

Effect of processing method on proximate composition of gutted fresh Mcheni (*Rhamphochromis species*) (Pisces: Cichlidae) from Lake Malawi

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Abstract

The effect of sun drying, smoking, salting and combination of these processing methods on proximate composition of fresh gutted *Rhamphochromis* fish from Lake Malawi were investigated against whole fish as a control. Fresh whole fish had $57.24 \pm 4.57\%$, $49.5 \pm 0.18\%$, $35.8 \pm 0.02\%$, $11.9 \pm 0.04\%$ and $25.6 \pm 0.41\%$ for mean moisture, crude protein, crude fat, ash and energy, respectively. Fish that were salted then later sun dried had significantly high mean moisture content ($16.7 \pm 0.24\%$) while lowest mean moisture content ($9.6 \pm 0.16\%$) was obtained in smoked fish ($P < 0.05$). Smoked fish also retained more crude protein ($45.2 \pm 0.05\%$) while fish that were salted then sun dried had highest mean loss in crude protein ($34.1 \pm 0.07\%$) ($P < 0.05$). Highest and lowest mean crude fat was obtained in sun dried fish ($34.9 \pm 0.02\%$) and salted then sundried ($25.8 \pm 0.16\%$) fish respectively ($P < 0.05$). Fish that were salted then smoked had highest mean ash value ($20.4 \pm 0.23\%$) while lowest mean values ($11.4 \pm 0.15\%$) were recorded in sun dried then smoked fish ($P < 0.05$). Smoked fish had higher mean energy levels ($23.2 \pm 0.04\%$) while fish that were salted then sundried had lowest mean energy levels ($20.1 \pm 0.12\%$) ($P < 0.05$). The general observation was that smoking fish increases protein retention while addition of salt result into loss of protein and fat. Furthermore, smoked fish had lowest moisture content and average fat levels suggesting a longer shelf life. This study recommends smoking as a way to obtaining maximum nutritional quality as well as longer storable product amongst four species of seaweed.

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Keywords

Rhamphochromis

Gutting

Salting

Smoking

Sun drying

Introduction

Fish are a rich source of essential nutrients required by humans of all ages (Abdullahi *et al.*, 2001). In Malawi, it is the major and most affordable source of dietary animal protein. *Rhamphochromis* species (locally known as Mcheni) is one of the most important fishery and preferred by many consumers in Malawi (Kaunda *et al.*, 2003). The fish is characterized by its high fat content which if unprocessed, makes it to spoil fast. Many nutritional studies have demonstrated that nutrients in fish that are required by the consumer are lost during processing (Chukwu and Shaba, 2009; Mansur *et al.*, 2013). This is because when a product is subjected to heating and high concentration of salt, there are a series of chemical and physical changes which result into hydrolysis of protein and polyunsaturated fatty acid compounds, thus increasing digestibility (Tao and Linchun, 2008). Preparation of fish which involves processing and preservation is therefore critical to conserving nutrients. In Malawi, the commonest processing methods for fish are sun drying

and smoking. It is important therefore to determine how these processing methods affect the retention of nutrients in fish. Information which is available on nutrient composition of *Rhamphochromis* fish species in Malawi (Mumba and Jose, 2005) was only for smoked samples that were collected from markets. Thus, no literature is available for the other methods of processing, especially for fish that are gutted and processed. The present study investigated the effects of processing gutted *Rhamphochromis* fish by sun drying, smoking, salting and combination of these methods, on its proximate composition. The possible effects of different processing methods on the nutritive value of this fish species were evaluated; and the values determined were compared with the values from whole fish.

Materials and Methods

Fish sample collection

Fresh fish, *Ramphochromis* species (1,080) (Figure 1) were collected from Lake Malawi and immediately packed in a cooler box and preserved

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Table 1. Mean moisture content (MC), crude protein (CP), crude fat (CF), ash and energy (E) for fresh whole and gutted *Rhamphochromis* species processed using different methods

Nutrient	Processing Method					
	Whole	Sundried	Smoked	Sun dried+Smoked	Salted+Sun dried	Salted+Smoked
Moisture	57.2±4.57 ^{ab}	10.2±0.07 ^{gh}	9.6±0.16 ^{hi}	10.3±0.08 ^{hi}	16.7±0.24 ^d	13.5±0.22 ^{de}
Crude protein	49.5±0.18 ^a	43.4±0.04 ^a	45.2±0.05 ^b	44.4±0.23 ^c	34.1±0.07 ^k	36.1±0.23 ^l
Crude fat	35.8±0.02 ^c	34.9±0.02 ^{de}	30.1±0.68 ^g	30.9±0.02 ^f	25.8±0.16 ^{hi}	26.2±0.43 ^k
Ash	11.9±0.04 ^{gh}	12.5±0.06 ^a	12.1±0.05 ^{ef}	11.4±0.15 ^l	16.4±0.12 ^d	20.4±0.23 ^c
Energy	25.6±0.41 ^a	23.0±0.09 ^g	23.2±0.04 ^{ef}	22.7±0.01 ^{gh}	20.1±0.12 ^l	22.3±1.44 ^{hi}

*Values (reported as ±Standard error) with the same superscript in the same row are not significantly different (P>0.05).



Figure 1. Fresh Mcheni (*Rhamphochromis* species) from Lake Malawi

with clean ice blocks before being transported to Bunda College Laboratory for analysis. In the laboratory, the fish were divided into two batches: The first batch had whole fresh fish as a control while the other batch was eviscerated (gutted). The gutted fish were further separated into five batches of 30 fish each as: i) Sun dried, ii) Smoked, iii) Sun dried and smoked, iv) Salted and sun dried and v) Salted and smoked.

Processing of fish samples

Fish were smoked for 2 hours in Ivory Coast Smoking kilns (Figure 2) using dry Palm nut kernels. A mesh wire drying rack was used to dry the fish in the open sun for 2 days while securely covered with mosquito netting material to avoid flies and predators. Gutted fish were salted by dipping them into a brine of 5% concentration (Sodium chloride) for 30 minutes.

Nutrient composition determination

Samples of the processed fish were taken into the laboratory for proximate composition analyses. Body moisture, crude protein, crude fat, ash and energy

were 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.

Statistical analysis

Data were entered into Microsoft Office Excel for Windows 2003 and analysed using SPSS for Windows Version 15.0 Software. Treatment means were compared using Analysis of Variance. Means that were significant were separated using Duncan's Multiple Range Test.

Results

Results for mean moisture content, crude protein, crude fat, ash and energy of fresh gutted *Rhamphochromis* species processed using different methods are presented in table 1. Fresh whole fish had 57.24 ± 4.57%, 49.5 ± 0.18%, 35.8 ± 0.02%, 11.9 ± 0.04% and 25.6 ± 0.41% respectively for mean moisture, crude protein, crude fat, ash and energy. For the gutted and processed samples, fish that were salted then later sun dried had significantly high mean moisture content (16.7 ± 0.24%) while lowest mean moisture content (9.6 ± 0.16%) was obtained in smoked fish from the initial 57.2% in whole fish. Smoked fish also retained more crude protein (45.2 ± 0.05%) while fish that were salted then sun dried had highest loss in crude protein (34.1 ± 0.07%). Highest and lowest mean crude fat was obtained in sun dried fish (34.9 ± 0.02%) and samples that were firstly salted then sundried (25.8 ± 0.16%) respectively.



Figure 2. The Ivory Coast Smoking Kilns used for smoking fish

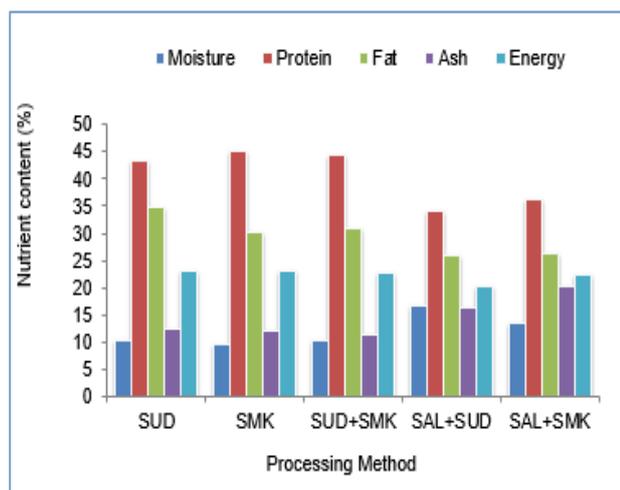


Figure 3. Mean nutrient composition for whole and gutted fresh *Rhamphochromis* species fish processed using different methods (SUD=Sundried, SMK=Smoked, SAL=Salted)

Fish that were salted then smoked had highest mean ash value ($20.4 \pm 0.23\%$) while lowest mean values ($11.4 \pm 0.15\%$) were recorded in fish samples that were sun dried then smoked. Smoked fish had higher mean energy levels ($23.2 \pm 0.04\%$) while fish that were salted then sundried had lowest mean energy levels ($20.1 \pm 0.12\%$).

Generally, processing methods that involved application of smoke resulted into a greater retention of nutrients principally, crude protein and to a less extent, crude fat while fish that were sun dried maintained average nutrient content from the normal i.e. whole and unprocessed fish samples (Figure 3). On the other hand, it was observed that when salt was added to the fish before processing them whether by sun drying or smoking, significant loss in nutrients was incurred mainly crude protein and crude fat.

On the contrary, ash values and moisture content increased with addition of salt to the fish samples before sun drying or smoking. Results (Figure 3) show that fish that were sun dried then later smoked, presented a balanced (average) level of nutrients in the

final product. Generally, it was observed that unlike with the other nutrients that were analysed, none of the processing methods resulted into any significant changes in energy levels in the fish samples.

Discussion

Results for whole fresh *Rhamphochromis* fish indicated that the fish has high nutrient composition with about 50% and 46% protein and fat levels respectively. The observed drastic decline of these nutrients in the fish after processing agrees with several earlier reports (Chukwu and Shaba, 2009; Ahmed *et al.*, 2011; Immaculate *et al.*, 2013; Akintola *et al.*, 2013) regarding changes in nutrients due to processing.

The reduced moisture content of $16.7 \pm 0.24\%$ (highest) and $9.6 \pm 0.16\%$ (lowest) from the initial $57.24 \pm 4.57\%$ in whole fish after sun drying and smoking the fish respectively is widely reported due to the fact that application of heat decreases water activity in fish tissue (Akintola *et al.*, 2013). Similar values were reported for several Indian Hill stream fishes (Hei and Sarojnalini, 2012). While high moisture content provides a conducive environment for spoilage by microbes in fish (Akintola *et al.*, 2013), the lowest moisture content recorded in smoked fish samples entails a longer shelf life of the product. In fact, the determined moisture levels in this study were below 20% in all the processing methods which is considered acceptable for smoked dried fishes to inhibit both bacterial and mould/fungal growth (Lilabati and Vishwanath, 1996). Salting before sun drying or smoking yielded a product of high moisture, agreeing with Bille and Shamkai (2006). An increase in moisture of salted samples could be due to the hygroscopic nature of Sodium chloride (NaCl). Khan and Khan (2001) observed that in saturated brine-treated dried fish, moisture rose from 20% to 24% due to the hygroscopic action of sodium chloride.

High levels of crude protein in smoked fish obtained in this study have been reported by several workers (Ahmed *et al.*, 2011; Immaculate *et al.*, 2012; Ayinsa and Maalekuu, 2013). It is also widely reported that smoke-drying increases protein attributing this to dehydration in the proteins resulting into its aggregation (Ninawe and Rathnakumar, 2008; Olayemi *et al.*, 2011; Oparaku and Mgbenka, 2012). In the salted fish samples, protein loss may have been due to denaturation by salt (Pannevis, 1993). Audrey (2006) reported that smoking causes nutrient loss due to associated heat flow of gases and interaction of the smoke components with protein. Thus, such a decrease in protein may be due to denaturation by heating. Protein levels reported in this study are nevertheless, relatively lower than those reported for other fish species such as tilapia (Mumba and Jose, 2005; Fapohunda and Ogunkoya, 2006; Ahmed *et al.*, 2011) suggesting that *Rhamphochromis* is a low protein fish. It was also observed that protein levels increased with decreasing moisture content earlier reported by Aliya *et al.* (2012) and Daramola *et al.* (2007). Except for fish that were salted before sun drying or smoking, results for the other processing methods show that *Rhamphochromis* is within the range of normal to high protein level fish. Normal protein in fish is around 40% (Murry and Burt, 2001).

Highest and lowest crude fat was obtained in sun dried fish ($34.9 \pm 0.02\%$) and samples that were firstly salted then sundried ($25.8 \pm 0.16\%$) respectively. This was also observed by Akintola *et al.* (2013) in sun dried Giant Tiger Shrimp (*Penaeus monodon*). Though it is well reported that fat increases with heat processing and reduction in moisture content (Chukwu and Shaba, 2009; Chukwu, 2009; Akintola *et al.*, 2013), results in this study were lower ($P < 0.05$) than the initial for whole fish ($35.8 \pm 0.02\%$) in all the processing methods. Reduction in fat content of the processed fish could be due to the evaporation of moisture content together with the lipids also earlier reported by Immaculate *et al.* (2012) and Akintola *et al.* (2013). However, fat levels reported in this study were higher than those reported for other processed fish species. Chukwu (2009) reported 28.0% while Chukwu and Shaba (2009) determined 21.2% fat for kiln dried tilapia (*Oreochromis niloticus*) and Cat fish (*Clarias gariepinus*) respectively. *Rhamphochromis* species are therefore rich in fats which are the much needed nutrients in people's diet. Fish species with more than 20% fat content are considered fatty (Murry and Burt, 2001). Increased fat in human diets provides and sustains energy in the body (Chang *et al.*, 2009). Fat is also important for normal functioning of the brain which is made up of nearly 60% fat (Kaunitz

and Dayrit, 1992). Importantly, fat helps in boosting the immune system (Black and Sharpe, 1997).

Higher ash values in processed fish than the initial whole fish may be due to moisture loss due to the heat during processing. Increased ash content in processed products has been reported by many workers (Akintola *et al.*, 2013). The highest ash content was observed when salting and sun drying methods were combined. Bille and Shamkai (2006) found that smoking significantly increased ash in the dagga fish more than sun-drying method. An increase in ash content by a combination of processing methods involving smoking can also be attributed to protein denaturation due to a reduction in moisture and consequently loss of water holding capacity of the protein in the samples.

High energy levels in smoked fish determined in this study have been earlier reported by Ayinsa and Maalekuu (2013) for Red fish. Ojewola *et al.* (2003) observed that processing methods accounted for the differences observed in the composition and gross energy content of all test samples which they studied. Aberoumad and Pourshafi (2010) observed that the lower the percentage of water denotes a greater lipid and protein content resulting into higher energy density of the fish. This suggests that since the smoked fish had the highest protein content, it implies that energy levels would also be high.

Reduced levels of crude protein and fat in salted *Rhamphochromis* fish samples were also reported by Ayinsa and Maalekuu (2013) and Pace *et al.* (1989) who observed protein losses in processed Red fish and tilapia fish respectively. Possibly, some protein and fat may have diffused out of the fish during immersion in brine contributing to the reduced protein and fat content of the brine treated fish earlier reported by Oboh and Onoahbhagbe (2013). It is reported (Bligh *et al.*, 1988) that salting exerts an osmotic effect on fish flesh resulting into loss of oil and other constituents from fatty fish. This could have been due to physical losses necessitated by the breakdown of tissue cells during salting, followed by the heating effect of sun-drying (Pace *et al.*, 1989). The higher levels of moisture content in the fish sample that were brined may be attributed to the hygroscopic property of the salt (Oboh and Onoahbhagbe, 2013).

Conclusion

Smoking fish increases protein retention while addition of salt results into loss of protein and also fat. Furthermore, smoking fish leads to reduced moisture content and average fat levels suggesting a longer shelf life. While high moisture content provides

conducive environment for spoilage by microbes in fresh fish and moulds in dried fish, hot smoking decreases water activity in fish tissue thus creating unfavourable conditions for growth of microbes. It is also concluded that though salt has strong preservative properties, its use results into significant nutrient loss chiefly protein and fat. Sun dried processing method appeared to present a product with average nutrient quality. This study recommends processing by smoking as a way to obtaining maximum nutritional value as well as a product with a longer shelf life suggesting high economic value. Caution should also be exercised when using salt in processing to prevent loss of the most required dietary nutrients in fish.

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