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Effect of Sun-drying, Smoking and Salting on Proximate Composition of Fresh Fillets of Mcheni (*Rhamphochromis* species - Pisces: Cichlidae) from Lake Malawi, Malawi

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Abstract A study was conducted to determine effect of sun-drying, smoking and salting on proximate composition of fresh fillets of *Rhamphochromis* species fish (local name: Mcheni) from Lake Malawi, Malawi. Fresh fillets prepared from the fish were sun dried, sun dried then smoked, smoked fresh, salted then sun dried, and salted then smoked. The processed fillets were then analysed for proximate composition. Highest and lowest moisture content was observed in fish that were salted then smoked (28.99±0.02) and sundried then smoked (8.56±0.51) ($P<0.05$). Sundried and salted then smoked fish had the highest and lowest protein (53.68±0.79, 32.53±0.17) and energy (24.00±0.05, 16.31±0.02) levels respectively ($P<0.05$). More fats were retained in sundried fish (27.25±0.02) while fish that were salted then sundried had the lowest fat content (11.09±0.05) ($P<0.05$). Salted then sundried fish had more ash (18.83±0.12) while lowest ash levels were observed in fish that were smoked (5.03±0.03). A general observation was that sundried fillets had higher protein, fat and energy content while smoking significantly reduced nutrient levels. On the other hand, salting increased ash levels in the fillets and a combination of sun drying and smoking helped to produce a product with very little moisture content. Results suggest that consumers would have a more nutritive product by avoiding adding salt to *Rhamphochromis* fillets but rather sun drying and smoking. The lowest moisture content in sundried and smoked fillets also suggest a processed product with a longer shelf life as moisture favours microbial growth that are responsible for most spoilage in fresh foods.

Keywords *Rhamphochromis* Species; Fillets; Smoking; Salting; Proximate Composition

1 Introduction

Fish is a good and highly nutritious food among many reasons, its high quality proteins, vitamins and minerals (Ojutiku et al., 2009). In Malawi, fish provides the most affordable source of the much needed animal protein because it is widely distributed and presented in forms that even low income people can afford. Fish is nevertheless highly perishable due to complex processes involving physical, chemical and microbiological activities (Sallam, 2007; Ojutiku et al., 2009). *Rhamphochromis* species are a high commercial value predatory fish usually caught by hand lining. It is generally considered as fatty compared to other fish species endemic to Lake Malawi such as Tilapia hence spoils fast due to fat oxidation. The need to preserve and/or process fish soon after capture is mandatory in order to prolong its shelf life. The commonest processing methods for fish in Malawi are sun drying and smoking. A considerable portion of fresh fish is also salted especially gutted larger sized fish that are later sun dried or smoked.

Drying involves the application of heat to remove moisture from a product hence preserves fresh fish by inactivating enzymes and removing moisture necessary for bacterial and mould growth (Duan et al., 2004). This explains why dried products exhibit a longer shelf life, enhance quality and provide ease of handling (Mujumdar, 2007). Smoking is probably one of the oldest and commonest methods of fish preservation and processing in

many developing countries (Kumolu-Johnson et al., 2010). Smoke preserves and increases shelf life of fish by drying, cooking, acting as an effective antioxidant, bacteriostatic and bactericidal agent (Rorvik, 2000; Ahmed et al., 2010; Daramola et al., 2013). Salting is usually used in combination with drying and smoking to remove water and lower the water activity through osmosis (Abbas Bakhiet and Khogalie, 2012).

Different processing methods have different effects on nutritional composition of fish (Eves and Brown, 1993). Studies have demonstrated that processing alter nutrient content of the processed fish products (Ahmed et al., 2011; Oparaku and Mgbenka, 2012; Makawa et al., 2014). The need to determine nutrient content of processed fish is therefore indispensable to ably inform consumers about nutritional composition of the processed fish which they buy on the markets. The objective of this study was to determine the effect of processing methods on the quality of fresh fillets of *Rhamphochromis* species (Mcheni) from Lake Malawi, Malawi.

2 Materials and Methods

2.1 Fish sample collection

A total of 1,080 fresh *Rhamphochromis* fish samples (individual weight ±300 g) (Figure 1) were collected (bought from fishers early in the morning) from the South-East Arm of Lake Malawi in Mangochi District, Malawi. Samples were quickly packed in plastic bags, and preserved in block ice then transported to the laboratory for analysis.

Figure 1 Freshly caught *Rhamphochromis* species (Mcheni) from Lake Malawi kept on block ice

2.2 Fish sample preparation and processing

The fish were washed and carefully prepared into fillets using a sharp knife without breaking the muscle (flesh). The fish fillets were separated into five (5) groups which were i) Sundried, ii) Sundried then smoked, iii) Smoked, iv) Salted then sundried, v) Salted then smoked. Some fillets were analysed fresh as a control. The trial thus had 6 treatments arranged in a factorial design in triplicate.

In sun drying, cleaned fish were spread over chicken wire on an open drying rack and exposed to the sun for about 4 days. In salting, fillets were immersed into a brine solution of 5% (Sodium chloride) per liter of water for half an hour while stirring every 15 minutes to achieve an even concentration. Smoking was done in the Ivory-Coast smoking kiln, a modification of the traditional smoking kiln using dry nuts of palm trees (Figure 2) which are common among fish processors. The Ivory-Coast kiln is a modification of the traditional smoking kiln which has demonstrated to produce high quality processed smoked product.

2.3 Proximate analyses

Proximate composition (moisture, protein, fat, ash and energy) was analyzed according to AOAC (2005) standard procedures. The following formulae were used for calculating respective variables: Dry matter (%DM) = Wt of sample after drying / Wt of sample before drying x 100. Moisture content (%) = 100 - % DM. Protein (%) = {0.01 x 14.007 x titration volume x 6.25 x (200/ 5) x 100}/ Wt. sample x 100. Crude fat (ether extract) (%) = (Wt of

crude fat / Wt of sample used) x 100). Energy (J/g) = (sample joules x 1) / sample wt. Ash (%) = (Wt. of ash / Wt. of original sample) x 100.

Figure 2 Dried Palm tree nuts used for smoking the *Rhamphochromis* fish fillets

2.4 Data Analysis

All statistical analyses were conducted using Microsoft Office Excel for Windows 2003. Treatment means were compared using Analysis of Variance (ANOVA) at 5% level of significance in SPSS for Windows statistical software version 15.0. Significant mean differences were separated using Duncans Multiple Range Test (DMRT) and results reported in mean standard error (±SE).

3 Results and Discussion

Results for proximate composition (moisture, protein, fat, ash and energy) of the *Rhamphochromis* fresh fillets are presented in Table 1. Highest and lowest moisture content was observed in fish that were salted then smoked (28.99±0.02) and sundried then smoked (8.56±0.51) ($P<0.05$). Fish that were sundried and salted then smoked exhibited the highest and lowest protein (53.68±0.79, 32.53±0.17) and energy I24.00±0.05, 16.31±0.02) levels respectively ($P<0.05$). More fats were retained in sundried fish (27.25±0.02) while fish that were salted then sundried had the lowest fat content (11.09±0.05) ($P<0.05$). Salted then sundried fish had more ash (18.83±0.12) and lowest ash observed in fish that were smoked (5.03±0.03). A general observation was that fillets that were sundried had better protein, fat and energy content while smoking of the product resulted into lowest levels of these nutrients. On the other hand, salting increased ash levels in the fillets and a combination of sun drying and smoking helped to produce a product with very little moisture content.

Table 1 Proximate composition of fresh *Rhamphochromis* fish fillets processed with different methods

Processing method	Nutrient				
	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Energy (kJ/g)
Unprocessed fillets	60.77±2.73^{a}	47.65±0.17^{c}	33.63±0.07^{a}	12.46±0.04^{c}	25.21±0.01^{a}
Sundried	10.45±0.82^{e}	53.68±0.79^{a}	27.25±0.02^{b}	5.54±0.61^{e}	24.00±0.05^{b}
Sundried smoked	8.56±0.51^{f}	51.40±0.04^{b}	17.83±0.03^{d}	6.59±0.03^{d}	22.76±0.05^{c}
Smoked	11.93±0.46^{d}	45.17±0.05^{d}	20.51±0.02^{c}	5.03±0.03^{f}	22.25±0.14^{d}
Salted sundried	24.47±0.16^{c}	34.99±0.12^{e}	11.09±0.05^{ef}	18.83±0.12^{a}	17.20±0.12^{e}
Salted smoked	28.99±0.02^{b}	32.53±0.17^{f}	11.52±0.03^{ef}	16.99±0.11^{b}	16.31±0.02^{f}

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

Results agree with several earlier studies suggesting that processing alter nutrient content of food products (Eves and Brown, 1993; Ahmed et al., 2011; Oparaku and Mgbenka, 2012; Makawa et al., 2014).

3.1 Moisture

The low observed moisture content in this study for sundried and smoked fish has been earlier reported by Sveinsdottir (1998) attributing to the fact that smoking decreases water activity in fish tissue. The high moisture content in fillets that were salted before sun drying or smoking agrees with Bille and Shamkai (2006) who suggested that increase in the moisture content of salted dagga fish samples could be due to the hydroscopic nature of Sodium chloride (NaCl) which takes up moisture from the surrounding environment also reported by Khan and Khan (2001). Other authors (Hernandez-Herrero, 1997; Ahmed et al., 2010; Alsaban et al., 2014) also reported reduced moisture content with salting in fish. Sundried fish would therefore exhibit better storage properties because moisture favours microbial growth.

3.2 Protein

Protein decreased with salting in this study earlier reported by Holma and Maalekuu (2013) and Alsaban et al. (2014) while high protein content in sundried and smoked fillets has been observed by Fapohunda and Ogunkoya (2006). It is reported that the level of free amino acids in salted and sun dried fish decrease during storage (Smith and Hole, 1991). High protein content in smoked fillets could be due to concentration of nutrients due to loss of water (Doe and Olley, 1983). It is known that salt alters colloidal properties of the proteins and changes the nature of the water/protein relationship (Alsaban et al., 2014). This is explained by the denaturation of both sacoplasmic and myofibrillar proteins due to the effect heavy salting on fish muscle also reported by Ahmed et al. (2010). This suggests that sundried *Rhamphochromis* species is the best source of dietary animal protein and that addition of salt though increases shelf life compromises the nutritive value of the fish.

3.3 Energy

Results show a correlation between fat, protein and energy values in a way that energy decreased with decrease in fat content since fats are the energy source. It also follows that the higher the protein content, the higher the energy level (Holma and Maalekuu, 2013). The lower moisture content in sundried smoked fillets would mean more lipids and protein and consequently higher energy density in the fish (Aberoumad and Pourshafi, 2010).

3.4 Fat

Low fat content in salted fillets could be due to physical losses that are usually necessitated by the breakdown of tissue cells during salting, followed by the heating effect of sun-drying (Pace et al., 1989; Holma and Maalekuu, 2013). According to the Food and Culture Encyclopedia (2003), salted and sun dried fish are also more prone to oxidation than fish preserved by other methods because of their exposure to light and oxygen. The lowest fat content of 11.09% in the salted sundried fillets suggests that Rhamphochromis species are fatty fish because fish are only considered as lean when fat content below 5% (Ackman, 1989). In this study, there was a correlation of high moisture and fat content for salted fillets of which the implication would be a relatively short shelf life of the fillets due to microbial spoilage (high water content) and lipid oxidation.

3.5 Ash

Salting increases ash content (Ahmed et al., 2010; Alsaban et al., 2014). The increase in ash content during salting in this study may be due to the effect of extracted lipid which helps to create a crusted surface on each dried fish (Mohammed, 2007). Addition of salt may have added more ash components to the product (Beauchamp and Engelman, 1991). The effect of ground bones and scales in dried fillets could also have resulted into increase in ash content (Alsaban et al., 2014).

4 Conclusion & Recommendations

Sundried *Rhamphochromis* species is rich in protein - the most sought after nutrient in fish but also a fatty fish. Results further suggest that consumers would have a more nutritive product by avoiding adding salt to *Rhamphochromis* fillets but rather sun drying and smoking. The lowest moisture content in sundried and smoked fillets also suggest a processed product with a longer shelf life as moisture favours microbial growth that are responsible for most spoilage in fresh foods. It was observed that processing method (sun drying then smoking)

that increase (concentrate) protein in the fillets also reduced fat content. This is an advantage because a fatty product undergoes rapid spoilage due to lipid dehydrogenation.

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