American Journal of Food Science and Technology, 2016, Vol. 4, No. 3, 64-69
Available online at http://pubs.sciepub.com/ajfst/4/3/2

DOI:10.12691/ajfst-4-3-2

Proximate Composition, Fatty Acid and Mineral Contents of Four Freshwater Fish from Maga Lake (Far North Region of Cameroon)

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Abstract A study was conducted to explore the proximate composition, the fatty acids profile and the mineral contents of four freshwater fish namely mullet (*Liza falcipins*), carp (*oreochromis niloticus*), catfish (*Chrysichthys nigrodigitatus*) and kanga (*Heterotis niloticus*) collected from Maga Lake in Far North Region of Cameroon. It was been observed that moisture content (~78 g/100g fresh weight (FW) not varied between species (P>0.05). Nevertheless, ash content varied significantly (P<0.05) between species and carp presented a high ash content (9.04 g/100g dry weight (DW). The total lipid content was generally high, ranging from 18.88 to 55.19 g/100g DW. With regard to protein content, these fresh fish contained more than 39 g/100g DW. Significant differences (P<0.05) were observed in some fatty acids within the fish species analyzed. All these fish except carp were high in saturated, monounsaturated and polyunsaturated fatty acid, respectively. C16:0 and C18:1(n-9) were the predominant fatty acid in all fish analyzed (20-24 and 21-33 % repectively). The others major fatty acids detected were C18:2ω-6, C18:0 and C16:1ω-7. Although these four freshwater fish contained reasonable content of important polyunsaturated fatty acid such as eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and arachidonic acids, catfish presented the highest content of polyunsaturated fatty acids (PUFA). These fish contained appreciable ratio ω-3:ω-6 suggesting that these fish especially carp could be used as a source of healthy diet for humans. The fish analyzed have a good supply of minerals and can be used for enhancing mineral intake and protecting population from mineral deficiency disease.

Keywords: *proximate composition, fatty acid, mineral content, Maga Lake fish, Cameroon*

Cite This Article: Noël TENYANG, Roger PONKA, Bernard TIENCHEU, Fabrice TONFACK DJIKENG, and Hilaire Macaire WOMENI, “Proximate Composition, Fatty Acid and Mineral Contents of Four Freshwater Fish from Maga Lake (Far North Region of Cameroon).” *American Journal of Food Science and Technology*, vol. 4, no. 3 (2016): 64-69. doi: 10.12691/ajfst-4-3-2.

1. Introduction

In Cameroun, like in most sub-saharan Africa countries, traditional fishing is practiced in almost all rivers, lakes, ponds and represents an important part of total fish captures. It is an important sector in the national strategies of fight against poverty and food safety. One of the most important producing sites is the lake of Maga. The nutritional and health benefit from the consumption of seafood is one of the reasons for the increasing consumer demand for fish and shellfish. The fats are needed in diets to absorb fat-soluble vitamins A, D, E and K from food; and for regulating body cholesterol metabolism [1,2]. The fish fats contain important PUFA like EPA, C20:5n-3, DHA, C22:6n-3, and arachidonic (C20:4n-6) acids which are not synthesised in the human body but their inclusion in human diets is essential [3]. PUFA contained in fish is known to regulate prostaglandin synthesis and hence induce wound healing [4]. ω-3 and ω-6 polyunsaturated fatty acids (PUFA) have been shown to have positive effects on cardiovascular diseases and cancers [5]. PUFA composition may vary among species of fish, even among fresh water and marine fish [6], it is important for human health, to increase the consumption of fish and its products [7,8]. Fish also contains significant amounts of essential amino acids and certain amino acids like aspartic acid, glycine and glutamic acid are also known to play a key role in the process of wound healing [9]. Fish contains micronutriments such as minerals. Micronutrients have been reported to play important role in mounting immune response and prevention or treatment of disease [10]. Deficiency in one of the micronutrients has important implications for the pathogenesis of diseases, their morbidity and severity [11].

In Cameroon, little studies have been carried out on the chemical composition of fish commercialized in the wouri river coast [12], but the composition of freshwater fish of

Maga Lake has received little attention. Thus, this study was carried out to determine the proximate composition, the fatty acid profile and the mineral content of four fresh fish species from Maga lake (Far North Region of Cameroon).

2. Material and Methods

2.1. Sample Collection

The fish samples chosen for this study are the commonly consumed in Far North, Cameroon. About 500 g of each of four fish species: mullet (*Liza falcipins*), carp (*oreochromis niloticus*), catfish (*Chrysichthys nigrodigitatus*) and kanga (*Heterotis niloticus)* were bought from Maga fish market around of the Maga Lake in Far North Region of Cameroon. Once collected, they were immediately transported to the laboratory in ice boxes for identification and analyses. Fresh fish were washed with tap water several times to remove adhering blood and slime. In the laboratory, the fish samples were separated and reduced to filet.

2.2. Proximate Composition

The moisture, lipid, protein and ash in samples were determined by the recommended AOAC methods [13]. The moisture content was determined by drying fresh sample in an oven at 105°C until constant weight. The lipid content of the powdered fish was determined with the help of soxhlet apparatus using the non- polar organic solvent hexane. Crude protein was determined by nitrogen determination using the Kjeldahl micro method and conversion of nitrogen to protein by the factor 6.25. Ash content determined by burning the organic components from the known weight of the homogenised dried fish muscle by using a furnace at 550°C for 48h.

2.3. Fatty Acid Composition

Lipids were extracted from the powdered fish and fatty acid composition of oil were investigated after conversion of their Fatty Acid Methyl esters (FAME) using boron trifluoride-methanol method. The lipids were saponified and esterified for fatty acid analysis by the method of Metcalfe, Schmitz, and Pelka [14]. The fatty acid methyl esters (FAMEs) were analyzed on a Hewlett-Packard (HP) 5880 gas chromatograph (GC) with a flame ionisation detector (FID). The esters were separated on a 50 m × 0.20 mm i.d. Wall-coated open tubular fused silica capillary column coated with Carbowax 20 M. Column injector and detector temperatures were 200 and 300°C, respectively. Carrier gas was helium; split ratio was 100:1. Identification was achieved by comparison to retention times of authentic standards, argentation TLC followed by GC of the bands separated by a degree of unsaturation, and mass spectrometry.

2.4. Mineral Determination

The method described by AOAC [15] was used for mineral analysis. The minerals (Ca, Mg, Na, K, Fe, Zn, Cu and Mn) were determined by atomic absorption spectrometer (Varian 220FS Spectr AA, Les Ulis, France). The sample was ashed at 550°C and the ash boiled with 10 ml of 20% HCl in a beaker and then filtered into a 100 ml standard flask. P was determined colorimetrically using the vanado molybdate method.

2.5. Statistical Analyses

All analyses were performed in three replications. Data on the composition of fish samples were analysed by one way analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS 16.0 version). Differences between samples were tested according to Duncan test and considered to be significant at $P<0.05$.

3. Results and Discussion

3.1. Proximate Composition

The proximate analysis of the four freshwater fish is shown in Table 1. It appears that these fish are composed mostly of moisture (~80 g/100 g FW). These results are similar to those obtained by Zuraini *et al*. [16] and Tenyang *et al*. [12] in other fresh fish (~80.5 g/100 g FW) and were within the range cited by Yeannes and Almandos [17], for some freshwater fish (i.e. 70-85 g/100 g FW). This table revealed that ash content ranged from a low value 5.28 (kanga) to a high value 9.04 g/100g DW (carp). The high ash content obtained indicates that all these fish are rich in minerals. The ash content obtained in this investigation wa smilar to that found by Zuraina *et al*. [16] in three local Malaysian *Channa* spp. fish (1-1.8 g/100g DW).

The lipid content varied in all fish samples from about 18.88 to 55.19 g/100g DW (Table 1). Higher lipid content was characteristic of kanga, and lower contents were found for mullet fish. All these fish can be classified as a fat fish because their lipid content were above 10 g/100g DW [18]. The lipid content found in this study for carp, catfish and mullet are above the percentage reported by Tenyang *et al*. [12] (15.32 and 23.02 g/100g DW, respectively), in a work developed in Littoral Region of Cameroon. In another study, the total lipid content found in tilapias was 1.1 g/100g DW [19]. Still in Brazil, Souza *et al*. [20] reported values of 8.06% for total lipids in gutted tilapias. Lipid content is influenced by species, geographical regions, age, and diet [21,22]. Much of the crude lipid content is constituted by unsaturated fatty acids, which have important physiological functions according to previous studies [3].

Table 1. Proximate composition of four raw fish species collected in Maga Lake (Far North-Cameroon)

Fish Species	Moisture (g/100g FW)	Ash (g/100g DW)	Lipid (g/100g DW)	Protein (g/100g DW)
Mullet	81.64 ± 1.79^{a}	8.72 ± 0.06^{ab}	18.88 ± 0.89^{d}	62.80 ± 0.03^{a}
Carp	81.20 ± 0.87^{a}	9.04 ± 0.24^{a}	21.76 ± 0.70^{c}	52.47 ± 0.32^{b}
Catfish	78.46 ± 5.96^{a}	7.32 ± 1.27^{ab}	30.34 ± 2.16^{b}	39.73 ± 0.20^{c}
Kanga	78.59 ± 1.26^{a}	5.28 ± 0.28^{c}	55.19 ± 1.58^{a}	52.30 ± 2.00^{b}

Mean values in the same column with different superscript letters are significantly different ($P< 0.05$). FW: Fresh weight ; DW: Dry weight.

The freshwater fish uses in this study were found to be rich source of protein. The crude protein contents of these fish differed significantly among fish species (P< 0.05) (Table 1). Catfish was lowest in crude protein content (39.73 g/100g DW), when mullet was highest in crude protein (62.80 g/100g DW). The crude protein content of carp, mullet and catfish obtained in this study were comparable to those obtained by Tenyang *et al*. [12] in the same species (69.72 and 64 g/100g DW, respectively). Protein is necessary for building the structural components of human body, such as muscles and organs. The consumption of kanga can be encouraged because it has a higher protein content, which could help to prevent some problems due to protein deficiencies.

3.2. Fatty Acid Composition

A fish lipid contains long chains polyunsaturated fatty acids, which have a number of nutraceutical and pharmacological application and have all the essential fatty acids required by humans for normal growth and healthy life [3].

The compositions of fatty acids of the four raw fish species of Maga Lake are shown in Table 2. The results show that each fish species contained at least twenty-four fatty acids. Remarkable changes in the individual fatty acids within the species are noted. The most abundant fatty acid containing in all the fish for this study are palmitic acid (C16:0) ranging from 20 % to 24 % and oleic acid (C18:1 (n-9) ranging from 21% to 33% The high percentage of palmitic acid was found to carp fish, while the low percentage was obtained in kanga. Catfish contain the high level of oleic acid, while the low content was obtained in carp and kanga. The other major fatty acid was C18:2 (n-6). In particular, catfish has more C18:1 (n-9) than C16:0. These results are in agreement with the literature where C16:0 was reported as the most abundant fatty acid in six fish species commercialized in the wouri river coast in Cameroon and three freshwater fish species in Malaysian [12,16]. Meanwhile, Osman *et al.* [23] reported that C16:0 was not the most abundant fatty acid present in some Malaysian waters fish.

Table 2. Fatty acid composition (g/100g) of four raw fish species collected in Maga Lake (Far North-Cameroon)

Fatty acid as % of total fatty acids	Mullet	Carp	Catfish	Kanga
C12 :0, Lauric	ND	ND	1.03±0.08^a	ND
C14.0, Myristic	3.37±0.02^a	2.47±0.01^c	2.84±0.04^b	2.86±0.01^b
C15 :0, Pentadecanoic	1.67±0.01^a	0.96±0.04^b	1.08±0.05^b	1.92±0.02^a
C16 :0, Palmitic	22.49±0.05^c	23.99±0.02^a	22.75±0.03^b	20.07±0.03^d
C17 :0, Heptadecanoic	3.04±0.02^c	1.60±0.01^d	3.12±0.02^b	3.31±0.03^a
C18 :0, Stearic	7.27±0.10^c	6.37±0.05^d	9.97±0.07^a	8.92±0.03^b
C20 :0, Arachidique	0.57±0.01^c	0.65±0.05^c	1.96±0.03^b	2.63±0.10^a
C22 :0, Behenic	0.25±0.05^c	0.29±0.02^c	0.38±0.07^b	0.52±0.03^a
C23 :0, Tricosanoic	0.96±0.06^b	0.27±0.02^d	0.38±0.05^c	1.15±0.03^a
C24 :0, Lignoceric	0.14±0.02^b	0.10±0.01^c	0.04±0.01^d	0.28±0.03^a
ΣSFA	**39.76±0.34^c**	**36.70±0.23^d**	**43.52±0.45^a**	**41.66±0.31^b**
C16 :1, Palmitoleic	7.41±0.10^b	6.97±0.08^c	7.02±0.05^c	10.11±0.06^a
C17 :1n Cis-10 heptadecenoic	1.15±0.04^a	1.03±0.03^b	1.15±0.01^a	0.93±0.02^c
C18 :1 (n-9), Oleic	24.60±0.19^b	21.10±0.12^c	32.96±0.23^a	21.42±0.14^c
C20 :1, cis-11 Eicosenoic	0.54±0.02^c	0.89±0.09^b	1.22±0.04^a	ND
C22 :1, Erucic	0.06±0.01^c	0.07±0.02^c	0.18±0.01^a	0.13±0.03^b
ΣMUFA	**32.61±0.28^b**	**30.06±0.34^c**	**42.53±0.34^a**	**32.59±0.25^b**
C8 :2, Linoleic (ω-6)	12.36±0.12^a	12.49±0.09^a	3.77±0.07^c	8.86±0.10^b
C18 :3, Ɣ-linoleic (ω-6)	0.55±0.01^c	0.72±0.03^a	0.18±0.01^d	0.67±0.02^b
C18 :3, α-linoleic (ω-3)	4.16±0.20^b	11.15±0.15^a	1.60±0.60^d	3.26±0.26^c
C20 :2, cis 11, 14 Eicosadienoic	0.43±0.03^c	0.52±0.02^b	0.77±0.07^a	0.80±0.05^a
C20 :3, cis-8, 11, 14 Eicosatrienoic (ω-6)	0.97±0.06^c	2.37±0.11^a	1.26±0.06^b	0.70±0.04^d
C 20 :4, Arachidonic (ω-6)	2.41±0.10^b	1.21±0.05^d	1.91±0.15^c	4.35±0.13^a
C20 :5, Eicosapentaenoic (EPA) (ω-3)	1.42±0.03^b	0.66±0.06^d	1.07±0.02^c	1.66±0.10^a
C22 :6, Docosahexaenoic (DHA) (ω-3)	2.13±0.09^c	3.29±0.14^a	1.06±0.05^d	2.51±0.11^b
ΣPUFA	**24.43±0.64^b**	**32.41±0.65^a**	**11.62±1.03^d**	**22.81±0.81^c**
Σω-3PUFA	**7.71±0.32**	**15.10±0.35**	**3.73±0.35**	**7.43±0.47**
Σω-6PUFA	**16.29±0.29**	**16.79±0.28**	**7.12±0.29**	**14.58±0.29**
ω-3 :ω-6	**0.47**	**0.90**	**0.52**	**0.51**
Other fatty acids	3.2	0.83	2.30	2.94

Mean values in the same row with different superscript letters are significantly different (P < 0.05).
ND: not detected; SFA : Saturated fatty acid ; MUFA : mono-unsaturated fatty acid PUFA : Polyunsaturated fatty acid.

A total saturated and unsaturated fatty acid composition of the four selected fish species is presented in Table 2. Catfish is recognized as a species, which has the higher percentage of saturated fatty acid (43.51 %). However, carp is a fish, which has the lowest saturated fatty acid content (36.70%). The high content of saturated fatty acid obtained in this work for these fish samples are in the line with those presented by Tenyang *et al*. [12] in Cameroon, and Gutierrez and Silvia [24] in Brazil on some marine fish. In generally, the MUFA contents for all fish species except the carp were much higher than the PUFA. Others researchers have also shown that freshwater fish have lower contents of PUFA compared to MUFA [25]. The trend is different when compared to an earlier study of freshwater fish, where the concentration of PUFA was higher than MUFA [23]. The difference can be attributed to the environment, age, genetic or nutrition of fish. Catfish presented the higher MUFA contents and lowest PUFA compared to others fish species in this study. The values for MUFA (30.06-42.53%) in the fish analysed, were higher than menhaden oil which is a marine fish oil (19,4%) reported by Osman *et al*. [23]. These fish species from Maga Lake in Far North region of Cameroon are sources of polyunsaturated fatty acid of the ω-6 family especially linoleic acid (C18:2) which is essential in human nutrition as these fatty acid are not synthesised in the body but are required in the tissue development (Table 2). These results were different when compared to an earlier study on some marine fish, where the concentration of PUFA ω-3 were higher than PUFA ω-6 [12], but were in agreement with the results presented by Fatima *et al*. [27] on some freshwater fish in Brazil. The difference can be attributed to the fact that marine fish staple diets are many zooplancton, which are rich in PUFA ω-3. The concentration of ω-3 PUFA of carp in this study (15.1%) was found to be much higher than those for others fish analysed. Catfish presented the low concentration of ω-3 PUFA. The value of ω-3 PUFA of catfish (3.73 %) in this work was lower than those reported by others researchers (14.73 %; Tenyang *et al*., [12]). The predominant ω-3 PUFA present in these fish analysed were α-linolenic acid (C18:3ω-3), eicopentaenoic acid (C20:5ω-3; EPA) and docosahexaenoic acid (DHA). Carp fish presented the higher content of C18:3ω-3 and C22:6ω-3, while mullet and kanga presented the higher concentration of C20:5ω-3. The lowest value of DHA and EPA were obtained respectively in catfish and carp. The presence of EPA and DHA in all the fish analysed suggest that these fish can have a healing effect to alleviate muscle pain inflammation. DHA and EPA have been reported to have preventive effects on human coronary artery diseases [27]. DHA is essential for the development of the foetal brain and the eye retina [28]. Significant levels of EPA and DHA in fish species of this work indicated that those fish could be used to supplement essential fatty acids in the human diet.

The contents of arachidonic acid (C20:4ω-6) of fish analysed ranged from 1.21 to 4.35%. Carp fish presented the lower content of arachidonic acid (1.21 %), while kanga presented the higher content (4.35 %). Arachidonic acid presented in all the fish species in this work is a precursor for prostaglandin and thromboxane biosynthesis [29]. Arachidonic acid can facilite the blood clotting process and attach to endothelial cells during wound healing. The inclusion of the fish analysed in human diets might help in the wound healing process of the consumer.

The ratio of ω-3:ω-6 has suggested to be a useful indicator for comparing relative nutritional value of fish oils. It was suggested that a ratio of 1:1-1:5 would constitute a healthy human diet [21]. All four fresh fish species had the ratio of ω-3:ω-6 within the recommended ratio. A higher ratio was observed in carp, this means that carp has a higher nutritional value compared t other fish. Although these ratios were lower than those obtained by Osman *et al*. [21] for some marine fish (2.16-4.14) in Malaysia, there were higher than those presented by Farhat and Abdul [30] on three freshwater fish species in Pakistan (0.23-0.27).

3.3. Minerals Composition

3.3.1. Macroelements Contents

In Table 3, the macromineral contents of four raw fish species collected in Maga Lake in Cameroon are presented. There were significant differences (P<0.05) in the macromineral composition between the four freshwater fish. The macroelements analysis (Table 3) indicates high concentration of calcium (Ca) in all these four fish species (3733.49- 9777.48 mg/100 g DW). Carp is very rich in Ca while kanga has the lowest calcium value. The calcium obtained in this work is higher than those obtain by other authors [12,31]. Consumption of carp fish could be recommended to a subject who has problems of hypocalcaemia.

Table 3. Macro-nutrients contents (mg/100g DW) of four raw fish species collected in Maga Lake (Far North-Cameroon)

Fish species	Ca	Mg	K	Na	P
Mullet	6349.19±20.00^{c}	205.95±5.00^{a}	1044.31±14.18^{a}	110.67±2.67^{c}	3545.88±15.44^{b}
Carp	9777.48±17.48^{a}	211.44±2.22^{a}	781.67±11.00^{c}	141.33±2.03^{a}	3880.46±10.20^{a}
Catfish	8293.89±22.00^{b}	179.78±2.10^{b}	611.75±11.00^{d}	107.23±3.00^{c}	3539.48±20.00^{b}
Kanga	3733.49±25.00^{d}	149.80±4.10^{c}	1009.57±10.00^{b}	121.80±1.80^{b}	2065.70±20.00^{c}

Mean values in the same column with different superscript letters are significantly different (P< 0.05).

The magnesium (Mg) content oscillated between 149.80 (kanga) and 211.44 mg/100 g DW (carp). The Mg value obtained in catfish in this study is higher than those obtained by Beyza and Akif [31] in African catfish.

Calcium and magnesium plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls [32]. Calcium assists in teeth development [33]. Magnesium is essential mineral for enzyme activity, like calcium and chloride; magnesium also plays a role in regulating the acid-alkaline balance in the body [34].

Potassium (K) content ranged from 611.75 (catfish) to 1044.31 mg/100 g DW (mullet). These values are higher than K contents obtained from trout described by Wheaton and Lawson [35] (280-350 mg/100g). The K content for catfish in this work is lower than those obtained by Tenyang *et al*. [12] (683.3 mg/100 g DW) for the same fish. Mean while the K content of mullet reported by Tenyang *et al*. [12] (764.4 mg/100 g DW) is lower than those obtained on the same species of fish in this study. Sodium (Na) was found to be high ranged 107.23 (catfish) to 141.33 mg/100 g DW (carp) in our samples than those reported on others fish samples (30.8-91.7 mg/100 g DW) [12,31].

The Na/K ratio is very low in mullet fish (0.11), which is interesting from the point of view of nutrition, since the intake of sodium chloride and diets with a high Na/K ratio have been related to the incidence of hypertension [36].

Phosphorus (P) is a major constituent of bones together with calcium and magnesium. This mineral showed significant concentration variability between fish species ranging from 2065.70 to 3880.46 mg/100 g DW. Carp presented the highest value of P while kanga has the lowest content. The P concentration range obtained in this work is higher than the FAO [37] range of 68-550 mg/100 g DW, and other freshwater fish obtained by Alas *et al*. [38], (232-426 mg/100 g DW). The recommended dietary allowance for adults is 700 mg of P. About 20 g of catfish and mullet, 18 g of carp and 34 g of kanga fish in this study can contribute at 100 % of the daily requirement.

3.3.2. Microelements Contents

Micronutrient deficiencies are a major public health problem in many developing countries, with infants and pregnant women especially at risk [36,39]. Fish accumulate mineral in the head and viscera, so consumption of small fish which is eaten whole, can contribute significantly towards micronutrients intakes. Table 4 presented the concentration of zinc, copper, manganese and iron in four fresh fish species of Maga Lake obtained in this study.

Zinc (Zn) content ranged from 11.34 (carp) to 14.37 mg/100 g DW (mullet). These values were higher than those reported by Mogobe *et al*. [40] in Botswana for some common fish species (1.63-8.47 mg/100 g DW). The Zn content of catfish in this study was similar than those obtained by Beyza and Akif [31] in African catfish. Zn is usually taken to stimulate the immune system and human growth. It is a component of many metallo-enzymes, important for gene expression [41]. The Zn recommended dietary allowance for adult 8-11 mg and all these fish can provide 100% of the requirement in 100 g of fish, making them a good source of Zn. This species can be beneficial to population because help to combating malnutrition.

Table 4. Micro-nutrients contents (mg/100g DW) of four raw fish species collected in Maga Lake (Far North-Cameroon)

Fish species	Zn	Cu	Mn	Fe
Mullet	14.37±1.00[a]	0.63±0.02[c]	3.41±0.20[c]	5.47±0.30[b]
Carp	11.34±0.30[c]	0.89±0.07[a]	5.24±0.12[b]	7.98±1.00[a]
Catfish	12.28±0.28[bc]	0.71±0.03[b]	6.67±0.05[a]	7.72±0.60[a]
Kanga	12.75±0.80[b]	0.71±0.01[b]	1.64±0.02[d]	5.72±0.40[b]

Mean values in the same column with different superscript letters are significantly different (P< 0.05).

The Cu content of the four freshwater fish ranged from 0.63 to 0.89 mg/100 g DW. Carp has the highest content of Cu (0.89 mg/100 g DW) while mullet maintained the lowest content of Cu (0.63 mg/100 g DW). The Cu content obtained in this work is higher compared to those obtained by Mogabe *et al*. [40] in some common fish in Botswana (0.02-0.21 mg/100 g DW). Like Zn, Cu is also a part a many enzyme. It is involved in stimulating the body defence system and required for antibody development [42]. Cu occurs in very low level in food. According to Widman and Medeiros [43], the recommended daily requirement of copper in human nutrition is ranged to 1.5-2.5 mg. The Cu content of the different fish in this study is lower than the recommended daily intake, assuming a single serving of 100g of fish per day.

Manganese (Mn) concentration level in fish for this work ranged between 1.64-6.67 mg/100g. The highest content of Mg is found in cathfish (6.67 mg/100 g DW) while the lowest content is obtained to kanga (1.64 mg/100 g DW). These value are low compared to those found by Tenyang *et al*. [12] in some fish commercialized in Littoral region of Cameroon (102-466 mg/100g), but remain higher than those obtained by Mogobe *et al*. [40] for some local fish species in Botswana (0.06-1.08 mg/100g). Mn is a part of enzyme involved in urea formation. It activated several enzymes systems and in this capacity it can is required in for the synthesis of acid mucopolysaccharides to form the matrice of bones and egg shells. Consequently skeletal deformaties and defects in shell qualities occur when the Mn intakes is inadequate [44]. The recommended dietary allowance for Mn is 3.8 mg [45]. Mullet can contribute to 90% and Kanga to 43% of the daily Mn requirement if 100 g of these fresh fish is consumed. Consumption of 72.5 g of carp or 57 g of catfish can provide sufficient supply of Mn for the day.

Iron (Fe) value of the fish from this work ranged from 5.47-7.98 mg/100 g DW. Carp and catfish has the highest content of Fe (~8 mg/100 g DW) while mullet and kanga has the lower content (~5.5 mg/100 g DW). These results are in good agreement with those found by FAO [37] and Mogobe *et al*. [40] for some fish muscles. Fe has several vital functions in the body. It serves at carrier 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 system in various tissues. Iron deficiencies cause anaemia, one of the commonest mineral deficiency diseases in Africa with 206 million people at risk [46]. The recommended nutrient intake of Fe for female adults between the ages to 19-55 years is 24 mg/day. Carp and catfish can provide 33% while mullet and kanga can contribute 23% of the daily Fe requirement for women if 100 g of fish is consumed.

The difference in mineral contents from those reported in the literature [12,37,40] possibly results from geographical place of harvest, seasonal, annual and environmental factors and species.

4. Conclusion

This study has demonstrated that the nutritional composition of raw Maga Lake fish used in this work change within the species. These fish species were found to be a fat fish. There were good sources of protein, fatty acids composition and essential mineral. DHA and EPA contained in these fish are good for health. Carp fish from this study was more beneficial for human health in developing country than others fish analysed due to the richer ω-3 fatty acid percentage composition and the ratio ω-3:ω-6. The data on the nutritional and nutraceutical composition of these fish analysed can be used as guideline for promoting the consumption of these fish and for further studies.

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