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Nutrient composition of solar dried and traditionally smoked *Oreochromis mossambicus* (Peters, 1852)

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Abstract

Fish is a highly nutritious food in Malawi providing the most affordable dietary animal protein. In the lower Shire valley area of the country, the commonest consumed fish species is *Oreochromis mossambicus* (Mozambique Tilapia) which is usually smoked before marketing and/or consumption. Recently, the solar tent drying method has been introduced in the area as an environmentally smart technology to reduce dependency on use of fuel wood for processing fish as well as reducing problems faced during rainy season. However, processing affects nutrient value of foods underpinning the importance of consumer knowledge regarding proximate profiles in food to ensure that these are within the range of dietary requirement. This study determined the nutrient composition (protein, fat, ash and moisture; minerals – calcium, iron and magnesium) of *Oreochromis mossambicus* processed in a solar drier and traditionally smoked. Protein content was 50.62%, 61.26% and 54.79%; while crude fat was 5.91%, 13.43% and 8.90% respectively for fresh, solar dried and traditionally smoked fish. Determined moisture content was 91.97%, 15.90% and 24.54% in fresh, solar dried and traditionally smoked fish respectively, with significant differences between treatments ($P<0.05$). Ash content was also significantly different ($P<0.05$) between treatments - 11.12% (fresh), 17.58% (solar dried) and 14.72% (traditionally smoked). Mineral contents did not show any significant differences ($P>0.05$). It is concluded that fish processed in the solar drier are more nutritious and with a longer storage period than traditionally smoked fish. The lower Shire valley is the hottest area in Malawi hence use of solar drier could be an efficient, affordable and sustainable method of processing fresh fish.

Introduction

Fish is an important source of livelihood as a source of income and food for the rural poor who in many cases suffer from malnutrition and micronutrient deficiencies (Charlton *et al*., 2016). In Malawi, about 40% of the total dietary protein for the population is obtained through the consumption of fish (Phiri *et al*., 2013). As a way of extending storage life and increasing its economic market value, fresh fish in Malawi is processed through sun drying, para-boiling and smoking. However, during rainy season, sun drying is a challenge due to high humidity and prolonged cloud cover resulting into loss of fish through spoilage. Para-boiling and smoking is dependent on availability of fire wood which is scarce in many parts of the country including the lower Shire valley. Recently, the local fishery has seen the introduction of solar driers which operate by concentrating solar radiation to dehydrate fish (Kaushik, 2010). Its efficiency and hygienic aspects have attracted the interest of many fish processors and consumers in most developing countries (Mustapha *et al*., 2014). Further, studies do not show that foods processed in a solar drier pose any threat to consumers (Mohamed *et al*., 2011; Kwenin *et al*., 2013; Mustapha *et al*., 2014; Dragon and Taflin, 2015). In the lower Shire valley area, the commonest consumed fish species is *Oreochromis mossambicus* (Mozambique Tilapia) which forms a significant proportion of the catch and is usually smoked before marketing and/or consumption (Chimenya *et al*., 2013; personal observation, n.a.). However, several reports have shown that processing methods affect nutritive value of products by altering its nutrient composition (Ahmed *et al*., 2011; Adeyemi *et al*., 2013; Makawa *et al*., 2015). The need for consumers to have knowledge of proximate profiles in food is necessary to ensure that these are within the range of dietary requirement (Fawole *et al*., 2007). This study investigated nutrient composition of *Oreochromis mossambicus* fish processed using solar drier and traditional smoking to establish nutritional benefits

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Figure 1. A simple modified Doe's model solar drying tent

consumers gain by consuming products processed using the two techniques.

Materials and Methods

Fish sample collection

Oreochromis mossambicus fish samples (125 g average weight) were bought from the Elephant marsh (Lower Shire area) in Nsanje district, southern Malawi. Samples were gutted and washed to remove viscera and dirt. The fish were then divided into 3 parts to be smoked, solar dried and kept fresh (control). Fresh samples were frozen immediately while those meant for smoking and solar drying were left over a wire mesh to drip off excess water for 10 minutes before being processed. All the treatments were replicated three times.

Sample processing

A modified solar tent design from Doe (1977) model was constructed (Figure 1) using locally available materials. The frame was constructed from bamboo with a height of 2 m and a base width of 2.25 m. Air vents were made on the opposite top and bottom sides measuring 5 cm. The drying rack was made of wire mesh and nylon netting and constructed at a height of 0.9 m with a black polythene plastic sheet pulled over the frame and bottom. Fish were loaded into the tent after sun rise and turned on every hour to ensure even exposure to solar radiation (heat). At sun set, the fish were removed to prevent rehydration overnight. Fish took 4 days to reach constant moisture levels. For the smoked fish, a traditional open pit was constructed and fish were laid over a wire mesh and put on the open pit fire made of dried hard wood. Smoking was done for 1½ hours until constant moisture level was reached.

Proximate analysis

Processed samples were analysed for proximate composition (crude protein, crude fat, ash and moisture) and minerals (iron, calcium and magnesium) following a procedure by AOAC (2005) at the Lilongwe University of Agriculture and Natural Resources (Aquaculture and Fisheries Science Department Laboratory).

Statistical analysis

Data were analysed using SPSS for Windows version 16.0. Treatment means were compared using one way analysis of variance (ANOVA) at 95% level of significance. Significantly different treatment means were separated using Duncan's Multiple Range Test.

Results

Results for proximate analyses of *Oreochromis mossambicus* fish samples for the three treatments – fresh, solar dried and traditionally smoked are presented in Figure 2 and Table 1. Fish processed in the solar drier had the highest crude protein, ash and fat content (61.26%, 17.58%, 13.43%) followed by traditionally smoked fish (54.79%, 14.72%, 8.90%) and 50.62%, 11.12%, 5.91% in fresh samples respectively ($P<0.05$). Lowest moisture was observed in the solar dried fish (15.90%) while fresh and traditionally smoked fish had 91.97% and 24.54% respectively ($P<0.05$). There were no significant differences ($P>0.05$) in the levels of minerals (iron, calcium and magnesium). The study observed an increase in protein, fat and ash content in the processed fish samples suggesting an effect of processing.

Discussion

Crude protein

Protein content in the processed fish increased with decreasing moisture agreeing with Kumolu-Johnson (2010) that protein nitrogen may not have been lost during drying resulting in increase in protein concentrations as the moisture reduced. Relatively high protein content observed in solar dried fish samples is similar to that earlier reported by Kwenin *et al.* (2013) for *Oreochromis niloticus* suggesting the superiority of the solar drying method. Akineye (2010) attributed the variation in protein content in solar dried and traditionally smoked fish to oxidation and denaturation effect of the smoking heat on protein in the fish samples. However, the increase in protein of smoked samples was less than those found in solar dried. It has been suggested that increase in the amount of compounds such as benzo (a) pyrene (B[a]

Table 1. Proximate and mineral composition of fresh, solar dried and traditionally smoked *Oreochromis mossambicus*

Treatment	Protein	Fat	Ash	Moisture	Fe	Ca	Mg
Fresh	50.62±0.78^{c}	5.91± 0.45^{b}	11.12±0.36^{c}	91.97±0.58^{a}	0.11±0.12^{a}	0.58±0.00^{a}	0.51±0.00^{a}
Solar	61.26±1.17^{a}	13.43±1.73^{a}	17.58±1.26^{a}	15.90±1.53^{c}	0.07±0.01^{a}	0.56±0.00^{b}	0.51±0.00^{a}
Smoked	54.79±1.09^{b}	8.90 ±0.68^{b}	14.72±0.29^{b}	24.54±0.88^{b}	0.03±0.12^{ab}	0.53±0.00^{c}	0.51±0.00^{a}

Values with a different superscript in a column are significantly different (P<0.05)

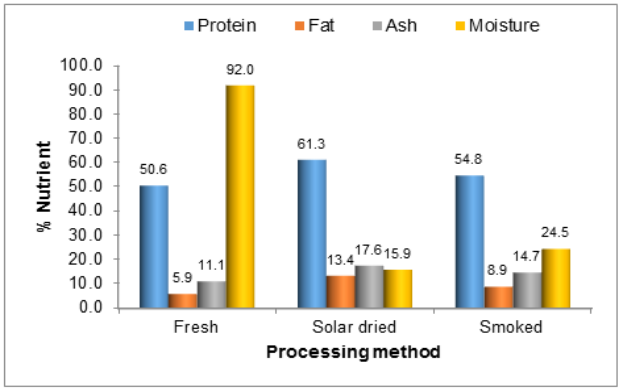

Figure 2. Summary mean proximate composition of fresh, solar dried and traditionally smoked *Oreochromis mossambicus*

P) during the smoking process affects fish nutrients like protein (Agbozu, 2014). Benzo (a) pyrene (B[a] P) is one of the substances in smoke vapours which dissolve in the liquid on the surface of the fish and have effects on fish protein among other elements. The open pit traditional smoking method used in this study has no smoke deposit regulating mechanism and may have exposed the fish to high amounts of smoke leading to the increased B[a] P resulting in decreased protein content in smoked fish. The high protein content in the present study supports Olopade *et al.* (2014) categorizing *Tilapia* species as high protein fish. Fish with a protein content of more than 20% are categorised as high protein (Murray and Burt, 2001).

Crude fat

Increase in fat content could be due to dehydration caused by processing heat in the solar drier and traditionally smoked fish which led to concentration of lipids (Chukwu and Shaba, 2009; Holm and Maalekuu, 2013). Aberoumad and Pourshafi (2010) concluded that the lower the percentage of water, the greater the lipid content. However, increase in crude fat content in smoked samples was slightly lower than in solar dried samples. Reduced fat content could be explained by oxidation and break down of crude fat into other components due to oxidation of poly-unsaturated fatty acids contained in the fish tissue to products such as peroxides, aldehydes, ketones and free fatty acids (Daramola *et al.*, 2007). High fat content recorded in solar dried fish is a good dietary attribute but may also cause storage problems due to the liability of fish oils to spoil (Holm and Maalekuu, 2013) hence need to exercise care during handling.

Moisture

Results for moisture content agree with Modibbo *et al*. (2014) that in fresh fish, moisture make up about 80% of body composition. Moisture for solar dried and smoked fish in this study was within the range reported by Kumolu-Johnson (2010). Decreasing moisture content in solar dried samples may be attributed to the dehydration effect of processing heat on the samples also reported by Akintola *et al*. (2013). Moisture content in the solar dried fish were within the 15% acceptable limit to prevent microbial spoilage (Immaculate *et al.*, 2012) suggesting a product with a longer storage (shelf) life.

Ash and minerals

Increased ash values in solar and smoked fish may be a result of concentration of salts in the flesh due to dehydration caused by heat (Kiini-Kabari *et al.*, 2011; Islam *et al*., 2012; Aberoumad, 2014). High ash content is consistent with bony fish such as tilapia species (Devi and Sarojnalini, 2012). Minimal or no variations in mineral content in processed fish show that processing methods have little or no effect on mineral composition (Sesugh *et al*., 2012). Iron is an essential component in the transfer of oxygen in the body and a deficiency of iron in the body may lead to anemia while magnesium is an activator of many enzymes systems and maintains the electrical potential in nerves and calcium is involved in bone formation (Aremu *et al.*, 2013). The levels of minerals found in this study are higher than those reported by Adewumi *et al.* (2014) in a study on *T. zilli* suggesting that *Oreochromis mossambicus* is a superior source of minerals for the human diet regardless of processing method used. Level of minerals recorded in this study agrees with Aremu *et al.* (2013) that high ash content in fish is indicative of high levels of minerals.

Conclusion

Study findings have demonstrated that fish processed in the solar drier retained more nutrients and hence may keep a longer storage period than traditionally smoked fish suggesting its superiority over the latter. As a tropical country, most areas in the Malawi experience plentiful solar radiation and high temperatures during most months of the year and the lower Shire valley is probably the hottest and driest area in the country. Use of solar driers for processing of fish should therefore be encouraged and up scaled in these areas in order to improve the nutritional well-being of the people through consumption of well processed and nutrient rich fish. Post-harvest losses which are high in rainy season could also be reduced greatly through use of solar driers which have demonstrated to be more efficient in moisture removal. Solar driers could also help in reducing dependency on fuel food for processing fish hence environmental friendly.

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