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Nutritive Profile of Sun Dried Fermented Mud Fish (*Clarias Anguiliaris*) and Tiger Fish (*Hydrocynus Vittatus)* Locally Known as Abil Alier Sold in Markets in South Sudan

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Abstract

Fishes are irreplaceable animal food in developing countries as a source of high quality protein and micronutrients. This study was carried out to determine the proximate composition, mineral content and fatty acids of sun-dried fermented Mud Fish (Clarias anguiliaris) and Tiger Fish (Hydrocynus vittatus) sold in local markets of South Sudan. International Organization for Standardization procedures were used to determine proximate composition, Atomic Absorption Spectrophotometer for mineral content and Gas Chromatography-mass spectrometry for fatty acids. C. anguiliaris had higher concentrations of crude protein (75.2%), crude fat (24.9%) and moisture content (14.3%) than H. vittatus with 65.98%, 7.81%, 8.12% respectively. H. vittatus had more ash content (4.1%) and carbohydrate (3.59%) than C. anguiliaris at 2.7% and 2.12% respectively. Palmitic fatty acid was the dominant saturated fatty acid in H. vittatus (21.12%) and C. anguillaris (21.32%). Eicosatrienoic acid was 11.21% in H. vittatus and 10.64% in C. anguillaris and was the highest polyunsaturated fatty acid. Calcium was the highest mineral followed by magnesium and zinc. Lead and mercury were significantly ($P < 0.0001$) higher in C. anguiliaris (0.104 ± 0.001 $g100g^{-1}$) than H. vittatus (0.06 ± 0.000 $g100g^{-1}$). C. anguiliaris and H. vittatus are highly nutritious and rich sources of protein, moisture, lipid, ash and minerals.

Keywords

South Sudan, tiger fish, mud fish, nutritive profile

1. Introduction

Fish, either produced through fish farming/aquaculture activity or caught from wild marine or freshwater stocks, is a primary source of protein and essential nutrients. There is a growing recognition of its nutritional and health-promoting qualities (Tahergorabi, Matak, & Jaczynski, 2014). The presence of essential nutrients (such as iodine, vitamin B12 and D), the long-chain fatty acids (LC-PUFA), eicosapentaenoic (EPA) and docosahexaenoic (DHA) omega-3 fatty acids, protein of high quality (with all the essential amino-acids) and fish is very rich content in calcium, iron, zinc and vitamin A, is well documented (Belton & Thilsted, 2014; Kawarazuka & Béné, 2011; Salem & Eggersdorfer, 2015). Fish contributes to 16% of all animal protein consumed worldwide (World Bank, 2013). Fish is a particularly nutritious food, rich in numerous micronutrients in their in bioavailability form (Golden et al., 2016) that are often missing in diets, particularly those of the poor. Recent studies have reported high micronutrient deficiencies. Globally, 0.9% of children under 5 years and 7.8% of pregnant women have Night blindness due to insufficient Vitamin A (Black et al., 2013). Africa has the highest proportion of pregnant women with iron deficiency anemia (20.3%) and zinc deficiency (23.9%) (Black et al., 2013). Their deficiencies pose risks of infant mortality, cognitive under-development, weak immunity, maternal and perinatal deaths and growth retardation (Schaible & Kaufmann, 2007). Fish is an essential, cheap and often irreplaceable animal food for the poor in developing countries with access to water resources (Youn et al., 2014).

Fish and fish-related products also provide income and livelihoods for numerous communities across the world (Food and Agriculture Organization, 2016) and is the fastest growing food-supply industry in the world (Béné, Barange, & Subasinghe, 2015). Fish, in a broad sense, including fisheries and aquaculture, plays a crucial role for food security as a purveyor of food (availability), livelihoods and income (Mcclanahan, Allison, & Cinner, 2015) particularly for some vulnerable and marginalized populations (accessibility) (Lynch et al., 2016). Consumption of fish is projected to increase by 57% by 2020 in developing countries (World Bank, 2013) , however, fish has a short shelf life.

Various methods food processing techniques such as salting, canning, drying, curing, freezing and fermentation are used for preservation and value addition (Hall, 2012). In South Sudan, sun-drying and fermentation are the most common traditional methods of fish processing. An estimate of proximate composition gives a good justification for better processing, preservation and provides the nutritional value of fish species. This study was carried out to determine the proximate composition, mineral content and fatty acids of sun-dried fermented Mud fish and Tiger fish locally known as Abil Alier and commonly sold in every markets in South Sudan.

2. Methods

2.1 Sample Collection

Fish samples of Abil Alier were aseptically collected from Konyokonyo market randomly and transported to Chemiphar food laboratory for analysis. Samples (n = 12) were cleaned manually and homogenized using a mixer grinder. The minced samples were then stored at -40°C for further use.

2.2 Proximate Composition

Crude protein, ash (mineral), crude fat, carbohydrate and moisture content were determined in triplicates using standard protocols. Standard procedures by the International Organization for Standardization (ISO) were used to determine moisture (ISO 1442:1997), fat content (ISO 1443:1973), ash content (ISO 936:1998) and crude fiber (ISO 5498:1981). Crude protein was determined according to Kjeldahl method (976.05; AOAC, 2000) and protein calculated from the nitrogen content multiplied by 6.25. Total carbohydrate content was determined using Antrone Method, using standard protocol D-glucose as standard (Dreywood, 1946).

2.3 Mineral Analysis

Samples were dried in an oven at 125°C and ashed at 550°C. The samples were then initially digested in 15 ml of HNO3 until colorless. Distilled water was added to make up 25 mL. Minerals including heavy metals were determined using Atomic Absorption Spectrophotometer (AAS) (AOAC, 2000). Analyses were carried out in triplicates and results expressed as dry weight mean values.

2.4 Fatty Acid Analysis

Total lipids in the fish samples were extracted using a method developed by Folch et al. (1957) and the fatty acids were classified using Gas Chromatography-mass spectrometry (Chatzimichalakis, Samanidou, & Papadoyannis, 2004). Each individual constituent was identified and quantified by comparing retention times and peaks with the standards.

2.5 Statistical Analysis

Statistical significance was analyzed by unpaired student's t-test method using Graph Pad Prism. $P < 0.05$ was considered statistically significant and the results were expressed in mean ±SE.

3. Results

There was a significant difference ($P < 0.0001$) in the proximate composition of C. *anguiliaris* and H. *vittatus*. H. *vittatus* had higher concentrations of crude protein (75.18%), ash content (4.1%) and carbohydrate (3.59%) than C. *anguiliaris* at 65.98%, 2.7% and 2.12% respectively. However, C. *anguiliaris* had more fat (24.9%) and moisture content (14.3%) than H. *vittatus* at 7.81% and 8.12% respectively (Table 1).

Table 1. Proximate Composition of C. *Anguillaris* and H. *Vittatus*

Component	Content (%)	
	C. *anguiliaris*	H. *vittatus*
Moistur	14.3 ± 0.62^a	8.12 ± 0.08^b
Protein	65.98 ± 0.01^a	75.18 ± 0.04^b
Fat	24.9 ± 0.93^a	7.81 ± 0.16^b

Carbohydrates	2.12 ±0.00[a]	3.59 ±0.01[b]
Ash	2.7 ±0.10[a]	4.1 ±0.21[b]
Crude fibre	0.062 ±0.002	0.185 ±0.006
Energy (kcal)	495.97 ±1.32	378.80 ±1.782

Values are reported as mean ± standard deviation of three replicates. Values for pairs with different superscripts across the rows are significantly different ($P < 0.05$).

The mineral composition of C. *anguillaris* and H. *vittatus* is presented in the Table 2. Minerals detected were zinc, magnesium, calcium, lead, mercury, and arsenic. The highest mineral in both fish species was calcium at 467.00 ±2.735 $g100g^{-1}$ and 388.51 ±8.691 $g100g^{-1}$ in C. *anguiliaris* and H. *vittatus* respectively. Heavy metals specifically lead and mercury were significantly ($P < 0.0001$) higher in C. *anguiliaris* at 0.104 ±0.001 $g100g^{-1}$ and 0.06 ±0.000 $g100g^{-1}$ respectively than in H. *vittatus.*

Table 2. Mineral Composition C. *Anguillaris* and H. *Vittatus*

Mineral (ppm)	**Content ($g100g^{-1}$ of wet sample)**	
	C. *anguiliaris*	H. *vittatus*
Nutritional minerals		
Ca	467.00 ±2.735[a]	388.51 ±8.691[b]
Mg	241.72 ±0.029	242.65 ±2.25[a]
Zn	6.08 ±0.340[a]	4.24 ±0.175[b]
Heavy metals		
Pb	0.104 ±0.001[a]	0.096 ±0.001[b]
Hg	0.06 ±0.000[a]	0.045 ±0.005[b]
As	0.014 ±0.000[a]	0.014 ±0.000[a]

Values are reported as mean ± standard deviation of three replicates. Values for pairs with different superscripts across the rows are significantly different ($P < 0.05$).

More than half of the total fat content in H. *vittatus* and C. *anguillaris* constituted of total Saturated Fatty Acids (SFAs) at 58.94 ±0.32% and 60.36 ±1.99% respectively as shown in Table 3. Palmitic fatty acid (C16:0) was found to be the dominant SFA in H. *vittatus* (21.12%) and C. *anguillaris* (21.32%). Monounsaturated Fatty Acids (MUFA) was found to be at 9.27 ±0.83% and 8.70 ±0.33% for H. *vittatus* and C. *anguillaris* respectively. Oleic acid (C18:1 ω9) was the highest MUFA in H. *vittatus* (3.99%) and C. *anguillaris* (4.08%). The overall amount of PUFAs found in H. *vittatus* was 31.79 ±0.04% and 30.94 ±0.92% in C. *anguillaris*. The level of Eicosatrienoic acid (ETE) (C20:3ὠ3) was found to be 11.21% in H. *vittatus* and 10.64% in C. *anguillaris* which was the highest among all PUFAs, followed by linoleic acid (C18:2) and Eicosapentaenoic Acid (EPA) (C20:5ω3).

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Table 3. Fatty Acid Composition of C. *Anguillaris* and H. *Vittatus*

Fatty acid	**% composition of total area**	
	H. *vittatus*	C. *anguillaris*
Saturated (SFA)		
10:0	5.50	6.01
11:0	0.22	0.27
13:0	2.80	3.01
14:0	0.54	0.54
15:0	10.24	10.35
16:0	21.12	21.32
17:0	0.65	0.64
18:0	16.06	16.49
20:0	0.54	0.54
21:0	1.29	1.18
∑ SFA	58.94 ±0.32	60.36 ±1.99
Mono-unsaturated (MUFA)		
14:1	0.54	0.54
15:1	0.22	0.27
16:1	0.54	0.54
17:1	1.40	1.40
18:1	3.99	4.08
20:1	1.08	1.13
22:1	0.32	0.16
24:1	1.19	0.59
∑ MUFA	9.27 ±0.83	8.70 ±0.33
Polyunsaturated (PUFA)		
18:2	8.62	8.81
18:3 ω 6	2.05	2.20
18:3 ω 3	2.16	2.26
20:3 ω 6	0.43	0.43
20:3 ω 3	11.21	10.64
20:4 ω6	0.75	0.70
20:5 ω3	6.36	5.91
22:5 ω9	0.32	0.16
∑ PUFA	31.79 ±0.04	30.94 ±0.92
∑ ω-3	19.94 ±0.61	18.80 ±0.6

∑ ω-6	3.23 ±0.72	3.33 ±0.07
∑ ω-9	4.31 ±0.54	4.24 ±0. 41
Iodine value	23.35 ±2.19	23.41 ±0.15
Oleic acid(o)/Linoleic(I) ratio	0.46 ±0. 01	0.46 ±0.00

4. Discussion

Fish is the most efficient converter of feed into high quality food (High Level Panel of Experts on World Food Security, 2014). Fish is a good source of high quality protein with all the essential amino acids and micronutrients (Kawarazuka & Béné, 2011). However, its composition varies from one fishing ground to another, season to season, the amount and quality of feeds, amount of fish movement, size, sex, age, within and across fish species (Jan, Shah, Manzoor, & Ganie, 2012; Stansby, 1962) . In the present study, significant differences ($P < 0.05$) were observed in moisture, fat, protein, carbohydrate and ash content of the sun-dried fermented fish species of C. *anguiliaris* and H. *vittatus*.

Moisture content was found to be higher in C. *anguiliaris* than H. *vittatus.* This could be attributed to the duration and temperature of sun-drying as water is lost due to evaporation (Eyo, 2001). The fat content and moisture content in fish is said to be inversely related (FAO, 1999). This was found to be true for C. *anguiliaris* while in H. *vittatus* fat and water content were almost similar at 7.81% and 8.12% respectively. Fish feeds, habitat and geographical locations influences the protein and fat content of fish (Ahmed et al., 2015). Protein content was found to be higher in the H. *vittatus* than in C. *anguiliaris.* C. *anguiliaris* with a protein content of 65.98 ±0.01 was similar to a previous study by Idakwo et al. (2016) in fermented solar tent-dried fish. The time of reproduction may affect protein content because during spawning, protein is transferred from the muscle to the ovaries to meet the energy requirements (Jan et al., 2012). In addition, during the growth cycles, microbial metabolism is inhibited which decreases synthesis of proteins (Suchitra & Sarojinalini, 2012). The measure of mineral content is ash given it's the inorganic residue that remains after the organic matter has been removed (Ogundiran et al., 2014). The ash content observed was higher in H. *vittatus* than C. *anguiliaris.* H. *vittatus* is a predator that swallows small prey fish whole mainly of the families of Characidae and Cichlide (Gerking, 2014).

The amount of vitamins and minerals is species-specific and can furthermore vary with season. Fish meat is regarded as a valuable source of calcium and phosphorus in particular but also of iron, copper and selenium (FAO, 2016). The nutritional minerals observed in C. *anguiliaris* and H. *vittatus* fish were calcium, magnesium and zinc. Calcium was the highest mineral content as with other similar previous studies (Bogard et al., 2015; Mahanty et al., 2014). Calcium deficiency leads to the development of rickets especially in children (Craviari et al., 2008). Lead and arsenic concentrations observed in C. *anguillaris* differed from a study carried out on River Okpokwu, Nigeria which recorded 0.05 ±0.01 μg/g As and 0.08 ±0.03 μg/g Pb (Biosci, Abah, Ubwa, Onyejefu, & Nomor, 2013). The heavy metals in fish species could be due to the agrochemical wastes from pesticides, chemical fertilizers, herbicides, domestic wastes, and fuels in the water and their bio-accumulation in fish which can affect human health in the long term (Harikumar & Jisha, 2010). The levels of heavy metals observed in both fish species were below the recommended permissible limits of Pb 0.02 mg/g (World Health Organization, 2006) and As 0.01 mg/kg (Butu & Iguisi, 2013).

Fish is the richest source of long chain ὠ PUFA that improve human health and nutrition (Mahanty et al., 2014). Omega 3 and Omega 6 fatty acid have been found to reduce hypertension, cancer, coronary heart disease, atherosclerosis, Alzheimer's disease and dementia (Davis & Kris-Etherton, 2003; Shahid & Miraliakbari, 2004). Fatty acid profiles of C. *anguiliaris* than H. *vittatus* showed that they both contain more SFA than PUFA which was different from Mahanty et al. (2014) who reported more PUFA than SFA in P. *sophore.*

In conclusion, this study has shown that the Mud Fish (Clarias *anguiliaris*) and Tiger Fish (Hydrocynus *vittatus)* are highly nutritious. Both fish species are rich sources of protein, moisture, lipids, ash and minerals. More than half of the total fat content in H. *vittatus* and C. *anguillaris* constituted of total saturated fatty acids (SFAs) and Polyunsaturated Fatty Acids (PUFA) were Eicosatrienoic Acid (ETE), Linoleic Acid, Eicosapentaenoic Acid (EPA). Calcium was highest nutritious mineral followed by magnesium and zinc. Heavy metals detected were lead, mercury, and arsenic. Fish absorb and bio-accumulate minerals from their diets and the water bodies.

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