Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 74 (2014) 26719-26723

ISSN: 2229-712X

Mineral and fatty acid compositions of three fresh water fish samples commmonly consumed in south western states of Nigeria

Olaleye, A.A*, Ogungbenle, H.N. and Ayeni, K.E
Department of Chemistry, Ekiti State University, Ado-Ekiti, Nigeria.

ARTICLE INFO

Article history:
Received: 30 August 2013;
Received in revised form:
21 August 2014;
Accepted: 29 August 2014;

Keywords
Cat fish,
Snake fish,
Tilapia fish,
Minerals,
Fatty acids.

ABSTRACT

The levels of minerals and fatty acids in *Clarias gariepinus*, *Channa striatus* and *Tilapia zillii* were determined using standard analytical techniques. Results showed high levels of most of the minerals especially sodium 49.9-84.6 mg/100g and potassium 67.5-93.2mg/100g. The zinc contents (21.3-36.4 mg/100g) were above the recommended daily allowance (RDA) whereas, the iron levels (10.5-18.4mg/100g) fell within the range of 10-15mg, 18mg and 12mg requirements for children, women and men respectively. The most concentrated saturated fatty acid in the samples was palmitic acid (22.3 – 23.5%) and it was equally the most concentrated of all the fatty acids determined. The total saturated fatty acid (SFA) ranged between 35.0 – 38.1%. The monounsaturated fatty acid (MUFA) ranged between 38.3-39.4% whereas, polyunsaturated fatty acid (PUFA) ranged between 22.5-26.1%. Total unsaturated fatty acid (MUFA + PUFA) range was 61.9 – 64.9%. MUFA/SFA range was 1.03 – 1.11 whereas PUFA / SFA ranged between 0.59 - 0.75. This range is reasonable enough to discourage the development of atherosclerosis. The n-6 / n-3 ratios in *C. striatus* (7.75) and *T. zillii* (5.78) compare favourably with the recommended range of 5-10 whereas, that of *C. gariepinus* (274) was much higher.

Introduction

Animal protein intake by Nigerians has been very low due to reduced animal production per capital (Olayide *et al*., 1972) and the rising growth in human population (Oyenuga, 1968). Petrides (1968) had indicated that fish and meat from wild animals are the diets of the rural communities especially in the Southern States of Nigeria. Fish is known for its high nutrition due to its high protein content, phospholipids and polyunsaturated fatty acids (PUFA) as well as the covering percentage of the essential minerals RDA/RDI (recommended daily allowance / intakes) (Simopoulos, 2002). Polyunsaturated, especially n-3 and n-6 fatty acids are particularly important in fish, since their consumption reduces the appearance of cardiovascular diseases (Kris-Etherton *et al*., 2003). Recently, there has been expansion of aquaculture in Nigeria, especially cat fish and tilapia fish due to their tolerance to wide range of temperature, fast growth and adaptation to diversed environments as well as to low oxygen and high salinity levels (Hecth *et al*., 1996). Snake fish has pharmaceutical values and has been used to reduce the post natal and post surgery pains (Mat Jais *et al*., 1994). It is highly priced in the market because of its good delicate taste (Qin and Fast, 1998). Hence, the determination of the chemical composition of fishes is an important part of aquaculture research. The objective of this study therefore is to investigate the nutritionally valuable minerals and the fatty acid content of *Clarias_gariepinus*, *Channa striatus* and *Tilapia zillii*. This will provide more useful information that can further suggest the three fish samples as major sources of nutrients especially for populations of the developing countries.

Materials and methods

Sample Collection and Preparation

All the three samples *C. gariepinus*, *C. striatus* and *T. zillii* were obtained from Mokoko and Epe landing sites in Lagos Nigeria. The samples were brought into the laboratory, all bone heads removed and the oven dried at 55^{0}C for 5h. The cooled samples were ground separately using mortar and pestle into a fine powder and kept separately in a dry, cool place prior to use.

The minerals were analysed from solutions obtained by first dry ashing the samples at 550^{o}C to constant weight. Sodium and potassium were determined using flame photometer (Model 405, corning, UK). All other metals were determined by means of an atomic absorption spectrophotometer (Bulk Scientific Instrument).

Fatty Acid Analysis

About 100mg of each sample part was weighed into the extraction thimble and the fat extracted with petroleum ether (40-60^{0}C boiling range) using a soxhlet apparatus (A.O.A.C., 2005). The extraction lasted for 6h. The oil extracted was converted to the methyl ester using the boron trifluoride method (A.O.A.C., 2005). The gas chromatographic conditions for the analysis of fatty acid methyl esters were as follows:

GC: HP 6890 powered with Hp, Chemstation rev.A09.01 (1206) software, injection type: split injection, split ratio: 20:1, carrier gas: Nitrogen, inlet temperature: 250^{0}C, column type: HP INNOWax, column dimensions: 30m x 0.25mm x 0.25µm, oven program: initial temperature at 60^{0}C. Firs ramping at 10^{0}C / min for 20min, maintained for 4 min, second ramping at 15^{0}C/min for 4 min maintained for 4 min. Detector: flame ionization detector (FID).

Detector temperature: 320^{0}C, hydrogen pressure: 22 psi, compressed air: 35 psi. The peaks were identified by comparison with standard fatty acid methyl esters.

Calculations:

Total fatty acid = sample fat x 0.70

$$\text{Fatty acid as food} = \frac{\text{Total fatty acid x individual fatty acid}}{100}$$

Tele:
E-mail addresses: lebdul@yahoo.com

Results and discussion

The mineral contents of cat fish (*Clarias gariepinus*) snake fish (*Channa striatus*) and tilapia fish (*Tilapia zillii*) are shown in Table 1. The sodium content of *Clarias gariepinus* and *Tilapia zillii* (68.5mg/100g and 84.6mg/100g respectively) were higher than the range of 12.5 – 63.1mg/100g) reported for most Nigerian fresh-water fishes (Adeyeye *et al*., 1996) whereas, that of *Channa striatus* fell within. The sodium contents in the three samples (49.9 – 84.6mg/100g) were higher than the value (36.6mg/100g) reported for grasshopper (*Zonocerus variegatus*) (Olaofe *et al.*, 1998) and 31.5mg/100g recorded for silkworm (*Anaphe infracta*) larvae (Adeyeye, 2008). The values reported for potassium in the present study (67.5-93.2mg/100g) were far above 36.7mg/100g reported for A. infracta larvae (Adeyeye, 2008), 12.5 – 16.9mg/100g for most Nigerian fresh water fishes (Adeyeye *et al*., 1996) and 45.0mg/100g in *Z. variegatus* (Olaofe *et al*., 1998). *Tilapia zillii* had the highest concentration of sodium and potassium (84.6mg/100g and 93.2mg/100g respectively) among the three samples. Both sodium and potassium are required to maintain osmotic balance of the body fluid, the pH of the body, regulate muscles and nerve irritability, control glucose absorption and enhance normal retention of protein during growth (NRC, 1989). The values reported for calcium (21.9-38.7mg/100g) in the samples were much higher than 8.4mg/100g in *Z. variegatus* (Olaofe *et al.*, 1998) and 1.38 – 1.81mg/100g in *Illisha africana* fish (Adeyeye, 1996). The concentrations of zinc (21.3-36.4mg/100g) and manganese (1.85-4.22mg/100g) in the present study were higher than 10.8mg/100g (zinc) and 0.07mg/100g (manganese) in *A. africana* (Adeyeye, 2008). However, the calcium levels were lower than the recommended daily allowance (RDA) level of 800mg (Adeyeye, 2011[a]). If Ca is adequately present in the diet, Fe is utilized to better advantage. This is an instance of 'sparing action' (Fleck, 1976). The zinc levels in this report are fairly above zinc allowance of about 15-20mg per day (Fleck, 1976). The level of iron in this study ranged between 10.5-18.4mg/100g. The iron requirement by humans is 10-15mg for children, 18mg for women and 12mg for men (Fleck, 1976). Lead, chromium and nicked were not detected in any of the samples. The absence of lead in the samples was an indication that the environment might not have been contaminated by it. The K/Na, Na/K and Ca/Mg ratios are also shown in Table 1. The K/Na ratios in the samples ranged between 1.1-1.35 meaning that more sodium is required to balance up to 1:1. K/Na ratios enhance the salt balance of the body fluid (Adeyeye, 2011[a]). The Na/K ratios (0.74-0.91) were fairly higher than the 0.6 requirement to avoid high blood pressure (Adeyeye and Adamu, 2005). The Ca/Mg weight ratio in *Tilapia zillii* was higher than the recommended value of 1.0 (NRC, 1989), whereas those of *C. gariepinus* (0.64) and *C. striatus* (0.30) were comparatively lower.

Table 2 presents the crude fat and total fatty acid levels of the fish samples. The crude fat ranged between 7.16 – 8.79 and the total fatty acids ranged from 5.01 – 6.15. This shows that snake fish (*C. striatus*) had the highest concentrations of the two parameters. Also, little variation existed among the samples as this was evident in the value (10.3) of coefficient of variation percent (CV%). The total fat values (7.16 – 8.79mg/100g) were much lower than the value in duck's meat and skin (43%), chicken's meat and skin (18%), lamb fat (72%) and pork fat (71%) (Bender, 1992).

Table 3 reveals the percent values of various fatty acids in the fish samples. The most concentrated saturated fatty acid (SFA) was palmitic acid (22.3-23.5%). [This is close to the values (28.3-27.8%) reported by Adeyeye (2011[b]) for Tilapia (*Oreochromis niloticus*)] fish skin and muscle respectively. Arachidic, benenic and lignoceric fatty acids recorded very low concentration. The values of palmitic acid in the three samples were close with low level of coefficient of variation percent (CV%) of 2.90. It has been established that saturated fatty acids elevate serum cholesterol while the polyunsaturated fatty acids (PUFA) lower serum cholesterol (Hegsted *et al*., 1993). However, stearic acid (C 18.0) may not be as hypercholesterolemic as other SFA. This is because it is converted to oleic acid (Bonanome and Grundy, 1988). Also, for calcium to be incorporated into the skeletal structure, at least 50% of the dietary fats should be saturated (Watkins *et al*., 1996). Among the monounsaturated fatty acids (MUFA), cis–petroselinic acid had the highest concentration (15.3 -15.7%) in all the three samples and it is generally the most concentrated fatty acid. Docosahexanoic acid was the most concentrated polyunsaturated fatty acid (10.9-12.3%).

The calculated total fatty acids as shown in Table 2 are depicted in Table 4. It showed how the sample fatty acids would be if they were taken as dietary fat. It was observed that most of the values reported for *C. gariepinus* and *C. striatus* were considerably higher than the corresponding values in *T. zillii*. This might be due to the calculated total fatty acids which were more in the first two samples.

Table 5 summarizes the fatty acid levels to SFA, MUFA, DUFA, TUFA and other PUFA. The total SFA ranged between 35.0-38.1% whereas MUFA concentrations were in the range 38.3-39.4%. The total MUFA for the three samples in the present report (38.3-39.4%) were higher than those reported for skin (24.0) and muscle (24.3%) of Tilapia (*Oreochromis niloticus*) fish (Adeyeye, 2011[b]). The values of MUFA/SFA (1.03 – 1.11) showed that MUFA concentrations were just fairly above those of SFA. The relative proportion of SFA to MUFA is an important aspect of phospholipid compositions and abnormal changes to this ratio have been claimed to have effects on disease states such as cardiovascular disease, obesity, diabetes, neuropathological condition and cancer (Christie, 2011). The total unsaturated fatty acids in the samples were 61.9% (*C. gariepinus*), 63.2% (*C. striatus*) and 64.9% (*T. zillii*); this was made up by MUFA and PUFA. The relative amounts of PUFA and SFA in oils is important in nutrition and health. The ratio of PUFA/SFA (P/S) is therefore important in the determination of the dentrimental effects of dietary fats. The higher the P/S ratio, the more nutritionally useful is the oil. This is because the severity of atherosclerosis is closely associated with the proportion of the total energy supplied by saturated fats and polyunsaturated fats (keys, 1972; Honatra, 1974). The PUFA/SFA ratios in the present report are good enough to discourage atherosclerosis tendency. The 2n-6/3n-3 ratios in this study were 274 (*C. gariepinus*), 7.75 (*C. striatus*) and 5.78 (*T. zillii*). Polyunsaturated linoleic acid (n–6) moderately reduces serum cholesterol and low density lipoprotein bonded cholesterol (LDL-C) levels (WHO/FAO 1994). Linoleic (n-6) and α-linolenic (n-3) acids are the most important essential fatty acids required for growth, physiological functions and body maintenance (Salunkhe *et al*., 1985). n-6 and n-3 fatty acids have critical roles in the membrane structure (Lynch and Thompson, 1984; Kinsella, 1990) and they are precursors of eicosanoids, which are potent and highly reactive compounds. Since both n-6 and n-3 compete for the same enzymes and have different biological roles, the balance between the two of them is important (WHO/FAO, 1994).

Table 1: Mineral content (mg/100g) of cat fish, snake fish and tilapia fish samples

Parameter	Sample			Mean	SD	CV%
	CF	SF	TF			
Sodium	68.5	49.9	84.6	67.7	17.4	25.7
Potassium	91.8	67.5	93.2	84.2	14.5	17.2
Calcium	34.3	21.9	38.7	31.6	8.71	27.6
Magnesium	53.5	73.1	11.2	45.9	31.6	68.8
Zinc	36.4	21.3	27.9	28.5	7.57	26.6
Iron	15.5	10.5	18.4	14.8	4.00	27.0
Manganese	4.22	1.85	4.16	3.41	1.35	39.6
Lead	ND	ND	ND	-	-	-
Chromium	ND	ND	ND	-	-	-
Nickel	ND	ND	ND	-	-	-
K/Na	1.34	1.35	1.10	1.26	0.14	11.1
Na/K	0.75	0.74	0.91	0.80	0.10	12.5
Ca/Mg	0.64	0.30	3.46	1.47	1.73	118

CF= cat fish, SF= snake fish, TF= tilapia fish, SD= standard deviation
CV% = coefficient of variation percent

Table 2: Crude fat acid total fatty acid levels of cat fish, snake fish and tilapia fish (g/100g dry weight)

Parameter	CF	SF	TF	Mean	SD	CV%
Crude fat	8.24	8.97	7.16	8.06	0.83	10.3
*Total fatty acid	5.77	6.15	5.01	5.64	0.58	10.3

* Crude fat x 0.70

Table 3: Fatty acid composition of cat fish, snake fish and tilapia fish samples (% total fatty acid)

Fatty acid	CF	SF	TF	Mean	SD	CV%
Dodecanoic acid	0.44	0.17	0.45	0.35	0.16	45.7
Myristic acid	2.55	4.30	3.89	3.58	0.92	25.7
Palmitic acid	23.5	23.4	22.3	23.1	0.67	2.90
Stearic acid	11.5	8.87	8.30	9.56	1.71	17.9
Arachidic acid	0.03	0.04	0.02	0.03	0.01	33.3
Behenic acid	0.03	0.04	0.02	0.03	0.01	33.3
Lignoceric acid	0.003	0.005	0.002	0.003	0.002	66.7
Myristoleic acid	0.004	0.005	0.003	0.004	0.001	25.0
Palmitoleic acid	7.10	6.11	7.34	6.85	0.65	9.49
Petroselinic acid	15.3	15.3	15.7	15.4	0.23	1.49
Oleic acid	11.1	13.7	12.5	12.4	1.30	10.5
Cis-II Gondoic acid	4.61	1.88	1.90	2.80	1.57	56.1
Erucic acid	1.32	1.31	1.40	1.34	0.05	3.73
Nervonic acid	0.003	0.005	0.002	0.003	0.002	66.7
Trans-petroselinic acid	0.01	0.01	0.008	0.009	0.001	11.1
Elaidic acid	0.0009	0.001	0.001	0.001	0.0001	10.1
Trans-II vaccenic acid	0.00	0.00	0.01	0.003	0.01	33.3
Linoleic acid	8.22	9.07	7.52	8.27	0.78	9.43
Eicosadienoic acid	0.004	0.006	0.003	0.004	0.002	50.0
Docosadienioc acid	0.39	0.08	0.31	0.26	0.16	61.5
Rumenic acid	0.01	0.02	0.01	0.01	0.01	10.0
α- Linolenic acid	0.03	1.36	1.46	0.96	0.80	84.2
Dihomo-□-Linolenic acid	0.37	0.21	0.37	0.32	0.09	28.1
α-Linolenic acid	0.03	1.17	1.30	0.883	0.70	84.3
Eicosatrienoic acid	0.02	0.03	0.01	0.02	0.01	50.0
Arachidonic acid	1.12	0.23	1.37	0.91	0.60	65.9
Timnodonic acid	1.35	1.15	1.46	1.32	0.16	12.1
Docosahexanoic acid	10.9	11.5	12.3	11.6	0.70	6.03

Table 4: Fatty acid values per 100g cat fish, snake fish and tilapia fish samples as food

Fatty acid	CF	ST	TF	Mean	SD	CV%
Dodecanoic acid	0.025	0.01	0.023	0.019	0.008	42.1
Myristic acid	0.147	0.265	0.195	0.202	0.059	29.2
Palmitic acid	1.36	1.44	1.12	1.31	0.17	13.0
Stearic acid	0.663	0.546	0.416	0.542	0.124	22.9
Arachidic acid	0.0017	0.003	0.001	0.002	0.001	50.0
Behenic acid	0.0017	0.003	0.001	0.002	0.001	50.0
Lignoceric acid	0.0002	0.0003	0.0001	0.0002	0.0001	50.0
Myristoleic acid	0.0002	0.0003	0.0002	0.0002	0.0001	50.0
Palmitoleic acid	0.41	0.376	0.368	0.385	0.022	5.71
Petroselinic acid	0.883	0.941	0.787	0.870	0.0.7	8.97
Oleic acid	0.64	0.843	0.627	0.703	0.121	17.2
Cis-II Gondoic acid	0.266	0.116	0.095	0.159	0.093	58.5
Erucic acid	0.076	0.081	0.07	0.076	0.006	7.89
Nervonic acid	0.0002	0.0003	0.0001	0.0002	0.0001	50.0
Trans-petroselinicacid	0.0006	0.0006	0.0004	0.0005	0.0001	20.0
Elaidic acid	0.00005	0.0001	0.0001	0.0001	0.00003	30.0
Trans-II vaccenic acid	0.0	0.0	0.001	0.0003	0.0006	20.0
Linoleic acid	0.474	0.558	0.377	0.470	0.091	19.4
Eicosadienoic acid	0.0002	0.0004	0.0002	0.0003	0.0001	33.3
Docosadienioc acid	0.022	0.005	0.016	0.014	0.009	64.3
Rumenic acid	0.0006	0.001	0.001	0.001	0.002	20.0
□- Linolenic acid	0.0017	0.084	0.073	0.053	0.045	84.9
Dihomo-□-Linolenicacid	0.021	0.013	0.019	0.018	0.004	22.2
α-Linolenic acid	0.0017	0.072	0.065	0.046	0.039	84.8
Eicosatrienoic acid	0.0012	0.002	0.001	0.001	0.001	100
Arachidonic acid	0.065	0.014	0.069	0.049	0.031	63.3
Timnodonic acid	0.078	0.071	0.073	0.074	0.004	5.41
Docosahexanoic acid	0.629	0.708	0.616	0.651	0.050	7.68
Total	5.77	6.36	5.02	5.72	0.67	11.7

Table 5: Summary of Table 3 into SFA, MUFA, DUFA, TUFA and PUFA values (% total fatty acid)

Fatty acid	CF	SF	TF	Mean	SD	CV%
SFA	38.1	36.8	35.0	36.6	1.56	4.26
MUFA –cis	39.4	38.3	38.8	38.8	0.55	1.42
-trans	0.01	0.01	0.02	0.01	0.01	100
Total	39.4	38.3	38.8	38.8	0.55	1.42
DUFA –cis	8.61	9.16	7.83	8.53	0.67	7.85
-trans	0.01	0.02	0.01	0.01	0.01	100
Total	8.62	9.18	7.84	8.55	0.67	7.84
TUFA –cis	0.45	2.77	3.14	2.12	1.46	68.9
-trans	-	-	-	-	-	-
Total	0.45	2.77	3.14	2.12	1.46	68.9
Other PUFA	13.4	12.9	15.1	2.12	1.15	8.33
Grand total	100	100	99.9	100	0.06	0.06
Total MUFA + DUFA + TUFA	48.5	50.3	49.8	49.5	0.93	1.88
Total DUFA +TUFA + Other PUFA	22.5	24.9	26.1	24.5	1.83	7.47
MUFA + PUFA	61.9	63.2	64.9	63.3	1.50	2.37
MUFA / SFA	1.03	1.04	1.11	1.06	0.04	3.77
PUFA / SFA	0.59	0.68	0.75	0.67	0.08	11.9
2n-6 / 3n-3	274	7.75	5.78	95.8	154	161

The ratio of n-6 to n-3 in the diet should be between 5:1 and 10:1 (WHO/FAO, 1994) or 4-10g of n-6 fatty acids to 1.0g of n-3 fatty acids (SRC, 1990 and Nestel, 1987). The present report for *Channa_striatus* and *Tilapia zillii* showed that the n-6 / n-3 values were still within the recommended ratios. This study also showed that cat fish (*Clarias gariepinus*) contained much more omega-6 (n-6) than omega–3 (n-3), hence must be supplemented with omega–3 when it serves as the only dietary food. Generally, most of the values in Table 5 were very close when viewed on pairwise basis as this was evident in the levels of the coefficient of variation percent (CV%).

Conclusions

The findings of this study showed that the samples contained unequal distribution of most of the minerals determined. Also, the mineral components were good as most of the metals were fairly higher or fell within the range of the recommended daily allowance (RDA). The saturated fatty acids in the samples were of appreciable levels but were comparatively lower than the total unsaturated fatty acids. The ratio of n-6 to n-3 fatty acids favoured *C. striatus* and *T. zillii* but *C. gariepinus* contained too much n-6 and would need fortification with n-3. Generally, the samples are good sources of minerals and essential fatty acids especially for rapid growth and development of children.

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