice-versa were clearly observed in present finding.

Ali (*et al.,* 2017) reported the moisture content of *Synagris japonicas* were (43.9%) and (47.1%) for ventral and dorsal region respectively which is contrary with present study. This might be *S. japonicas* were from marine while *O. niloticus* from fresh water in which they faced different osmoregulation mechanisms. This could be explained that fresh water fish has higher salt concentration inside their body which cause water from surround enter into the fish body due to osmosis that make higher water to be stored in their body. On the other hand marine fish challenged to store higher amount of water in their body due to the salt content in their blood is much lower than that of seawater, they constantly tend to lose water (Zadunaisky, 1996).

The protein compounds in fish are made up of all the essential amino acids, with an abundant amount of lysine and tryptophan (like milk, protein, eggs and meat of mammals), and this confirms a high biological value of the fish meat (Effiong & Fakunle, 2011). The present study agreed with the literature that muscle tissue of the fish is rich in protein content and it is the second major content next to water. In present finding crude protein content was ranged from (15.65 ± 0.32% to 17.87 ± 0.844%) which was found within the permissible value (15 - 28%) for fish and fisheries product (Massresha *et al.*, 2018). On the other hand, the results recorded in small size were relatively higher compared with medium size, since there were no pronounced differences.

Emire & Gebremariam, (2009) reported that the crude protein content of Nile Tilapia ranges between (18.52 ± 0.08%) and (17.25 ± 0.09%) which is not coincides with the present study. It was probably due to water body difference which indicated food, temperature, PH, and different factors variation. Visentaine (*et al.,* 2005) reported that feeding conditions has association with proximate composition. However, it is in agreement with muscle protein content of the Nile Tilapia reported by Tsegaye *et al.*,(2016) from Ashenge and Tekeze reservoir.

Additionally, compared with other tissues highest protein content was observed in the muscle tissues of the fish following skin. This is may be due to muscle of the fish contain highest moisture content than skin and negative correlation was observed between protein and moisture content. On the other ways, skin stored more dried matters which have high protein as a major content than moisture content compared to muscle tissue. The present study informed that muscle is a good source of protein for the consumers and dietary supplements.

On the other hand, the values recorded for crude fat were ranged in between (0.71 ± 0.01% and 0.82 ± 0.038%) which was lowest value compared to other tissues. The results agreed with the work of (Barua *et al.,* 2012; Alemu *et al.,* 2013; Massresha *et al.,* 2018) who have reported the group with high moisture content is resulted in low crude fat content. The variation was due to inverse relationship between moisture content and crude fat and also muscle is the site of high metabolic rates. Additionally, SIMÕES *et al*. (2007) assessed the physical and chemical composition of tilapia fillet in Thai strain and found moderate lipid and high protein contents, and characterized tilapia as fish with intermediate fat and high protein contents. Compared to the present studies low fat were found with high protein contents. A variation might be due to seasonal variation, types of food they feed, stage life of the fish and others factors.

The values for Ash were ranged from (1.12 ± 0.0062%) for the small sized male muscle to (1.28 ± 0.06%) for small sized female muscle. The findings agreed with literature reports of (Massresha *et al.,* 2018) and it indicates muscles are good source of minerals like calcium, potassium, zinc, iron and magnesium. However, compared to other tissues the lowest value for Ash percentage was recorded in muscle. This might be related with the ability of muscle to store mineral in which less amount of mineral were found due to high metabolic rate of the muscle compared to others tissues.

Skin is one of the tissues that traditionally consumer discarded as residue. The results for the skin tissues indicated consumer was losing many important nutrients by discarding this tissue. Moisture content in the skin tissues were varied from (69.39 ± 1.99% to 69.86 ± 0.60%) in which relatively higher value were recorded in small size compared to medium size. While the oppose value were registered for crude protein in which higher value were recorded in medium size versus small size. Comparing with other tissues skin was stored more dry matter with protein as major content and less moisture. It was probable due nature of the skin and inverse relation of moisture and protein.

Based on the crude fat value of skin that ranges from (2.20 ± 0.048% to 2.24 ± 0.146%) the fish was grouped to low fat fish (2 - 4%) (Ackman, 1989). Although, there was no pronounced difference, relatively medium sized group had higher fat content than small sized which was in accordance with reports of (Toppe *et al*., 2006; Alemu *et al*., 2013).

On the other hand, maximum value (4.011 ± 0.265%) ash content was registered for medium size female and minimum value (3.95 ± 0.079%) was recorded for small size male. Skin tissues were ranked on the second next to stomach based on ash values which indicates as the good source of minerals. Additionally, highest values of carbohydrate were estimated for skin which ranges from (2.41 ± 0.050%) to (2.45 ± 0.16%) compared with other tissues.

The findings for stomach tissues of proximate composition revealed the highest moisture (81.41 ± 0.901%) was recorded in small size female and lowest value (80.23 ± 0.25%) was recorded in male medium size which was very close to the value recorded for muscle. However, percentage of crude protein in the stomach were lowest than the rest tissue which ranges between (7.49 ± 0.36%) and (7.97 ± 0.103%) and also below the permissible value (15 - 28%) of protein for fish and fishery products (Massresha *et al*., 2018). On the other hand the result found for the ash content was higher that ranges from (6.79 ± 0.32% to 7.24 ± 0.09%) than the rest tissues. Stomach has high potential to store mineral that was the indication for highest value of ash recorded and the findings was agreed with the reports of Uysal, (2011). Crude fat is also ranged from (3.27 ± 0.15%) to (3.48 ± 0.11%). This was found within the same ranges with the reports of Ali (*et al*., 2017) on dorsal and ventral region of *Synagris japonicas*.

Gills are the most important organ that used to performing vital functions such as gas exchange and ion osmoregulation. The moisture content in gill was ranged from (75.39 ± 0.77% to 77.83 ± 1.1%7) which was the second lowest value recorded next to skin and agreed with the reports of Kebede and Wendimu, (2004). Next to stomach the lowest crude protein was recorded in the gill tissues of the fish which varied from (10.34 ± 0.5% to 10.8 ± 1.14%) for each group of the fish. Compared to the reports of Benu and Noorjhan, (2017) on *Trichogaster trichopterus* gill which ranges (2.03 ± 2.57% to 6.9 ± 2.57%) the highest protein values were found in the gill of Nile tilapia. This is probably due to species variation and water bodies. In today's study highest crude fat was recorded for the gill comparing with the rest tissues that ranged between (7.13 ± 0.3760%) for small size male and (7.92 ± 0.24%) in medium size female. The inverse relation between moisture content and fat also clearly observed that agreed with reports of different researchers (Kebede and Wendimu, 2004; Hantoush, 2015; Ahmed, 2016; Massresha *et al.*, 2018).

According to the value of the crude fat for gill the fish was grouped in to moderate fatty fish (4 - 8%) (Ackman, 1989). On the other hand ash content which is the good indicator of mineral presence was varied between (3.37 ± 0.17% to 3.74 ± 0.11%). While the value recorded for the carbohydrates were ranged from (1.3 ± 0.07% to 1.45 ± 0.04%). Compared with other tissues the value recorded for the gill was low except for crude fat and it was probably due to gills was most affected organ than that of other tissue by environmental factors (Benu and Noorjhan, 2017). Based on the present study better for the consumer to prefer gill as source fat.

In present investigation, moisture content of the liver within the tissues had no remarkable differences compared to other tissues and also the values were very close to each other for each group fish tissue that ranged from (79.26 ± 0.37% to 79.92 ± 0.62%). The same results were reported by Kebede & Wendimu, (2004) from Lake Ziway and Awassa on Nile tilapia. The crude proteins found within the liver tissue were ranged between (12.31 ± 0.38%) and (12.7 ± 0.23%) which was below the permissible value (15 - 28%) of protein for fish and fishery products (Massresha *et al*., 2018). The value of crude protein (4.76 ± 0.45%) reported by Benu and Noorjhan, (2017) on *Trichogaster trichopterus* liver were lower compared to present studies of liver protein. The reason behind was the liver of *T. trichopterus* were highly contaminated by pollutants which in turn reduced the protein storing capacity of the tissue.

However, crude fat percentage were better compared to other tissues which ranged from (3.04 ± 0.094%) for medium size female to (3.14 ± 0.057%) for medium size male liver of the fish. The result recorded for the fat liver in present study were low compared to findings reported by Pilla, (2014) on *Lutjanus Johni* of liver tissues which ranges between (5.01 ± 0.24%) and (8.24 ± 0.49%). The variation could be due to different species, feeding type and environmental condition variation.

The ash value also shows no great difference within the tissues but there were remarkable variation compared to other tissue. It was possible to predict liver is good source of mineral based on the value recorded for the ash that ranges between (3.2 ± 0.09%) and (3.3 ± 0.06%) and the results for mineral was agreed with the ash values. Additionally, the estimated value for carbohydrate was ranged between (1.508 ± 0.04%) and (1.55 ± 0.04%).

On the other hand the value recorded for all others parameters crude protein, crude fat, ash content and carbohydrates shown great difference between each tissue. In which lowest CP (7.49±0.36) within stomach and highest (21.89±121) with in skin, lowest CF (0.71±0.003) with in muscle and highest (7.92±0.24) within gill, lowest ash (1.12±0.023) within muscle and highest ash (7.24±0.09) within stomach were recorded. The correlation test shown crude protein of skin was perfectively positive correlated with crude fat of skin, ash of skin and carbohydrate of skin. While moisture content of liver shown perfectively negative correlation with crude fat, crude protein and carbohydrates value recorded for liver. In each tissue Moisture content has shown perfectively negative correlation with crude protein, crude fat, ash content and carbohydrates. While perfectively positive correlation were observed between the others parameters (protein, fat, ash and carbohydrate) within each tissue (Appendix One).

5.2 Amino Acid and Fatty Acid

5.2.1 Amino acid

In present study the amino acid profile was analyzed from fish blood. Out of nine identified amino acid, leucine, methionine, phenylalanine and valine where essential amino acid while Glycine and Tyrosine are conditionally essential. On the other hand the value recorded for amino acid shown Glycine was the predominated with the value recorded (1616.3±905.4 µmol/l) from male Bore site and followed by Alanine with value recorded (547.23±141.57 µmol/l) from same site and sex. From essential amino acid leucine were the predominate (417.65±128.11 µmol/l.) and followed by valine (292.16±76.33 µmol/l) while methionine recorded the lowest value (42.07±7.27 µmol/l).

From previous reports by Suvitha *et al.*, (2015) on five different marine fish phenylalanine were the predominate and followed by lysine and Iso-leucine from EAA. Kumaran *et al.*, (2012) were studied the essential and non-essential composition on *M. cephalus*. In this species ten essential amino acid and eight non-essential amino acids were detected. Among eight amino acid, glutamic acid and aspartic acid are found as a predominant components in *M. cephalus.* The result disagreement with present study's may be due to sampling difference, feeding and site difference of the fish species. In present studies in the data recorded for all amino acid there were no great difference between each site and sex. Though, there were great differences, the value recorded for the male were higher than female.

5.2.3 Fatty acid

In today's study eleven saturated fatty acid and seven unsaturated fatty acid were identified from the blood of fish. From which Linoleic acid (C18:2) and Tetradecenoylcarnitine (C14:2) were polyunsaturated fatty acid and the rest five were monounsaturated fatty acid. The composition of fatty acid profile of Nile tilapia shown higher percentage were found to be saturated fatty acid and followed by MUFA and PUFA. It was in accordance with the reports of (Suloma *et al*., 2008; Abelti, 2017).

Highest total saturated fatty acid were observed from the blood of female Bore site and followed by Male Deneba site. Additionally, the total saturated fatty acids identified were ranged from (1.719 µmol/l) to (2.584 µmol/l). Of saturated fatty acid, Butanoic acid were found to have the greatest value and followed by Pentanoic acid from short chain fatty acid. While previous reports indicated Hexadecanoic acid or palmitic acid (C16:0) were the predominated from saturated fatty acid (Sriket*et al*. 2007;Orban *et al.*,2008; Usydus *et al*., 2011; Abelti, 2017) and in agreement with current studies for long chain fatty acid. Tetradecanoic acid (14:0) which implicated in hypercholesterolemia in humans (Fernandes *et al.*, 2014) where found in lower value and low amounts are beneficial to human health. On the other hand the value for Octadecanoic acid (C18:0) where ranged from (0.038 ± 0.007 µmol/l) to (0.128 ± 0.01 µmol/l). However, comparing with myristic acid and palmitic acid; stearic acid (C18:0) is regarded as a neutral fatty acid which has no effect on blood cholesterol levels in human (Hodson *et al.*, 2008).

Regarding unsaturated fatty acid the value recorded where ranged from (0.0885 µmol/l) to (0.105 µmol/l). Relatively from MUFA the value for oleic acid where higher in all site and sex which is directly related to dietary FA content and depends on the metabolism of species (Rodrigues *et al.*, 2017). Tetradecenoylcarnitine (C14:2) and Linoleic acid (C18:2) where the two polyunsaturated fatty acid identified in today's study, that ranged between (0.015 and 0.02 µmol/l). Dietary intake of PUFA plays an important role in human health and reported as preventing several diseases, mainly of the cardiovascular system (Nachi *et al.*, 1998).

5.3 Distribution of mineral in different tissues of fish.

In present study sixteen different minerals were identified in five different tissues of Nile tilapia. Among the identified both essential and toxic minerals were considered. The values recorded for each mineral were significantly different between each tissue except Co, Cr and Cu. It indicated their accumulation concentration were tissues specific that the highest concentration of each minerals were recorded in Liver, stomach and gill while the lowest value were recorded in muscle and skin. The results were in accordance with (Kebede & Wondimu, 2004; Uysal, 2011) reports.

All tissues were accumulated higher concentration of Fe and Al. Mean concentration mg/Kg of Fe were ranged between (483.6 ± 99.14) and (44096.3 ± 1299.2). However, Uysal, (2011) reported the concentration of Fe stored were ranged from (4.42 to 137.17 mg/kg) with in different tissues of five species fish which is contrary with present findings. This might be due to species difference, type of food and habitat factors or the ability of the species to absorb the minerals from diet.

Additionally, the highest value of Fe were recorded in stomach and followed by liver and gill while the lowest values were recorded in muscle and skin. The same reports were from Uysal, (2011). Stomach stored more Fe comparing with other tissue because of intestinal mucosa is a major site to absorb Iron (Watanabe *et al.*, 1997). Moreover, the reason for high concentration of Fe storing liver might be related with blood synthesis function of the organ.

On the other hand, Fe has an active part in oxidation/reduction reactions and electron transport which associated with cellular respiration and its deficiency could causes anemia (Roos *et al.*, 2007).Though, the registered values in all tissues were above allowed level of Fe daily intake; stomach, liver and gill are a very rich source of Fe for those individuals infants over 6 months, toddlers, adolescents and pregnant women (due to high requirements), older people and people consuming foods high in iron absorption inhibitors (due to poor absorption) and menstruating women or individuals with pathological blood loss (due to high blood losses) (EGVM, 2003).

The value detected for Cd and Pb were below 2.5 and 50 µg/Kg respectively for all tissues. Both Cd and Pb were known for their toxicity in organisms and their concentrations in all tissues were below the recommended dietary intake by European guideline standards (EFSA, 2006).Nickel concentration was less than (20 µg/Kg) in Gill, muscle and skin. However it was (60.76 ± 5.94 µg/ kg) in stomach and (38.8 ± 2.68 µg/kg) in liver. The recorded values were above the tolerable daily intake (2.8 µg/Kg) by (EFSA, 2015) in all tissues. On the other hand, the concentration of cobalt recorded in gill, skin, and muscle were similar (that was less than 10 µg/Kg) while (21.2 µg/kg) in stomach and (75.5 µg/Kg) in liver. The values recorded in gill, skin and muscle were below the tolerable limit of daily cobalt intake recommended (14 µg/Kg) by (EFSA, 2012). Moreover, highest concentration of Cr were stored by liver and followed by stomach while lower concentration in gill, skin and muscle. The recorded values were less than the recommended upper limit intake (25 – 35 µg/Kg) by (EFSA, 2006) except in liver.

Next to iron the highest concentration values were recorded for Aluminum in all tissues and there were significant difference among the tissues. On the other hands, concentration of Cu accumulated by liver was extremely high (9529.4 ± 134.18 mg/Kg) comparing with other tissues. Similar reports was by Kebede & Wondimu, (2004) on Lake Ziway and Lake Awassa for the distribution of trace minerals in different tissues of Nile tilapia shows that the concentrations of copper stored by liver was very high compared to other tissues. This might be due to copper has a role as being part of enzymes and the detoxification capacity of the organ by producing copper binding metallothionien (Cohen *et al*., 2001). Furthermore, the recommended Cu daily intake was 0.9 mg/day (EFSA, 2006). Therefore, it is important to be careful in the consumption of fish liver due to the high content of heavy metal (Uysal, 2011) unless it was from clean environments.

The values recorded for Mn was significantly different between each tissue in which highest value recorded (3896 ± 13.3 mg/Kg) in stomach and followed by liver (367.5 ± 29.6 mg/Kg). Uysal, (2011) reported no Mn was detected in the muscle tissue of the fish while gill of *R. rutilus* and *C. carpio*, the intestine of *C. carassius* were accumulated highest Mn. An inadequate supply of manganese usually results in retardation of growth (Watanabe *et al*., 1997).

In present study the value recorded for Zn, Na, Mg, K, Ca, P and S were reported in mg/g. Highest Zn were accumulated in liver and followed by stomach. A similar report was by Uysal, (2011). Zinc plays a central role in the immune system, affecting a number of aspects of cellular and Humoral immunity. However, zinc deficiency in humans is results in growth retardation, delayed sexual and bone maturation, skin lesions and etc. (FAO, 2001). Therefore, the present study indicated liver and stomach were a very rich source of Zinc. However the values ranged for Zn in all tissues was above upper limit in take recommended (7-14 mg) by (EFSA, 2006).

Mg is an essential element for human as a co-factor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis that have highest value (486 ± 58.64 mg/g) in stomach. Except in stomach all value recorded in other tissues were below upper tolerable limits of magnesium intake (380 mg). The same values were reported by Jim *et al.*, (2017) for Nile tilapia muscle. On the other hand, phosphorus also showed pronounced difference between each tissue. Furthermore, highest level of phosphorus was accumulated by skin while it was lowest in stomach. Phosphorus is widely found in foods as phosphates; especially foods rich in protein are usually high in phosphorus. Its range is vary in different nutrients in which it varied in dairy products (100-900 mg/100 g), meats (200 mg/100 g), fish (200 mg/100g) and grain products (100-300 mg/100 g) (EFSA, 2006). Moreover, the accumulated concentration of phosphorus in all tissues was below recommended value of daily intake that is 700 mg/day for adults and up to 1250 mg/day for adolescents (10-19 years) (EFSA, 2006).

Calcium is a bone mineral, which provides structure and strength to the body. It is tissue specific accumulated in which skin, gill and stomach accumulated more and less in muscle and skin. On the other hand, calcium levels in the body are under control of genetic and hormonal factors. Therefore an excessive accumulation of calcium in blood or tissue solely through excessive calcium consumption should not occur in the absence of diseases such as bone cancer, and hyperparathyroidism or in the absence of excessive vitamin D intake (Whiting and Wood, 1997). The recorded values for calcium level in all tissues were below the recommended values range for human daily intake that range up to 1200mg/days (EFSA, 2006).

In present findings compared with all other minerals muscle stored more potassium than other tissues. This might be due to a large proportion of the body pool of potassium is found in muscle. On the other hand, potassium can be used to balance acid-base level and it is the main intracellular cation. The values registered in all tissues were below the recommended value which range 3.1-3.5 g/day.

In today's study the level of accumulation of identified minerals in each tissue were put as follows by their descending order. For Al Stomach > liver > gill > skin > muscle, for Cr liver > stomach > skin > muscle > gill, for Cu liver > stomach > muscle > gill > skin, for Fe stomach > liver > gill > muscle > skin, for Mn stomach > liver > gill > muscle > skin, for Zn liver > stomach > gill > skin > muscle, for Mg stomach > muscle > livers > skin > gill, for Na liver > stomach > gill > muscle > skin, for S gill > stomach > liver > skin > muscle for Ca skin>gill>muscle>stomach>liver, for K muscle>liver>stomach>skin>gill for P skin>muscle>gill>liver>stomach.

In generally the highest concentration of mineral were accumulated in stomach of Nile tilapia and followed by liver. While the concentration of mineral recorded in skin and muscle of the fish were lower. This in agreement with previous reports (Uysal, 2011; Kebede & Wondimu, 2004; Bashir & Alhemmali, 2015; Silva *et al.,* 2016). There are two factors that affecting mineral distribution in different tissues of the fish. One is the physiological role of each element, and the other is the preference of an element to bind to or replace some elements in the tissue (Kebede & Wondimu, 2004). Additionally, Silva *et al*., (2016) reported the accumulation of higher amount of mineral in gill and liver were due to their low metabolic activities while lower amounts of mineral were accumulated in muscle due to its high metabolic activities. On the other hand, the physicochemical parameters of the reservoir revealed that the water bodies in good condition that can able to help the fish to survive (Appendix, 4).

6. Conclusion and Recommendation

6.1 Conclusion.

In the present study, all the targeted tissues of *O. niloticus* showed high nutritional value. However, remarkable variations were observed between targeted tissues in its proximate composition. Relatively higher proteins were accumulated in skin and muscle. On the other hand, gill accumulated more crude fat and highest ash concentrations were accumulated by stomach. The variation of each parameter in each tissue indicated different tissues were preferable for different source of nutrition. But mostly except muscle parts the other tissues were discarded as residue. The present study’s indicated that most important nutrients were lost with discarded parts. Additionally, the results of fatty acid and amino acid profile shown Nile tilapias were good source of PUFA and essential amino acid. Moreover, the accumulations of mineral were tissue specific. Relatively highest mineral concentration were accumulated by stomach and followed by liver and the value confirmed with the results of ash, used to estimate mineral accumulation. On the other hand, those tissues with high concentration of mineral can be a good indicator of water quality and environmental conditions. However, lowest values were recorded in muscle and skin. Among identified minerals from muscles and other tissues of Nile tilapia some of them were toxic and their concentrations were above recommended in take limit by European food safety authority in liver and stomach. But the guideline value of upper intake limit of mineral is not similar across the country. Therefore in order to determine the safety of the fish resources from Ethiopian water bodies, it’s imperative to establish national standards that consider the geographical location, feeding habits and atmospheric conditions of the consumer.

6.2 Recommendation

1. To encourage preference and consumption of targeted tissues of the fish, it is important that the consumers should be oriented about the nutritional value of discarded tissues.

2. Without concern to toxic elements, tissue of fish species analyzed in present study could be recommended for consumption to supplement deficiency of elements such as Fe, Cu, Zn and proximate composition.

3. The concentration of minerals (Cr, Co, Cu and Ni) was seen to be higher than the upper intake limit values of ESFA, (2006). Weather the measured values of these trace elements become toxic to the consumer require a comprehensive assessment of food, water and air.

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Appendix one: the results of for the correlation of proximate composition parameters between each tissue.

	MCS	CPS	CFS	AshS	CHOS	MCL	CPL	CFL	AshL	CHOL	MCst	CPst	CFst	Ashst	CHOst	MCgil	CPgil	CFgil	AshGil	CHOgil	MCm	CPm	CFm	Ashm	CHOm
MCS																									
CPS	-1.00**																								
CFS	-1.00**	1.00**																							
AshS	-1.00**	1.00**	1.00**																						
CHOS	-1.00**	1.00**	1.00**	1.00**																					
MCL	-0.18	0.18	0.18	0.18	0.19																				
CPL	0.18	-0.18	-0.18	-0.18	-0.2	-1.00**																			
CFL	0.18	-0.18	-0.18	-0.18	-0.2	-1.00**	1.00**																		
AshL	0.18	-0.18	-0.18	-0.18	-0.2	-1.00**	1.00**	1.00**																	
CHOL	0.18	-0.18	-0.18	-0.18	-0.2	-1.00**	1.00**	1.00**	1.00**																
MCst	0.39	-0.39	-0.39	-0.39	-0.4	0.69	-0.69	-0.69	-0.69	-0.69															
CPst	-0.39	0.39	0.39	0.39	0.38	-0.69	0.69	0.69	0.69	0.69	-1.00**														
CFst	-0.39	0.39	0.39	0.39	0.38	-0.69	0.69	0.69	0.69	0.69	-1.00*	1.00**													
Ashst	-0.39	0.39	0.39	0.39	0.38	-0.69	0.69	0.69	0.69	0.69	-1.00*	1.00**	1.00**												
CHOst	-0.38	0.38	0.38	0.38	0.37	-0.7	0.7	0.7	0.7	0.7	-1.00*	1.00**	1.00**	1.00**											
MCgil	0.47	-0.47	-0.47	-0.47	-0.5	-0.32	0.32	0.32	0.32	0.32	-0.03	0.03	0.03	0.03	0.04										
CPgil	-0.47	0.47	0.47	0.47	0.48	0.32	-0.32	-0.32	-0.32	-0.32	0.03	-0.03	-0.03	-0.03	-0.04	-1.00**									
CFgil	-0.47	0.47	0.47	0.47	0.48	0.32	-0.32	-0.32	-0.32	-0.32	0.03	-0.03	-0.03	-0.03	-0.04	-1.00*	1.00**								
AshGil	-0.47	0.47	0.47	0.47	0.48	0.32	-0.32	-0.32	-0.32	-0.32	0.03	-0.03	-0.03	-0.03	-0.04	-1.00*	1.00**	1.00**							
CHOgil	-0.47	0.47	0.47	0.47	0.47	0.31	-0.31	-0.31	-0.31	-0.31	0.03	-0.03	-0.03	-0.03	-0.04	-1.00*	1.00**	1.00**	1.00**						
MCm	0.14	-0.14	-0.14	-0.14	-0.2	0.05	-0.05	-0.05	-0.05	-0.05	-0.11	0.11	0.11	0.11	0.1	-0.21	0.21	0.21	0.21	0.22					
CPm	-0.18	0.18	0.18	0.18	0.18	-0.06	0.06	0.06	0.06	0.05	0.06	-0.06	-0.06	-0.06	-0.05	0.18	-0.18	-0.18	-0.18	-0.18	-1.00**				
CFm	-0.18	0.18	0.18	0.18	0.18	-0.06	0.06	0.06	0.06	0.05	0.06	-0.06	-0.06	-0.06	-0.05	0.18	-0.18	-0.18	-0.18	-0.18	-1.00**	1.00**			
Ashm	-0.18	0.18	0.18	0.18	0.18	-0.06	0.06	0.06	0.06	0.05	0.06	-0.06	-0.06	-0.06	-0.05	0.18	-0.18	-0.18	-0.18	-0.18	-1.00**	1.00*	1.00**		
CHOm	0.22	-0.22	-0.22	-0.22	-0.2	0.02	-0.02	-0.02	-0.02	-0.02	0.51	-0.51	-0.51	-0.51	-0.5	0.49	-0.49	-0.49	-0.49	-0.49	-.73*	0.67	0.67	0.67	1

Where mcs: moisture content of skin; cps crude protein of skin; Ashs ash of skin ; CHOs carbohydrate of skin; mcl moisture content of liver; cpl crude protein of liver; Ashl ash of liver; chol carbohydrate of liver; mcst miosure content of stomach; CPst moisture content of stomach; CFst crude fat of stomach; CPst crude protein of stomach; Ashst ash of stomach; CHOst carbohydrate of stomach; MCgill moisture content of gill; CPgill crude protein of gill; CFgill crude fat of gill; Ashgil ash of gill; CHOgill carbohydrate of gill; MCm moisture content of muscle; CPm crude protein of muscle; CFm crude fat of muscle; Ashm ash of muscle; CHOm carbohydrate of muscle.

Appendix two.Physicochemical properties of the reservoir.

Physicochemical parameters	Water Body site	
	Dam 1	Dam 2
Temperature ()	28.47±0.93	27.97±2.14
DO (mg/l)	6.63±0.445	8.03±1.33
Oxygen saturation	104.45±5.99	125.22±17.023
Conductivity (uS/cm)	104.45±5.99	83.2±4.36
PH	8.03±0.33	8.03±0.33
Turbidity (NT)	27.57±1.2	52.8±23.72
COD (mg/l)	12.12±0.85	12.85±0.506
NO3-N (mg/l)	0.209±0.089	0.212±0.027
PO4-P (mg/l)	0.037±0.012	0.06±0.043
NH4-N (mg/l)	0.098±0.02	0.1±0.0079
Chloride (mg/l)	9.24±0.96	9.24±0.96
TP (mg/l)	0.12±0.018	0.127±0.012
TDS (mg/l)	85.33±3.78	82.5±2.88

Data source (Bekan, 2018).