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Protein and Micronutrient Composition of Low-Value Fish Products Commonly Marketed in the Lake Victoria Region

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Abstract: Increase in demand of fish from Lake Victoria region has created gaps in local fish supplies and this raises concern since there are reports of limited animal-source food consumption plus protein and micronutrients deficiencies in this region. To fill the gap, less-preferred pelagic fish species such as *Mukene* (*Rastreneobola argentea)* and by-products from filleting Nile perch (*Lates niloticus*), which were commonly used for animal feeds, are increasingly being minimally processed and marketed for direct human consumption. These fish products constitute what has been termed as 'low-value fish products'. This study was carried out to assess the nutrient content of low-value fish products (LVFPs) so as to document their potential contribution to protein and micronutrient intake of individuals who depend on these products as their major animal source food.Commonly marketed samples of fresh, smoked, deep fried and sun-dried Nile perch by-products and *mukene* were collected from factories, by-product processing sites and markets to determine their nutrient contents. The results show that most LVFPs had protein levels comparable to Nile perch fillet but *mukene* products had the highest crude protein (47.9% to 58.8%), followed by fresh perch eggs products (32.1% to 38.7%). On dry weight basis, the concentration of iron was highest in *mukene* products (8.18 -10.91 mg/100g) and lowest in perch fillet (1.06 mg/100g); zinc was highest in *mukene* products (4.07-10.25 mg/100g) and fresh perch eggs (4.07 mg/100g); while calcium was highest in perch skin (1827.4 -1986.3 mg/100g) and *mukene* products (1556.4-1866.5 mg/100g). Perch fillet was among the products with lowest amounts of iron, zinc and calcium.These findings suggest that LVFPs can improve protein and micronutrient intake of individuals with limited access to animal-source foods. There is need to educate communities to improve processing, handling and acceptability of LVFPs products for direct human consumption.

Key words: Low-value fish products · Animal-source food · Calcium · Iron · zinc

INTRODUCTION

Analysis of trends in global animal source food consumption indicate decreasing fish consumption in developing countries; yet these countries already had low per capita consumption of animal source foods [1]. This situation raises concern because less developed countries continue to record high prevalence of undernutrition and this is partly attributed to limited dietary intake of nutrient dense foods such as animal-source food products. This study investigated the nutrient content of less valued fish products such as *mukene* (a pelagic fish species), by-products from filleting Nile perch and juvenile fish in order to determine whether these products provide a good alternative source for protein and micronutrients among populations that cannot access high value animal-source food products such as mature fish and fillet.

Some of the strategies proposed to improve fish supply for human consumption include increased use of underutilized species and reduction in fish wastage in form of unintended by-catches and post-harvest losses [2]. At the moment, the only underutilized fish species in the Lake Victoria region are small pelagic fish species

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such as *Rastrineobola argentea* (which is commonly called *mukene* in Uganda, *dagaa* in Tanzania and *omena* in Kenya) and haplochromines (*Nkejje*). Unintended by-catches in Nile perch and tilapia fisheries are often comprised of indigenous fish species such as *Protopterus* (lung fish or *Mmamba*) and catfishes (specifically *Bagrus docmac*, *Synodontis victoriae*, *Clarias gariepinus* and *Schilbe intermedius)* but these indigenous fishes are highly valued and fully utilized for local consumption [3]. Another category of by-catches from the Lake Victoria are *mollusca* (specially *P. Aethiopicus*) and *caridina nilotica* (which are commonly called prawns or shrimp); however *Mollusca* are not harvested for direct human consumption because they are considered disease vectors while the harvest of prawns for direct human consumption is banned in the Lake Victoria region since prawns constitute a major prey for Nile Perch. A review of low-value fish products marketed in the Lake Victoria region [3] revealed that the bulk of LVFPs traded and consumed by populations in the region were comprised of fish frames (backbone and fins with or without heads), heads, roe (eggs) and skin generated from filleting Nile perch [3]. These products in combination with *mukene* and by-catches of juvenile fish are the fish products that are referred to as low-value fish products (LVFPs) in this paper.

Promoting LVFPs has high potential to improve food and nutrition security in the Lake Victoria region because this region is experiencing increased demand for its fish at international and regional markets; however fish stocks and catches have been declining over the years. As a result, artisanal fisherfolk in Lake Victoria region have diverted to harvesting of immature fish (mostly juveniles of tilapines, Nile perch and catfishes) and pelagic fish (mostly *mukene*) while artisanal processors have diverted to processing by-products from fish filleting factories as a strategies to improve gaps in local fish supply [3]. The dilemma in using LVFPs for direct human consumption is that these products are often handled as trash and crudely processed for local and informal regional markets [4-6]. The poor handling and minimal processing often induces degradation and is expected to result in products with limited nutritive value. Hence, the purpose of this study was to determine the nutritive value of LVFPs commonly marketed in the Lake Victoria region in order to assess their potential contribution to improving dietary intake of protein and micronutrients among populations who depend on these LVFPs as their major animal-source food.

MATERIALS AND METHODS

Sample Collection: The number of samples collected for each product depended on the number of processors or vendors dealing in the product. Efforts were made to collect each sample from at least three processors or vendors. The samples collected were categorized by processing method which included fresh (unprocessed), deep fried, smoked and sundried (includes salted) products. Although *mukene* is a sundried fish product, in this study *mukene* (which is commonly called *omena in* Kenya and *dagaa* in Tanzania) is considered as a separate category of LVFPs because the dynamics of its harvest and trade differs from other sundried LVFPs that were studied.

***Fresh LVFPS*:** Fresh skins, frames and heads of Nile perch (*L. niloticus*) were acquired from the same filleting factory. Nile perch eggs (roe) were acquired from artisanal LVFP processors in Katwe food market while *Mukene* was acquired from fisherfolk at Kiyindi landing site.

Deep Fried Products: Some of the fresh skins, frames and heads described above were taken to artisanal processors who deep fried these products to generate the deep fried samples used in this study. Artisanal processors deep fried these LVFPs using the oil they were using to deep fry other products for their usual business. Oil used for deep frying was a mixture of vegetable oil and oil generated from Nile perch by-products. Most processors used vegetable oil as base oil to start off the frying process but the volume of deep frying oil was maintained by adding fat pads generated from perch frames. None of the eight processors interviewed could tell for how long they had used the oil. Other food products that were deep fried in the same oil included chips of fresh sweet potatoes and fresh cassava.

Salted and Sun-Dried Products: Dried perch heads, frames and chips (also called trimmings or off-cuts) were bought from artisanal processors at the Busega by-products processing site. In general, traders were not willing to sell sundried products. Hence, samples of about 2-3 kg each of heads and frames (without head) were obtained from four artisanal processors. The samples of chips (about 1 kg in total) were collected from two processors.

Mukene: Freshly dried samples of about 10-15 grams were bought from artisanal processors that were drying *mukene* at landing sites in Kiyindi and Buvuma islands. Other samples were collected from traders that were airing *mukene* at Kiyindi landing site. Older samples were collected from retail fish mongers in food markets around Kampala. Salted, dried *mukene* samples were collected from a commercial processor at Kiyindi landing site.

Smoked Products: Freshly smoked samples of fish skins were purchased from the by-product processing site in Busega. Freshly smoked samples of juvenile perch were bought from artisanal processors in Buvuma islands. Older samples of juvenile Nile perch were purchased from retail fish mongers in food markets around Kampala; however, since vendors get products through middlemen, it was not possible to determine how long these samples had been on the market.

With the exception of salted *mukene* and perch fillet, all LVFPs assessed were collected from artisanal processors to allow for generalizing of findings to usual processing conditions. All samples were put on ice bags in thermo cooling boxes immediately after they were collected in order to reduce spoilage during transportation.

Sample Preparation: Sample preparation involved cooking (steaming or boiling) fish samples and extracting edible tissue from the cooked products. Edible tissue was extracted from the bones on day of collection manually using a kitchen knife. Extracted edible tissue was then ground using a heavy duty blender to obtain a homogenate which was stored in non-transparent plastic containers in a freezer. *Mukene* samples were stored as purchased and ground right before nutrient determination. All samples were analyzed within 1 week of collection.

Nutrient Determination: All experiments on determination of moisture content, crude protein, fat and minerals (calcium, iron and zinc) were performed in triplicate.

Determination of Moisture Content: Moisture content was determined using the dry oven method AOAC [7]. For each low-value fish product, three samples of 3 - 4 g were placed in dry moisture dishes of known weight and weighed using a digital food weighing scale. Dishes with sample were then placed in oven and dried for 4 hours at 125°C after which dried samples were weighed again to determine moisture loss.

Determination of Crude Protein: Crude protein was determined by the Kjeldahl methods (AOAC 954.01) using sulphuric acid for sample digestion. Total nitrogen was quantified by titrating the distillate against 0.05M 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.

Determination of Crude Fat: Crude fat was determined using AOAC methods [7]. The sample was extracted with petroleum ether (BP 40-60°C) in Soxhlet type continuous extraction apparatus.

Determination of Mineral Content: Calcium, iron, zinc and sodium content were determined quantitatively using atomic absorption spectrophotometric methods [7].

Statistical Analyses: Results were subjected to analysis of variance (ANOVA) using Stata statistical software (Stata Corporation, Texas, USA). Multiple comparisons of means were done using the Bonferroni method and p-values < 0.05 were considered statistically significant.

RESULTS

Table 1 summarizes the major findings from this study. In general, all low-value fish products (LVFPs) assessed had high levels of micronutrients investigated.

Moisture Content: As shown in Table 1, moisture content of LVFPs assessed varied based on processing method and the type of product. Moisture content of fresh products ranged from 62.4% to 81.1%. Moisture content of all dried products exceeded the 12% cut-off. Products with the least moisture content were freshly sundried *mukene* (12.4%), deep fried *mukene* (14.2%) and smoked juvenile perch on the market (14.2%). Smoked juvenile perch on the market had about half the moisture content of freshly smoked juvenile perch.

Crude Protein: Dried *mukene* (*R. argentea*) had the highest protein content (53.0- 58.8%) while smoked perch juveniles samples collected from the markets and fresh gills had the least protein (10.4% and 16.2%, respectively). All other perch by-products did not significantly differ from perch fillet.

Table 1: Nutrient Composition of Commonly Consumed Low-value Fish Products

		Nutrients per 100 g dry matter of edible portions						
Fish product	Processing method[β]	% Moisture content	% Crude fat	% Crude protein	Iron (mg)	Zinc (mg)	Calcium (mg)	Sodium (g)
Perch head	Fresh, boiled (n=6)	74.7 ± 0.7^{f}	2.49 ± 0.9^{a}	29.38 ± 1.77^{c}	6.05 ± 3.26^{b}	1.72 ± 0.09^{a}	72.43 ± 40.70^{a}	0.13 ± 0.04^{a}
	Deep fried, boiled (n=8)	62.2 ± 2.5^{e}	8.87 ± 2.29^{b}	27.26 ± 2.73^{c}	2.38 ± 1.15^{a}	1.48 ± 0.23^{a}	159.19 ± 4.34^{a}	0.28 ± 0.12^{a}
	Salted sundried, boiled (n = 6)	48.6 ± 1.9^{d}	4.34 ± 0.59^{a}	28.57 ± 2.44^{c}	2.96 ± 1.22^{a}	1.16 ± 0.68^{a}	87.29 ± 73.38^{a}	4.96 ± 0.08^{c}
Perch gills	Boiled (n=2)	42.3 ± 0.6^{c}	4.19 ± 2.03^{a}	12.54 ± 1.62^{a}	3.51 ± 1.04^{a}	2.34 ± 0.04^{a}	87.53 ± 12.06^{a}	0.68 ± 0.07^{a}
Perch frame	Fresh, boiled (n=6)	72.5 ± 0.3^{e}	1.71 ± 0.24^{a}	20.51 ± 1.91^{b}	2.71 ± 0.31^{a}	1.77 ± 0.11^{a}	-	0.70 ± 0.01^{a}
	Deep fried frame (n=8)	52.2 ± 1.4^{d}	17.40 ± 1.82^{c}	28.24 ± 1.02^{c}	3.19 ± 1.54^{a}	1.67 ± 0.11^{a}	-	0.21 ± 0.08^{a}
Perch skin	Fresh, boiled (n = 3)	69.4 ± 1.9^{e}	3.90 ± 0.21^{a}	29.28 ± 2.40^{c}	2.54 ± 0.25^{a}	2.31 ± 0.07^{a}	1827.38 ± 624.84^{b}	0.09 ± 0.03^{a}
	Salted sundried, boiled (n=4)	67.1 ± 1.1^{e}	1.81 ± 0.20^{a}	20.49 ± 2.37^{b}	2.72 ± 1.26^{a}	1.14 ± 0.05^{a}	1830.52 ± 382.15^{b}	0.94 ± 0.02^{b}
	Deep fried, boiled (n = 3)	59.9 ± 0.5^{e}	23.53 ± 1.35^{d}	34.84 ± 3.11^{c}	2.35 ± 0.21^{a}	2.03 ± 0.15^{a}	1836.10 ± 573.56^{b}	0.21 ± 0.08^{a}
	Smoked, boiled (n = 3)	48.0 ± 1.1^{d}	-	30.78 ± 2.31^{c}	-	-	1986.28 ± 394.16^{b}	-
Perch chips	Salted sundried, steamed (n=1)	43.1 ± 0.7^{c}	6.93 ± 0.84^{b}	16.24 ± 1.37^{b}	4.47 ± 0.59^{a}	0.78 ± 0.16^{a}	227.33 ± 14.02^{a}	-
Perch oil	Crude (n=1)	-	-	-	2.76 ± 0.68^{a}	Trace	Trace	-
Perch eggs	Fresh, deep fried (n=2)	-	28.53 ± 1.40^{d}	32.06 ± 0.09^{c}	5.42 ± 0.23^{b}	4.37 ± 0.03^{b}	Trace	-
	Fresh, steamed (n=2)	-	3.61 ± 0.42^{a}	38.74 ± 0.25^{d}	5.67 ± 0.84^{b}	2.35 ± 0.16^{a}	Trace	-
Juvenile perch	Smoked fresh from kiln (n=3)	31.2 ± 1.4^{b}	0.70 ± 0.04^{a}	34.05 ± 1.06^{c}	-	-	-	-
	Smoked from market (n=4)	14.2 ± 0.2^{a}	2.01 ± 0.06^{a}	10.40 ± 0.36^{a}	-	-	-	-
R. Argentea	Fresh, boiled (n = 2)	81.1 ± 0.0^{g}	0.17 ± 0.06^{a}	15.56 ± 0.27^{b}	2.60 ± 1.51^{a}	4.07 ± 0.49^{b}	866.50 ± 2.11^{b}	-
	Market, dried boiled (n=7)[β]	66.2 ± 0.0^{e}	0.78 ± 0.27^{a}	29.23 ± 2.36^{c}	8.18 ± 0.24^{c}	10.12 ± 0.57^{c}	1669.38 ± 610.41^{b}	0.10 ± 0.020^{a}
	Landing site, dried salted (n=1)	17.1 ± 0.4^{a}	13.16 ± 0.03^{c}	47.95 ± 0.07^{e}	10.91 ± 0.03^{c}	-	-	2.28 ± 0.37^{c}
	Landing site, dried unsalted (n=8)	12.4 ± 1.4^{a}	12.54 ± 0.74^{c}	58.79 ± 1.24^{e}	10.68 ± 0.51^{c}	10.25 ± 1.39^{c}	1556.39 ± 108.45^{b}	-
Perch fillet	Fresh (n=1)	84.2 ± 0.0^{g}	1.98 ± 0.74^{a}	58.79 ± 0.25^{b}	1.06 ± 0.03^{a}	0.72 ± 0.12^{a}	134.24 ± 0.68^{a}	-

[β] n refers to number of processors or vendors from whom samples were collected. All samples were analyzed in triplicate.

Means with the same letter in the same column are not significantly different (P=0.05). Data are represented as means ± standard deviation

Fat Content: Of the products assessed in this study, crude fat was lowest in smoked juvenile perch (0.7% to 2.0%) and highest in perch chips (6.9%). Deep frying increased fat content by 6-fold in perch skin (3.9% to 23.5%) and by 10-fold in meats scrapped from perch frames (1.7% to 17.4%). Sundried *Mukene* products had an average of 12.5-13.2% fat per 100 g of dry matter, which was higher than all perch products that were not deep fried.

Iron Content: Iron content varied significantly across the different products. Sundried *mukene* products had the highest amounts of iron (8.2 to 10.7 mg per 100 g of dry matter). Meats from perch head were mostly comprised of red meats, hence also had high levels of iron (6.1mg/100 g). Perch eggs, which had an average of 5.4 mg to 5.7 mg per100 g of dry matter, were also among the products with significantly higher iron content. Perch fillet was comprised of white meat only and its iron content was 1.06 ±0.03 mg per 100 g dry matter, which puts fillet among the products with the least amounts of iron.

Zinc Content: Zinc was highest in sundried *mukene* products (10.1-10.2 mg/100 g) and in perch eggs (2.3-4.4 mg/100 g). All other products had zinc contents higher than fillet but the differences were not statistically significant.

Calcium Content: *Mukene* and Nile perch skin were determined to have the highest amounts of calcium. As shown in Table 1, the calcium content of perch skin (without scales) ranged from 1827 to 1986 mg/100 g dry matter while *mukene* was composed of 1556 to 1866 mg/100 g dry matter. Amounts of calcium in perch fillet were not significantly different from chips, gills and meats extracted from perch heads. Perch eggs had negligible amounts of calcium.

DISCUSSION

In general, all low value fish products assessed had high levels of iron and zinc. In addition Nile perch skin and *mukene* (*Rastrineobola argentea*) products had exceptionally high levels of calcium. The micronutrient profiles of LVFPs investigated in this study indicate that low value fish products can contribute to nutrition security of low income populations that depend on these products as their major animal source food. Although this study only focused on iron, calcium and zinc, the high levels of these nutrients suggest that low-value fish products are a good source of other micronutrients that are expected to be high in fish.

With the exception of *mukene*, all the low-value fish products assessed had slightly lower protein content than reported in other studies [6] that have looked at high value fish. This can be attributed to poor handling practices. For example, once the by-products were out of filleting factories, there was no cold chain for LVFPs and in most cases these products were handled as trash. Poor handling practices are likely to have induced spoilage in most LVFPs investigated and increased proteolytic processes and growth of microorganisms which resulted in low protein content. Further studies are needed to investigate protein losses along the LVFPs processing chain. In the meantime, it is important to have quality controls at processing and market level to ensure that consumers access wholesome products with acceptable nutritive and organoleptic properties.

Despite the belief that perch is a fatty fish, all perch products that were not deep fried met the 5% cut off criterion that I s used to classify fish as low fat [8]. The practice of deep frying fish products increases total fat and makes LVFPs less desirable for health conscious consumers. The amount of fat in *mukene* is high; however, the fatty acid profile reveals that *mukene* fat is mostly comprised of poly-unsaturated fatty acids (results reported elsewhere). Iron, zinc and calcium were also highest in *mukene* because this fish is eaten whole.

Like other small fish species [4, 9, 10], *mukene* was determined to be nutrient denser than all other LVFPs investigated. In this study, sundried *mukene* had the highest amounts of micronutrients than fillet and by-products generated from filleting Nile perch. When compared to perch fillet, *mukene* had 8- to 10-fold iron content, more than 14-fold zinc content and about 14-fold calcium content. This is an important finding given the fact that *mukene* stocks and catches have increased in Lake Victoria as a result of the dwindling stocks of Nile perch which is a major predator of *mukene*. However, the protein content of *mukene* was lower than determined from other studies. This could have resulted from inadequate drying which results in some *mukene* rotting as some samples were observed to have visible signs of rot and discoloration.

Smoking and sun-drying are major methods used to preserve fish in Lake Victoria region, however results from this study indicate that many of the LVFPs are not dried enough to arrest enzyme activity, lipid oxidation and hydrolytic reactions which are often associated with high water activity [11]. Smoked products were partially dried because of the need to save on fuel wood while sundried LVFPs were partially dried to avoid reductions in weight because these products are sold to traders on weight basis. As a result of inadequate drying and the consequent degradation, juvenile perch and *mukene* from artisanal processors had significantly higher amounts of protein than juvenile perch and *mukene* from the markets, respectively.

CONCLUSIONS

Overall, low-value fish products marketed in Lake Victoria region are nutrient dense and can contribute to improving the gap in local fish supply. There is need for policy to regulate diversion of these products into animal feeds and to regulate exportation of these products in order to improve access of LVFPs among populations at risk for malnutrition. Local utilization of LVFPs can be enhanced if the processing of these products is improved to avail consumers with visually appealing products with acceptable organoleptic properties. Given the fact that LVFPs are not kept under cold storage, there is need to improve smoking and sun-drying processes in order to ensure longer shelf life of these fish products. Adequate processing and appropriate packaging of LVFPs can improve the nutritive quality and utilization of LVFPs and thereby improve access to animal-source foods in the Lake Victoria region.

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