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Nutritive Value of Sun Dried and Traditionally Smoked *Oreochromis shiranus* (Boulenger, 1897) Raised in Earthen Ponds

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Abstract *Oreochromis shiranus* (Boulenger, 1897) is a strain of tilapia found in the Shire River (Malawi) and it is the commonest of the tilapia species raised by farmers in Malawi due to amongst many reasons, its ease of management and the ability to breed in captivity. Immediately after harvest from ponds, the fish are usually sold fresh. The need for consuming processed food products is however, rapidly gaining popularity among people with the knowledge that processed products are handy, nutritious and display a long shelf life. For nutritionists, it is also important to remember that processing also alters nutrient composition of food especially methods that involve use of heat. In this study, nutritional composition (moisture content, crude protein, crude fat and ash) of traditionally smoked and sun dried pond raised *Oreochromis shiranus* was analyzed. Sun dried fish had significantly ($P<0.05$) higher crude protein (62.43±0.50), ash (17.44±0.26) and crude fat (19.15±0.47) than smoked fish except for moisture ($P>0.05$). Apart from the high ash content in sun dried fish, nutrient content of the processed fish (smoked and sun dried) was significantly lower ($P<0.05$) than in fresh fish. Fish provides the highest source of dietary animal protein to many people in Malawi including those with low incomes who cannot afford other protein sources such as beef. The study provides empirical evidence to suggest that more nutrients can be obtained in sun dried *Oreochromis shiranus* hence recommending its use. Further, lower moisture content in sun dried fish may entail a product with qualities of a longer shelf life (storage) since moisture provides favourable environment for rapid microbial growth.

Keywords: *nutritive value, sun dried, traditionally smoked, Oreochromis shiranus, pond raised*

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1. Introduction

Oreochromis shiranus (Boulenger, 1897) – the Shire River Tilapia strain (locally known as Makumba) is a Tilapia strain endemic to Lake Malawi and the Upper Shire River. It is the mostly cultured species in Malawi because of its adaptability to captivity. In Malawi, pond raised fish are usually sold at the farm gate while fresh immediately after harvest [1].

Fresh fish are however, perishable products due to the high susceptibility to degradable organisms which are present in the slime, gills and intestine and on the surface of the fish [2]. Body composition and fish handling techniques after harvesting are also some of the contributing factors to spoilage in fresh fish [3]. It is therefore recommended to keep fresh fish at low temperature immediately after harvest to reduce activity of microbes and enzymes [4]. However, in rural areas and probably most Malawians, refrigeration is not available and as such, fish are processed by way of smoking or sun drying to extend their shelf life and reduce postharvest losses. In processed fish, several chemical and physical reactions take place that improve and impair their nutritive and commercial value [5,6]. In fact, the need for consuming processed food products is rapidly gaining popularity among people with knowledge that processed products are handy, nutritious and have long shelf life [7]. Processing methods nevertheless, tend to alter the nutritive value and quality of food products especially where heat is added as is the case in smoking and sun drying [8,9,10].

During sun drying, the sun's radiation removes moisture from a product hence preserves fresh fish by inactivating enzymes and creating unfavourable conditions for microbial growth [4,11]. Smoking is the oldest and commonest method of fish preservation and processing in many developing countries [12] including Malawi. Smoke also dries up moisture of a product but also contains strong antioxidants, bacteriostatic and bactericidal agent that preserves and increases shelf life of fish, [13,14,15]. This study analyzed the nutritive value of sun dried and traditionally smoked *O. shiranus* raised in earthen ponds.

2. Materials and Methods

2.1. Collection of Fish Samples

Live *Oreochromis shiranus* fish with an average size of 120g were harvested from an earthen fish pond and

divided into three batches. One batch was iced and put in sterilized cooler box and taken straight to the laboratory for analysis. Fish in the other two batches were processed by sun drying and traditional smoking respectively.

2.2. Proximate Analyses

Fresh, sun dried and traditionally smoked *O. shiranus* were analyzed for moisture content, crude protein, crude fat and ash content using guidelines of the Association of Official Analytical Chemist [16].

2.2.1. Protein Determination

Micro-Kjeldahl method was used to determine protein. Crude protein content (%) of a sample was obtained by measuring its total (N) content (%) and then multiplying N content with the empirical factor of 6.25. The factor is based on assumption that the average protein contains 16% N but the nitrogen content of the protein is dependent on its amino acid composition and the content of the nitrogenous substances.

2.2.2. Moisture Determination

Moisture content was expressed as the amount of water as a percentage (%) and the remaining portion is the dry matter content using Air Oven Method. The principle is that the sample is dried to constant weight in the air oven.

2.2.3. Fat Determination

The Soxhlet method was used to determine fat content and involve the extraction of the ether component from various samples materials. Fat is extracted with petroleum ether from the dried residue obtained in the determination of the moisture content. The solvent is removed by evaporation and the residue of fat weighed. The percentage of the fat content was calculated according to AOAC [16].

2.2.4. Ash Determination

Ash determination was done by is burning off as low temperature as possible and the remaining inorganic material realized as the ash content. A 5.0g of prepared sample in crucibles then ashed at 550^{o}C overnight inside a muffle furnace. The crucibles removed from the muffle furnace and placed in desiccators to allow cooling to room temperature. Each crucible plus ash was re-weighed and the percentage of ash was calculated.

2.3. Data Analysis

Data collected was entered into Microsoft Excel spreadsheet and analyzed using Statistical Package for Social Scientists (SPSS version 16.0). Analysis of Variance (ANOVA) was used to compare treatment means at 5% level of significance. Duncan Multiple Range Test (DMRT) was used to separate significantly different treatment means.

3. Results

Results for proximate composition of fresh, smoked and sun dried *O. shiranus* fish are presented in Table 1. Sun dried fish had significantly (P<0.05) higher crude protein (62.43±0.50), ash (17.44±0.26) and crude fat (19.15±0.47) than smoked fish except for moisture which was not significantly different (P>0.05).

Table 1. Mean proximate composition of fresh, traditionally smoked and sun dried pond raised *Oreochromis shiranus*

Processing method	Nutrient (%)			
	Moisture	Ash	Protein	Fat
Fresh	93.31±0.16^{a}	13.52±0.72^{c}	63.41±0.14^{a}	21.75±0.47^{a}
Smoked	93.42±0.47^{b}	15.82±0.45^{b}	60.80±0.54^{c}	15.17±1.53^{c}
Sun dried	92.23±0.37^{b}	17.44±0.26^{a}	62.43±0.50^{b}	19.15±0.47^{b}

Means with same superscript in a column are not significantly different (P>0.05).

Apart from high ash content in sun dried fish, nutrient content of the processed fish (smoked and sun dried) was significantly lower (P<0.05) than in fresh fish.

4. Discussion

Proximate composition is a reliable objective indicator for determining nutritional value and quality of fish [17]. Fish provides the most affordable and high quality dietary animal protein in Malawi [18] and hence, a deliberate choice of processing method that retains more nutrients and principally protein is important.

It is widely reported that smoking increases protein content in fish due to heat dehydration which concentrates proteins thus increasing the nutritional value of the processed fish product [8]. Reduced protein content in smoked fish observed in this study has been earlier reported by several authors [2,19,20] and attributed to the loss in available lysine which usually varies from 6-33% at 25°C to 53-56% at 40°C during hot smoking, and a 25% loss of available lysine on the surface, followed by a 12% loss at the centre of hot smoked fish. It is known that reduction in lysine is directly proportional to the temperature and duration of smoking [19]. Reduction in protein for smoked fish could also be due to associated heat, flow of gases and interaction of the smoke components with protein for fish processed in the open smoking [21]. Higher level of protein in this study has earlier been reported by Chukwu and Shaba [22]. Sun dried fish had comparatively the lowest moisture content and vice versa for fish that were smoked. Low protein in the smoked fish could therefore be explained by the fact that protein contents increase with decrease in moisture content [20,23,24].

Many reports exist that show low fat content in smoked fish as observed in this study [8,20,22,24,25]. Reduction in fat content may be explained by oxidation and break down of crude fat into other components due to oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes, ketones and the free fatty acids [15]. Reduction in fat could also be attributed to possible loss of fat due to the high temperature [8,24]. Increased fat in sun dried appeared to be directly related to low moisture content.

This agrees with earlier reports [15,20] attributing increased fat content to loss in moisture content which lead to concentration of fats.

Low and high moisture content in sun dried and smoked fish respectively could be attributed to differences in the moisture of the smoked fish relative to the surroundings [15,20]. Lowest moisture in sun dried fish was within the acceptable limit for prevention of microbial spoilage [26] because water activity determines storage life of fish [15]. This may suggest a product with long storage (shelf) life. Significant loss in moisture in the traditionally smoked and sun dried fish might be through evaporation due to exposure to heat [24]. Fresh fish had the highest moisture content compared to traditionally smoked and sun dried fish agreeing with Kumolu-Johnson *et al*. [12]. The main constituent of fish flesh is water which is lost as fish is exposed to heat [27].

Ash content is generally influenced by size of fish. Smaller sized fish species tend to have higher ash content due to the higher bone to flesh ratio [15]. Lean fish have been reported to have high ash content [28]. High ash content in smoked fish in the current study could therefore be due to size as well as loss in moisture [15]. Sun dried fish in this study appear to be the most nutritious due to high protein and fat content previously reported by other authors [8,20,22]. The applicability of these findings to local conditions is that sun drying is cost effective and relatively environmental friendly because no firewood is required hence affordable and sustainable through use of freely available radiation energy.

5. Conclusion

Sun dried fish had significantly higher crude protein, ash and crude fat than smoked fish except for moisture. Apart from the high ash content in sun dried fish, nutrient content of the processed fish (smoked and sun dried) was significantly lower than in fresh fish. It is established therefore in this study, that processing alters nutrient content in fish echoing previous reports. Results in this study have thus, demonstrated that more nutritional benefits can be obtained when fish are processed through sun drying although smoked fish are preferred by many people in Malawi over sun dried fish. Further, sun dried fish exhibit better storage properties due to low moisture retention.

6. Recommendations

Fish provides the highest source of dietary animal protein to many people in Malawi including those with low incomes who cannot afford other protein sources such as beef. Results provide empirical evidence to suggest that more nutrients can be obtained in sun dried *Oreochromis shiranus* hence recommending its use. This is an advantage both to the environment as no firewood is required and to people in rural areas where refrigeration as a means of preserving fish is not common but mostly rely on processing.

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