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# Proximate composition and mineral contents of Pebbly fish, *Alestes baremoze* (Joannis, 1835) fillets in relation to fish size

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## Abstract

***Alestes baremoze* (Joannis, 1835), locally known as Angara in Uganda, is native to fresh water systems in Africa, thriving well in both lacustrine and riverine conditions. It is part of the routine diets of families in northern Uganda, South Sudan, the Sudan and the Democratic Republic of Congo. The objective of this study was to determine the proximate composition and mineral contents of *A. baremoze* fillets according to fish size. The mineral contents of *A. baremoze* from Lake Albert were analysed using standard procedures. The fish samples were categorised into three size-groups; <1 kg (880–990g), 1-1.5 kg and 1.6-2.5 kg. On wet weight basis, there were no significant differences (p>0.05) in crude protein and ash content among the different fish sizes. However, there were significant differences (p<0.05) in crude fat, carbohydrate, gross energy and vitamin A. Crude fat (0.35%), carbohydrate (0.37%) and gross energy (597.6 Kcal/100 g) were significantly higher in medium sized fish (1 to 1.5 kg) compared with the larger fish category. Vitamin A contents of different fish sizes ranged from 55.1 to75.3 µg RAE/100g. The contents of magnesium and iron were highest in sizes <1 kg (5.34 mg/100 g) and (3.58 mg/100 g), respectively. It was observed that potassium content (339.33 mg/100 g) and calcium (29.75 mg/100 g) were significantly higher (p<0.05) in fish >1.5 kg. These findings suggest that taste, freshness and other related external appearances should not be the only factors to be considered in making choice for marketing and consumption of *Alestes baremoze*.**

**Key words:** *Alestes baremoze*, Lake Albert, mineral content, proximate composition

## Introduction

Fish is known to be one of the cheapest sources of animal protein and other essential nutrients required by many people, especially in developing countries. It is widely consumed because it has high protein content, low saturated fat and also contains omega fatty acids known to support good health (Erkan and Ozden, 2007). The nutritional value of fish meat comprises the contents of moisture, protein, lipids, vitamins, minerals and the caloric value (Chandrashekar and Deosthale, 1993). Minerals components such as potassium, magnesium, calcium, iodine, phosphorus are important for human nutrition (Erkan and Ozden, 2007). However, the nutritional components of the fresh water fishes tend to differ

between species, sexes, sizes, seasons and geographical localities (Huss, 1995; Zenebe *et al.,* 1998). The measurements of some proximate profiles such as protein contents, carbohydrates, lipids, moisture contents and ash percentagesare often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000).

*Alestes baremoze* (Joannis, 1835) is native to fresh water systems in Africa, thriving well in both lacustrine and riverine conditions. It belongs to order Characiformes and family Alestidae (Akinyi*et al.,* 2010). It is highly marketable and highly value fish in northern Uganda, South Sudan, Sudan and the Democratic Republic of Congo (Kasozi *et al.,* 2013). In Uganda, *A. baremoze* gross value increased from US$1.2 million in 2007/08 to 1.7 in 2012, from catches harvested from Lake Albert (Mbabazi *et al.*, 2012). Despite being an important regional foreign exchange earner and a delicacy in the zone, there is currently no information available on its nutritional composition, yet consumers are interested not only in whether this fish tastes good, but also its nutritional value. With the anticipated development of *A. baremoze* aquaculture in Uganda, generating knowledge on the nutrient composition will become of significant practical interest. It is, therefore, important to generate nutritional data on this fish in order to make use of it as food and also develop suitable processing method. This study determined the proximate composition and mineral contents of *A. baremoze* fillets based on fish size.

## Materials and methods

### *Sample collection and preparation*

Eighteen fish of various sizes were caught from Lake Albert, at Abok landing site (02° 14.46‘N 31°19.15‘E) using 3" beach seine net. The samples were divided into three groups according to total weight; namely <1 kg, 1-1.5 kg and 1.6-2.5 kg. Then, the samples were beheaded, gutted, washed and filleted. The fish fillets were immediately transported in ice cooled boxes to the Department of Food Technology and Nutrition, Makerere University for laboratory analysis. All procedures on determination of moisture content, crude protein, fat and minerals were performed in triplicate, using the method described by AOAC (2000).

### *Proximate composition*

Moisture content was determined using the dry oven method according to the AOAC (2000). For each size group, 5 g of homogenised samples were weighed out in triplicate into preconditioned moisture dishes. The dishes with samples were placed in oven and dried for 16 hours at 98 °C, as this temperature avoids loses of volatile food components (Pearson, 1976). After the 16 hr of drying, the dishes were cooled down in desiccators and the moisture content of the samples calculated accordingly.

Crude protein was determined by the Kjeldahl methods using sulphuric acid for sample digestion. Total nitrogen was quantified by titrating the distillate against 0.05 M hydrochloric acid. Methylene blue and methyl red mixture was used as indicator. Crude protein was determined by multiplying the nitrogen value by the

conversion factor of 6.25. Crude fat was obtained by exhaustively extracting 2.0 g of each sample in a Soxhlet apparatus using petroleum ether (b.p. 40 - 60 °C) as the extractant (AOAC, 2000).

Carbohydrate was hydrolysedwith acid and the absorbance was read in spectrophotometer at the specific wave length of 470 nm. Ash content was determined by igniting the sample for 12 hr in a furnace at 525°C. For vitamin A content, total carotenoids content were determined using the Harvest Plus method and the absorbance of the carotenoids were read in spectrophotometer at the specific wave length of 450 nm. This value was then converted to Vitamin A by dividing it with12 conversion factor. Vitamin A was expressed asretinol activity equivalent (RAE).

***Mineral analyses***

The preparation of samples for mineral elements analysis followed a method described by AOAC (2000). Approximately 5 g of each sample (wet weight) were placed in a Teflon digestion vessel and double acid digested with nitric acid ($HNO_3$) and perchloric acid ($HCLO_4$). Samples were then analysed for mineral contents of iron (Fe), manganese (Mn), zinc (Zn), potassium (K), calcium (Ca) magnesium (Mg) andmanganese (Mn) using the Atomic Absorption Spectrophotometer (Shimadzu AAS, AA-6300). Total phosphorus was determined by spectrophotometric vanadium phoshomolyb date method. The concentration of iodine was determined by iodo-titrimetric method. The samples for total mercury analysis were treated with conc. nitric acid, sulphuric acid, hydrogen peroxide, potassium permanganate and Hydroxylamine hydrochloride before being analysed by cold reduction vaporisationAtomic absorption spectrophotometric Method (Shimadzu AAS, Model AA-6300 and Mercury Vapor Unit, MVU-1A).

***Statistical analysis***

Results were subjected to analysis of variance (ANOVA) using SAS statistical software (Stata Corporation, Texas, and USA). Multiple comparisons of means were done using the Duncan method and p-values<0.05 were considered statistically significant. Data are expressed as milligram per 100 gramme wet samples.

## Results and discussion

***Proximate composition***

The proximate composition of the analysed samples is shown in Table I. There were significant differences ($p<0.05$) in gross energy, vitamin A, carbohydrate, moisture and crude fat among the different sizes. In comparison with other fresh water species, Okeyo *et al.* (2009) reported that the chemical composition of Nile perch from Kenya was 78.5% moisture, 19.8% protein and 0.63% ash. Effiong and Fakunle (2013) found proximate composition of experimental samples from Nigeria to comprise 78.19% moisture; 17.38% crude protein for *lates niloticus*, 78.17% moisture; 19.83% for *Clarias gariepinus* and 79.40% moisture; 18.38% crude protein for *Oreochromis niloticus*.

The main constituent of fish flesh is water, which usually accounts for about 80% of the weight of a fresh white fish fillet (Murray and Burt, 1969). The highest moisture content of 75.5% in thisstudy was recorded from fish <1 kg weight. There were significant differences ($p<0.05$) in moisture contents between different sizes. Moisture content decreased with increased size of the fish. In comparison

**Table 1. Proximate analysis of *A. baremoze* fillets according to sample sizes in a study in Uganda**

| Chemical composition | Fish size classes (kg) | | |
|---|---|---|---|
| | Below – 1 | 1–1.5 | 1.6–2.5 |
| Moisture content (%) | 75.54±0.11[a] | 74.56±0.36[b] | 72.17±0.13[c] |
| Crude protein (%) | 18.01±0.51[a] | 17.77±0.27[a] | 18.44±0.37[a] |
| Crude fat (%) | 0.21±0.06[ab] | 0.35±0.1[a] | 0.13±0.1[b] |
| Ash content (%) | 7.56±0.30[a] | 7.34±0.44[a] | 7.25±0.12[a] |
| Carbohydrate (%) | 0.06±0.008[a] | 0.37±0.021[b] | 0.27±0.01[c] |
| Gross energy (Kcal/100g) | 546.5±1.7[a] | 597.69±1.3[b] | 576.08±3.3[c] |
| Vitamin A µg RAE/100g | 55.10±0.56[a] | 74.70±0.42[b] | 75.3±0.10[b] |

Means with the different letters in the same row are significantly different (P<0.05). Data are represented as means ± standard deviation

with other findings, Islam and Joadder (2005) reported that the moisture content of fresh water Gobi (*Glossobobius giuris*) increased as the length of fish increased from 18 cm to 20 cm. Different researchers have also reported that moisture contents can vary with sex of the fish (Amer *et al*., 1991; Islam and Joadder, 2005; Alemu *et al.,* 2013). The slightly lower moisture content of larger fish in the present study can be attributed to muscles containing more organic materials and less water than the young fish.

The protein values in the present study were in the range of (17-18%) and showed no significant differences (p>0.05) between different sizes. These values indicate that *A. baremoze* is a good source of protein. Olagunju *et al*. (2012) showed the same trend of crude protein for Tilapia (18.8%). Proteins are the second most important fish constituent (FAO, 2005). Fish protein is an excellent source of lysine, methionine and cysteine and can significantly raise the value of cereal-based diets, which are poor in these essential amino acids. The amount of protein in fish muscle is usually between 15 and 20%, even though in rare cases it has been found to be as low as 13.5% or as high as 28% (Murray and Burt, 1969).

Fat content was in the range 0.13 - 0.35% (Table 1). There was a sharp increase in fat content in growing fish within the range 1-1.5 kg and this could be attributed to gonad development and spawning. Lipids are known to play a number of roles in formation of vitellogenin, insulation of organ and buoyancy. MacFarlane *et al*. (1993) investigated the role of accumulated lipids in the mesentery of the yellowtail rockfish, *Sebastes flavidus*, and showed that a greater proportion was incorporated in the developing ovaries.

The ash contents were found to be in the range 7.25 - 7.56% (Table 1). No significant (p>0.05) variation in ash content was found between different fish sizes. The higher ash content reported in the current study could be attributed to increased minerals contents to correct ionic balance during starvation.

The levels of carbohydrate in the present study were low across the fish

samples below 0.5%. This is typical for striated muscle, where carbohydrate occurs in glycogen and as part of the chemical constituents of nucleotides (FAO, 2005). The amount of carbohydrate in white fish muscle is generally too small to be of any significance in the diet (Murray and Burt, 1969). The gross energy contents of fillets were found to be in the range 546.5 - 576 Kcal/100 g. The gross energy values reported in this study were relatively high compared to those demonstrated by Alemu *et al.* (2013) for Nile tilapia (60.2 Kcal/100 g). Higher gross energy could be attributed to the highly migratory nature of this fish.Akinyi *et al.* (2011) reported that *Alestes baremoze* undertake long seasonal potamodromous migrations from lacustrine environments or lower reaches of river channels to upstream spawning grounds. It is possible that the fish rely heavily on energy reserves during the seasonal migrations.

Vitamin A contents of different fish sizes were found to be in the range of 55.1 - 75.3 µg RAE/100 g. However, there were significant differences ($p<0.05$) with fish above 1.5 kg recording highest values of 75.3 µg RAE/100 g. The relatively higher amount of vitamin A reported in this study could be related to the amount and quality of food that the fish eats. Akinyi *et al.* (2010) reported that *Alestes baremoze* has considerable flexibility in diet as it shifts from zooplankton to zoobenthos, detritus and macrophytes as plankton densities decline. Vitamin A is a fat-soluble vitamin that has a role in the visual sensation, cell growth and differentiation, and reproduction (Murray and Burt, 1969). The vitamin content of individual fish of the same species, and even of different parts of the same fish, can also vary considerably (Murray and Burt, 1969). Vitamins which are necessary for good health in humans and domestic animals are present to some extent in fish, but the amounts vary widely from species to species, and throughout the year.

***Mineral analysis***

The mineral contents of *Alestes baremoze* are given in Table 2. Potassium, magnesium and iron were particularly abundant in the fish samples analysed. Zinc, phosphorus, iodine and mercurywere present in the fish tissues in trace amounts.The most abundant micro element in fish was zinc. Overall, potassium was found to be the mineral with highest concentration in all samples compared to all minerals analysed.

The zinc contents in fish samples of this study were within a broad range of 0.54 - 1.26 mg/100 g wet sample (Table 2). Zinc deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities (National Research Council Recommended dietary allowances, 1989). Zinc values showed no significant difference ($p>0.05$) between the different size groups. All the samples contained zinc lower than the limit set by FAO/WHO (1984) (150 ppm or 15 mg/ 100 g). Similar results have been reported by Kabahenda *et al.* (2011) for Nile perch fillet (0.72 mg/100 g Zinc). However, higher zinc content of fresh water *Rastrineobola argentea (*mukene) products ranging from (10.1-10.2 mg/100 g) and of perch eggs (2.3 - 4.4 mg/100 g) was reported by Kabahenda *et al.* (2011). Fawole *et al.* (2007) reported similar levels of zinc (0.43 mg/100 g) for *Oreochromis niloticus* and (0.40 mg/100 g) for *Clarias gariepinus.*

Phosphorous contents of fish sizes (1.6 - 2.5 kg) were found to be significantly higher ($p <0.05$) than those found in other

Table 2. Mineral contents of *A. baremoze*fillets in a study in Uganda

| Mineral (mg/100g wet sample) | Fish size classes (kg) | | |
|---|---|---|---|
| | Below – 1 | 1–1.5 | 1.6–2.5 |
| Zinc | 1.26±0.51[a] | 1.04±0.54[a] | 0.54±0.03[a] |
| Phosphorus | 0.31±0.06[ab] | 0.21±0.044[b] | 0.44±0.104[a] |
| Calcium | 17.43±2.25[a] | 26.28±1.17[b] | 29.75±6.87[c] |
| Potassium | 255.87±16.20[a] | 277.31±2.77[b] | 339.33±7.77[c] |
| Magnesium | 5.34±0.30[a] | 4.47±0.47[b] | 2.77±0.02[c] |
| Manganese | 0.368±0.14[a] | 0.27±0.09[ab] | 0.136±0.04[b] |
| Iron | 3.58±0.99[a] | 3.09±1.8[a] | 1.1±0.43[a] |
| Iodine | 0.01±0.001[a] | 0.16±0.01[b] | 0.066±0.01[c] |
| Mercury | 0.04±0.02[a] | 0.04±0.01[a] | 0.01±0.001[a] |

Means with the different letters in the same row are significantly different (P<0.05). Data are represented as means ± standard deviation

sizes (Table 2). The variations in phosphorous could be due to an increase in the proportion of bone to flesh as the fish grows. Gokoglu *et al*. (2004) reported phosphorous levels of 337.8 mg/100 g for (rainbow trout) which were far higher compared to *Alestes baremoze* (0.21-0.44 mg/100g wet sample) in the current study.

The range of calcium contents in all samples were between 17.43 and 29.75 mg/100 g wet sample (Table 2). Calcium contents of larger fish (1.6 - 2.5 kg) was significantly higher ($p < 0.05$) compared to other sizes. Similar results have been reported by Orban *et al*. (2000) for sea bream (22 - 23 mg/100 g). The benthopelagic nature of *Alestes baremoze* and its considerable flexibility in diet from zooplankton to zoobenthos, detritus and macrophytes could be a contributing factor for high levels of potassium and calcium in larger fish sizes.

The potassium concentrations were found to be in the range of 225 and 339 mg/100 g wet samples (Table 2). Overall, potassium was found to be the mineral with highest concentration in all samples analysed. Erkan and ozden (2007) reported similar levels of potassium (459.7mg/100 g) for sea bass and (393.8mg/100 g) for sea bream. Gokoglu *et al*. (2004) determined the potassium value in trout as 306 mg/100 g. The high levels of potassium in the fish samples may be attributed to the rate in which it is available in the water body and the ability of the fish to absorb these inorganic elements from their diet and the environment where they live.

Magnesium and manganese values contents of fish <1 kg were significantly higher ($p < 0.05$) than those found in other sizes (Table 2). For magnesium, the mean concentrations of the mineral ranged between 2.77 and 5.34 mg/100 g wet samples.Oksuz *et al*. (2009) reported magnesium values of 38.2 and 57.9 mg/ 100 g wet samples for rose shrimp and red shrimp samples, which were significantly lower compared to the current findings. Erkan and Ozden (2007) also reported magnesium values at 32.6 mg/ 100 g (sea bass) and 22.2 mg/100 g (sea bream); which were significantly higher

compared to all samples in the current study. The manganese contents in this present study were found to be in the range of 0.13 - 0.36 mg/100 g. Ikem and Egiebor (2005) reported similar levels of manganese 0.001- 0.046 mg/100 g in pink salmon, 0.001- 0.004 mg/100 g in red salmon, 0.008 - 0.063 mg/100 g in tuna, 0.003 - 0.127 mg/100 g in mackerel, 0.019 - 0.255 mg/100 g in sardine, and 0.011- 0.238 mg/100 g in herring. This could be due to the difference of species, seasons and area of catch.

Iron serves as a carrier of oxygen to the tissues from the lungs by red blood cell haemoglobin, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues. Adequate iron in the diet is very important for decreasing the incidence of anemia, which is considered a major health problem, especially in young children. Sea foods, especially darker fleshed fish, are reasonably good sources of iron, supplying 1- 2 mg/100 g muscle (Kinsella, 1988). Iron values in this study were within the range of 1.1 - 3.58 mg/100 g. Iron values showed no significant difference ($p > 0.05$) between the three fish sizes. This result is similar to the iron contents of Nile Perch fillet (1.06 mg/100 g dry matter) and sea bass (2.47 mg/100 g) reported by Kabahenda *et al*. (2011), and Erkan and Ozden (2007), respectively. This value was however lower than that reported by Kabahenda *et al*. (2011) for *Rastrineobola argentea* products (8.2 - 10.7 mg/100 g) and Nile perch eggs (5.4 - 5.7mg/100 g). These variations in the iron composition may be related to species, size, age, sex and post-harvest processing.

Iodine content varied significantly across the different fish sizes with highest value (0.16 mg/100 g of wet sample) found in fish within the range of 1- 1.5 kg (Table 2). Iodine is an essential trace element of great importance for human nutrition. The element is an essential part of the thyroid hormones, which in turn are necessary for human growth and development. The best known effect of iodine deficiency is endemic goiter. Sea water fish and other marine foods are frequently regarded as the most important natural source of dietary iodine, but there is little knowledge about fresh water fish (Eckhoff and Maage, 1997). The iodine content in this study is higher to those reported by Eckhoff and Maage (1997) for fresh water species barbus (0.0008 mg/100 g), catfish (0.0025 mg/100 g), tilapia (0.0015 mg/100 g), and carp (0.003 mg/100 g).

Mercury values rangedfrom 0.01 to 0.04 mg/100 g for all fish sizes examined (Table 2). Mercury values showed no significant difference *(*$p > 0.05$) between the different fish sizes. This result is similar to the mercury content of Nile perch (0.0031- 0.0684 mg/100 g wet weight) described by Machiwa (2005). Mercury is an element of special concern because its inorganic form is biologically transformed in aquatic environments into methylmercury (MeHg) (Olmedo *et al.,* 2013). This lipophilic organic compound bioaccumulates and biomagnifies as it moves up the aquatic food chain (Jaeger *et al.,* 2009; Gewurtz *et al.,* 2011). As a result, human populations with a traditionally elevated dietary intake have the highest potential exposure to MeHg and are at an increased risk for developing neurotoxic effects (Olmedo *et al.,* 2013).

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## References

Akinyi, E., Awaïss, A., Azeroual, A., Getahun, A., Lalèyè, P. and Twongo, T. 2010. *Alestes baremoze*. In: IUCN 2012. IUCN red list of threatened species. Version 2012.2.

Alemu, L.A., Melese, A.Y. and Gulelat, D.H. 2013. Effect of endogenous factors on proximate composition of Nile tilapia (*Oreochromis niloticus* L.) fillet from Lake Zeway. *American Journal of Research Communication* 1(11): 405 - 410.

Amer, H.A., Sedik, M.F., Khalafalla, F.A. and Awad, H.A. 1991. Results of chemical analysis of prawn muscle as influenced by sex variations. *Molecular Nutrition and Food Research* 35(2):133 - 138.

AOAC, 2000. Association of Official Analytical Chemists Official Methods of Analysis. 17th Edition. W. Hortuntzed (Ed.), Washington, USA. 21- 447.

Chandrashekar, K. and Deosthale, Y.G. 1993. Proximate composition, amino acid, mineral, and trace element content of the edible muscle of 20 Indian fish species. *Journal of Food Composition and Analysis* 6:195 - 200.

Eckhoff, K.M. and Maage, A. 1997. Iodine content in fish and other food products from East Africa analyzed by ICP-MS. *Journal of Food Composition and Analysis* 10: 270 - 282.

Effiong, B.N. and Fakunle, J.O. 2013. Proximate composition and fatty acid profile in some commercially important fish species from Lake kainji, Nigeria. *International Journal of Biology, Pharmacy and Allied Sciences* 2(4): 849 - 856.

Erkan, N. and Ozden, O. 2007. Proximate composition and mineral contents in aqua cultured sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*) analyzed by ICP-MS. *Food Chemistry* 102(3):721-725.

FAO/WHO. 1984. List of maximum levels recommended for contaminants by the Joint FAO/ WHO Codex Alimentarius Commission. Second Series. CAC/ FAL, Rome, Italy. 3: 1- 8.

FAO. 2005. Food and Agriculture Organisation. Fisheries and aquaculture topics. Composition of fish. Topics Fact Sheets. Text by LahsenAbabouch. In: FAO Fisheries and Aquaculture Department [online]. Rome [Assessed on 31 August 2014]. http://www.fao.org/fishery/topic/ 12318/en.

Fawole, O.O., Ogundiran, M.A., Ayandiran, T.A. and Olagunju, O.F. 2007. Proximate and mineral composition in some selected fresh water fishes in Nigeria. *Internet Journal of Food Safety* 9: 52 - 55.

Gewurtz, S.B., Bhavsar, S.P. and Fletcher, R. 2011. Influence of fish size and sex on mercury/PCB concentration: Importance for fish consumption advisories. *Environmental International* 37(2): 425 - 34.

Glover, C.N. and Hogstrand, C. 2002. Amino acids of in vivo intestinal zinc absorption in fresh water rainbow trout.

*Journal of Experimental Biology* 205: 151 - 158.

Gokoglu, N., Yerlikaya, P. and Cengiz, E. 2004. Effect of cooking methods on the proximate composition and mineral contents of rainbow trout (*Oncorhynchus mykiss*). *Food Chemistry* 84(1): 19 - 22.

Huss H.H. 1995. Quality and quality changes in fresh fish. FAO Fisheries Technical paper No. 348, Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

Ikem, A. and Egiebor, N.O. 2005. Assessment of trace elements in canned fishes (mackerel, tuna, salmon, sardines and herring) marketed in Georgia and Alabama (United States of America). *Journal of Food Composition and Analysis* 18:771-787.

Islam, M.N. and Joadder, M.A. 2005. Seasonal variation of the proximate composition of freshwater Go*bi, Glossogobius giurs* from the river padma. *Pakistan Journal of Biological Sciences* 8(4):532-536.

Jaeger, I., Hop., H. and Gabrielsen, G.W. 2009. Biomagnification of mercury in selected speciesfrom an Arctic marine food web in Svalbard. *The Science of the Total Environment* 407(16):4744 - 51.

Kabahenda, M.K., Amega, R., Okalany, E., Huske, S.M.C. and Heck, S. 2011. Protein and micronutrient composition of low-value fish products commonly marketed in the Lake Victoria Region. *World Journal of Agricultural Scie*nces 7 (5): 521 - 526.

Kasozi, N., Degu, G.I., Atibuni, K., Kisekka, M., Owori-Wadunde, A. and Mugerwa, S. 2013. Classification of ovarian stages of *Alestes baremoze* (Joannis, 1835): A step towards understanding its reproductive biology. *Frontiers in Science* 3 (4):107 - 113.

Kinsella, J.E. 1988. Fish and sea foods: Nutritional implications and quality issues. *Food Technology* 146 - 149.

Lourenco, H.M., Anacleto, P., Afonso, C., Ferraria, V., Martins, M.F., Calvarho, M.L., Lino, A.R. and Nunes, M.L. 2009. Elemental composition of cephalopods from Portuguese continental waters. *Food Chemistry* 113(4): 1146 -1153.

MacFarlane, R.B., Norton, E.C and Bowers, M.J. 1993. Lipid dynamics in relation to the annual reproductive cycle in yellow tail rock fish (*Sebastes flavidus*). *Canadian Journal of Fisheries and Aquatic Sciences* 50:391- 401.

Machiwa, J.F. 2005. Metals in Nile perch (*Lates niloticus*) and suspended particulate matter from Lake Victoria, Tanzania. *Journal of Environmental Science and Health*. Part A, *Toxic/ Hazardous Substances and Environmental Engineering* 40(9): 1809 - 1822.

Mbabazi, D., Taabu, M.A., Muhoozi, L.I., Nakiyende, H., Baasa, E., Muhumuza, M., Amiina, R. and Balirwa, J.S. 2012. The past, present and projected scenarios in the Lake Albert and Albert Nile Fisheries: Implications for sustainable management. *Uganda Journal of Agricultural Sciences* 13(2): 47 - 64.

Murray, J. and Burt, J.R. 1969. The composition of fish. Torry Advisory. Note 38, Torry Research Station, Aberdeen. Accessed on 31 August 2014. http://www.fao.org/wairdocs/tan/x5916e/x5916e00.htm.

National Research Council Recommended dietary allowances.

1989. (10th ed.). Washington: National Academy Press.

Okeyo G.O., Lokuruka, M.N.I. and Matofari, J.W. 2009. Nutritional composition and shelflife of the Lake Victoria Nile Perch (*Lates niloticus*) Stored in ice. *African Journal of Food Agriculture Nutrition and Development* 9(3): 901 - 919.

Oksuz, A., Ozyilmaz, A., Aktas, M., Gercek, G. and Motte, J. 2009. A comparative study on proximate, mineral and fatty acid compositions of deep sea water Rose Shrimp (*Parapenaeus longirostris*, Lucas 1846) and golden Shrimp (*Plesionika martia,* A. Milne-Edwards, 1883). *Journal of Animal and Veterinary Advances* 8(1):183-189.

Olagunju, A., Muhammad, A., Mada, S.B., Mohammed, A., Mohammed, H.M. and Mahmoud, K.T. 2012. Nutrient Composition of *Tilapia zilli*, *Hemisynodontis membranacea*, *Clupea harengus* and *Scomber Scombrus* locally consumed in Zaria. *World Journal of Life Sciences and Medical Research* 2:16 - 9.

Olmedo, P., Pla, A., Hernández, A.F., Barbier, F., Ayouni, L. and Gil, F. 2013. Determination of toxic elements (mercury, cadmium, lead, tin and arsenic) in fish and shellfish samples. Risk assessment for the consumers. *Environment International* 59: 63-72.

Orban, E., Di Lena, G., Ricelli, A., Paoletti, F., Casini, I. and Gambelli, L. 2000. Quality characteristics of sharpsnout sea bream (*Diplodus puntazzo*) from different intensive rearing systems. *Food Chemistry* 70 (1):27 - 32.

Pearson, D.A. 1976. Chemical analysis of foods (7th ed.) Edinburgh: Chruchhill, Livingstone. UK. pp. 422 - 51.

Waterman, J.J. 2000. Composition and quality of fish. Torry Research Station. Edinburgh. UK.

Zenebe, T., Ahigren, G., Gustafsson, B. and Boberg, M. 1998. Fatty acid and lipid content of *Oreochromis niloticus* L. in Ethiopian lakes. Dietary effects of phytoplankton. *Ecology of Fresh Water Fish* 7:146 - 158.