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Nutritional Composition of Smoked and Sun dried Pond raised *Oreochromis karongae* (Trewavas, 1941) and *Tilapia rendalli* (Boulenger, 1896)

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Abstract A study was carried out to determine nutritional composition of two pond raised tilapia fish species - *Oreochromis karongae* (Lake Malawi Tilapia) and *Tilapia rendalli* processed by smoking and sun drying. These are two of the four tilapia species (others are *Oreochromis mossambicus* and *Oreochromis shiranus*) that are raised in pond aquaculture in Malawi. Presenting pond raised fish in processed form would help farmers realise more economic benefits because processed products fetch better market prices. Results showed that both fish species are highly nutritious with high levels of the much needed dietary protein (fresh/unprocessed) 63.14±0.19 and 62.92±0.16 for *O. karongae* and *T. rendalli* respectively. However, protein content was significantly reduced ($P<0.05$) when both species were smoked - *O. karongae* (61.48±0.19) and *T. rendalli* (61.82±0.10). With an exception of ash for *O. karongae*, the other nutrients were also reduced in smoked fish in both species. Smoking therefore negatively affected the nutrient content of the fish. Protein and moisture content in *O. karongae* decreased (62.60±0.27; 8.33±0.33 respectively) with sun drying, while fat increased (11.67±0.88) and there were no changes in ash content (20.00±0.00) and vice versa in *T. rendalli* (63.26±0.13) ($P<0.05$). In sun dried *T. rendalli*, protein and fat content increased ($P<0.05$) (63.16±0.13 and 15.27±1.22 respectively) while a decrease was observed in ash and moisture levels ($P<0.05$) (20.00±0.00 and 7.67±0.33 respectively). Despite increasing fat content in both species, results demonstrated that a sun dried product was superior because of high protein retention hence more nutritious and comparatively low moisture suggesting a longer storage life.

Keywords: *proximate composition, pond raised tilapia, oreochromis karongae, tilapia rendalli*

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1. Introduction

Fish is a nutrient rich food and a very good source of vitamins and minerals required by humans [1,2]. Over 40% of the total consumed dietary animal protein in Malawi is obtained from fish – lower than the previous 70% due to decline of fish stocks in the natural waters [3]. In Malawi, fish is processed by roasting, frying and boiling to improve flavour and extend storage time. However, processing of fish especially where heat is involved alters its nutrient composition [4,5,6]. Consumers nowadays are becoming conscious of foods that retain high levels of nutrients after processing.

Oreochromis karongae (Lake Malawi Tilapia) and *Tilapia rendalli* are probably the most preferred indigenous aquaculture species in Malawi due to better growth [7]. Nutritional information is only available for the species in unprocessed (fresh) form [8] [9]. Studies further show that pond raised fish exhibit deviant flesh quality characteristics and nutrient content from wild fish [10]. The need to understand nutritional composition of fish raised in ponds stems from the fact that although aquaculture in Malawi is a fast growing investment, consumer acceptance of the fish against those from the wild is comparatively low. One way of removing consumer bias is to present fish from ponds in processed form (value addition).

The study was carried out to determine nutritional composition (protein, fat, ash and moisture) of smoked and sun dried pond raised *O. karongae* and *T. rendalli.*

2. Materials and Methods

2.1. Fish Sample Preparation and Processing

Freshly harvested pond raised *O. karongae* and *T. rendalli* fish (150g individual average weight) were washed to remove slime, gutted then washed again to remove blood and gut content smears. Each species of fish was divided into two batches, one smoked over charcoal and the other sun dried for five days in open ambient temperature.

2.2. Proximate Analysis

Samples for proximate analysis were prepared in triplicate for each of the two fish species and analysed following a procedure by AOAC [11].

2.2.1. Protein Determination

Protein was determined using the semi-micro kjeldahl method. One gram sample from each of the two species was digested in a kjeldahl flask using 98% sulphuric acid and a catalyst made from Potassium Sulphate and Cupric Sulphate. The sample was distilled and the distillate titrated using 0.05M Sodium hydroxide (NaOH). Crude protein content was determined as nitrogen and multiplied by 6.25 (Protein contains 16% nitrogen thus, 6.25 is 100/16).

2.2.2. Fat Determination

Fat content was determined using Soxhlet ether extraction. Petroleum ether was added to 2.0g sample of fish and placed in an extraction apparatus (a thimble). Extraction was carried out for 16 hours, after which the ether had evaporated to dryness and only fat remained in the flask. The amount of fat was obtained as the difference in the weight of the flask before and after drying off the ether.

2.2.3. Moisture Determination

One gram sample of ground fish was placed in a crucible and dried at 105 degrees Celsius to a constant weight after the initial weighing. Moisture content of the fish was calculated by subtracting the initial from the final weight of the fish sample.

2.2.4. Ash Determination

Two grams sample of ground fish was placed in a crucible then ashed at 600 degrees Celsius for 5 hours in carbolite muffle furnace then cooled to room temperature. The amount of ash was given by the difference in weight of the crucible before and after cooling.

2.3. Data Analysis

Data were entered into Microsoft Excel and analysed using SPSS for Windows version 15.0 software. Treatment means were compared using one way Analysis of Variance (ANOVA) at 5% level of significance reported as mean standard errors (±SE). Significantly different treatment means were separated using the Least Significant Difference (LSD).

3. Results

Results for proximate composition analysis (protein, fat, moisture and ash) for smoked and sun dried pond raised *O. karongae* and *T. rendalli* are presented in Table 1 and Table 2.

Determined protein content for *O. karongae* was 63.14±0.19, 61.48±0.19 and 62.60±0.27 for fresh, smoked and sun dried fish respectively (Table 1). Protein content was significantly reduced (P<0.05) in processed (smoked and sun dried) fish. Lowest protein levels were nevertheless observed in smoked fish. Highest and lowest levels of fat were recorded in sun dried (11.67±0.88) and smoked fish (9.33±0.88) respectively and were significantly different from unprocessed (fresh) fish (9.67±0.33) (P<0.05). Smoked fish had significantly high levels of ash (21.07±1.07) (P<0.05) but no differences were observed between fresh (20.00±1.16) and sun dried (20.00±0.00) fish (P>0.05). There were significant differences (P<0.05) in moisture content for *O. karongae* where lowest levels were recorded in sun dried fish (8.33±0.33).

Table 1. Proximate composition of fresh, smoked and sun dried pond raised *Oreochromis karongae*

Processing Method	Nutrient (%)			
	Protein	Fat	Ash	Moisture
Fresh	63.14±0.19^{a}	9.67±0.33^{b}	20.00±1.16^{b}	13.33±0.33^{a}
Smoked	61.48±0.19^{c}	9.33±0.88^{c}	21.07±1.07^{a}	10.33±0.33^{b}
Sundried	62.60±0.27^{b}	11.67±0.88^{a}	20.00±0.00^{b}	8.33±0.33^{c}

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

In *T. rendalli*, protein (63.26±0.13) and fat (15.27±1.22) content were highest in sun dried fish (P<0.05) while lowest amounts were recorded in smoked fish 61.82±0.10 and. 9.00±1.00 respectively (Table 2).

Table 2. Proximate composition of fresh, smoked and sun dried pond raised *Tilapia rendalli*

Processing Method	Nutrient (%)			
	Protein	Fat	Ash	Moisture
Fresh	62.92±0.16^{b}	10.00±0.00^{b}	23.00±1.16^{a}	10.67±0.33^{a}
Smoked	61.82±0.10^{c}	9.00±1.00^{b}	17.67±0.33^{c}	10.00±1.00^{a}
Sundried	63.26±0.13^{a}	15.27±1.22^{a}	20.00±0.00^{b}	7.67±0.33^{b}

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

Lowest and highest ash levels in *T. rendalli* were observed in smoked (17.67±0.33) and fresh (23.00±1.16) samples respectively (P<0.05). Moisture content was lowest in sun dried *T. rendalli* (7.67±0.33) (P<0.05) but no significant differences (P>0.05) were observed in smoked and fresh fish.

In summary, sun dried fish retained/increased protein and fat levels in both species while moisture was the lowest. Results for ash varied between species and processing methods.

4. Discussion

Results agree with earlier reports [9,10] that tilapia fish are highly nutritious. In Malawi, where fish provides the most affordable and high quality dietary animal protein [3], 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 [12,13]. Reduced protein content in smoked fish observed in this study has been reported by several authors [14,15,16] 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 center of hot smoked fish. It is known that reduction in

lysine is directly proportional to the temperature and duration of smoking [15]. 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 [17]. Fish in this study were smoked over an open fire where the fire temperature and smoke production is not controlled [18]. Higher level of protein in this study agrees with earlier reports [19]. Sundried fish had comparatively the lowest moisture content and vice versa. Low protein in the smoked fish could therefore be explained by the fact that protein contents increase with decrease in moisture content [20,21,22].

Observed low fat content in smoked fish in this study has been earlier reported by other authors [12,19,20,23]. 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 [24]. Reduction in fat could also be attributed to possible loss of fat due to the high temperature [12,20]. Increased fat in sun dried appeared to be directly related to low moisture content. This agrees with earlier reports - Daramola *et al*. [24,25,26,27] attributing increased far 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 because processing was not carried in temperature controlled conditions [24,26]. Lowest moisture in sun dried fish was within the acceptable limit for prevention of microbial spoilage [28] because water activity determines storage life of fish [24]. This may suggest a product with long storage (shelf) life.

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 [24]. This could explain the high ash content in fresh (unprocessed *T. rendalli*) considering the 150g sample size of the fish in this study. Lean Fish such as tilapia have high ash content [9]. In smoked *O. karongae*, high ash content could also be due size as well as loss in moisture [24,27].

Sun dried fish in this study appear to be the most nutritious due to high protein and fat content previously reported in several studies [12,19,29,30,31]. The applicability of these findings to local conditions is that sun drying is cost effect because no firewood is required hence affordable and sustainable through use of freely available radiation energy.

5. Conclusion

Fish provides most dietary animal protein to people in Malawi. Findings also confirm earlier reports that processing alters nutrient content in fish. Although smoked fish are mostly liked by many people, results in this study have demonstrated that more nutritional benefits could be obtained when fish are processed through sun drying. It has been shown also that sun dried fish exhibit better storage properties due to low moisture retention.

6. Recommendations

The study recommends sun drying of fresh pond raised *O. karongae* and *T. rendalli* for maximum nutritional benefits. This is an advantage especially 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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