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EFFECT OF COOKING METHOD ON PROXIMATE AND MINERAL COMPOSITION OF LAKE MALAWI TILAPIA (*Oreochromis karongae*)

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ABSTRACT

Fish is a nutritious food and an excellent source of animal protein in the human diet containing many vitamins and minerals that are essential for the human body. In Malawi, fish is the major source of affordable dietary protein for humans. Lake Malawi tilapia (*Oreochromis karongae*) locally known as *Chambo*, is the most preferred and highest value commercial food fish species obtained from Lake Malawi. Several methods are used to prepare/cook the fish viz.: boiling, deep frying in edible cooking oil, grilling, and/or roasting over fire. However, the fact that cooking alters the nutrient content in foods underscores the need to understand nutritional effects of different food cooking/processing methods. This study investigated effect(s) of cooking fresh fish (Lake Malawi tilapia) by boiling, roasting, pan frying and, using a locally made fireless cooker) on its proximate (protein, fat, ash and moisture) and mineral (calcium, magnesium, zinc, iron and phosphorus) composition. Highest and lowest values for crude protein were reported in fish processed using the fireless cooker (64.3±0.2%) and roasting (59.9±0.4%), respectively ($P<0.05$), against (64.4±0.3%) for the fresh fish (control). Fish that were pan fried showed significantly higher crude fat content (25.5±0.1%) ($P<0.05$) followed by samples prepared using the fireless cooker (15.3±0.1), and lowest values were found in fish that were boiled (12.1±0.2%). Fish from the fireless cooker had significantly high moisture content (10.6±0.1%), ash (17.1±0.3%), zinc (0.0±0.0μg/g), phosphorus (2.6±0.0μg/g) and reasonably, more calcium (54.2±7.0μg/g) and magnesium (0.5±0.0μg/g) ($P<0.05$). The lowest levels of minerals were recorded in fish that were roasted: calcium (44.8±0.1μg/g), magnesium (0.5±0.0μg/g), zinc (0.0±0.0μg/g) and phosphorus (2.0±0.1%) ($P\geq0.05$). The results suggest that fish processed in the fireless cooker were of higher nutritional quality principally due to the relatively high content of the most needed nutrient - protein. Adopting and encouraging use of the fireless cooker could also be a way of saving energy thus; curbing dependency on fuel wood. The results also showed that cooking does not have significant effect on minerals in fresh fish.

Key words: Fireless cooker, boiling, roasting, pan frying, tilapia, Lake Malawi, Malawi

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INTRODUCTION

Fish is a nutritious food and an excellent source of the much needed animal protein in the human diet, also being rich in essential vitamins and minerals [1]. In Malawi, fish is not consumed raw but rather processed using various cooking methods such as roasting, frying and boiling mainly to improve the flavour as well as the taste [2] but also to inactivate, inhibit or eliminate pathogenic microorganisms [3]. However, many studies have shown that various cooking methods invariably affect the nutritive value of fish, especially vitamins, flavour compounds and polyunsaturated fatty acids [4, 5]. Further, certain substances that are required for the proper functioning of the human body are lost during cooking of foods [2]. Lake Malawi tilapia (*O. karongae*) is the most commonly consumed cooked food fish sold in Malawi. While some information is available regarding the nutritive values of raw (unprocessed) Lake Malawi tilapia [6, 7], this information is lacking for fish processed using different cooking methods. The present study was, therefore, carried out to investigate the effects of different cooking methods (boiling, roasting, pan frying, and the use of a traditional fireless cooker) on the proximate and mineral composition of *O. karongae* (Lake Malawi tilapia).

MATERIALS AND METHODS

Freshly caught *O. karongae* (Lake Malawi tilapia) fish (average size 200g) were purchased from local selling outlets while fresh, kept at ambient temperature, and preserved in ice for about 4 hr (travel) until arrival at the laboratory for analysis. The samples were then washed with potable water and gut contents removed. Four different preparations were done: i) pan frying, ii) cooking using fire, iii) roasting, and iv) cooking using a fireless cooker. Each mode of preparation was replicated three times. The study emulated the local processing procedures that are usually carried out by households in Malawi.

Pan frying

Fish were slightly dried in the sun at ambient temperature of around 27^{o}C and turned twice for a few hours to rid them of excess water that would make frying difficult. The fish were then deep fried in edible sunflower vegetable oil for about 10 min and then removed to cool at a room temperature of 24^{o}C for about 15 min.

Cooking

The cleaned fish were put into a pot and a little water added. The fish were then cooked for about 30 min and allowed to cook in a mixture of water and steam as in the normal tradition of preparing stewed fish.

Roasting

Prepared fish were roasted directly over burning charcoal with periodic turning on both sides for about 15 min until they were fully done.

Fireless cooker

This was the main thrust of this study as the other methods are common except for the fireless cooker (Figure 1).

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A

B

Figure 1: The fireless cooker: A: = In the making, B: =Complete and ready for use

The fireless cooker is a simple insulated container (available in many designs) that uses the heat of the food being cooked to complete the cooking process [8, 9]. In fireless cooking, food is heated to the boiling point and then insulated. The fireless cooker normally requires up to twice as much time to cook food than the normal stovetop cooking time [8]. This simple and local innovation has many advantages such as preventing heat from escaping into the environment; hence no additional energy is needed to complete the cooking process [9]. The food can be left in the cooker until it is ready to serve and will keep hot for hours [8]. Also, foods which require long cooking can be prepared in the fireless cooker. Use of the fireless cooker could save fuel to the extent of one third of the total consumption by avoiding the need for reheating [8], which may save between 20 to 80% of the total energy. The decrease in wood burning limits contact with smoke, and is environmentally friendly [9].

The fireless cooker can be made from locally available materials such as dry grass, cotton, rice hulls, banana leaves, fur, wool, waste clothes, aluminum foil, newspapers and any other materials that can serve as insulation [9]. This study used dried banana leaves (Figure 1). Fireless cooking was done by initially heating some water for a few minutes to boiling. The fish were put into the pot with hot water which was placed inside the fireless cooker for about 40 min after which the fish were assumed to be completely cooked and ready to be consumed.

Determination of proximate and mineral composition

Proximate composition of whole gutted fish samples (moisture, crude protein, crude fat, ash and energy) and minerals, (calcium, magnesium, zinc, iron and phosphorus) of the fish samples prepared under the different cooking methods were determined following AOAC procedures [10].

Proximate analysis

All analyses of the whole fish samples were done in triplicate. Moisture content was estimated by drying samples to constant weight at 103±20°C using oven drying. Fat was determined using the Soxhlet extraction: % crude lipid = (wt of residue/original wt of sample) x 100. Fatty acid (FFA) by alkali titration was then expressed as percent oleic acid equivalent after running a standard curve. Protein was determined as nitrogen by the Kjeldahl procedure and multiplied by 6.25. To determine ash, fish samples were burned in a muffle furnace at 550°C for 16 hr. Percent ash was then calculated as: (wt of ash/wt of sample) x 100. Energy values were calculated by multiplying the protein, carbohydrate and fat by factors of 4, 4 and 9, respectively for 100g of fish.

Mineral analysis

Minerals (calcium, magnesium, zinc, iron and phosphorus) in the fish were analysed using an atomic absorption spectrophotometer (AAS) and UV spectrophotometer. In all mineral analyses, samples (1.0 g) were burnt in porcelain crucibles at 450°C overnight, and then treated with 5 ml of 6 M HCl, boiled to dryness on a hot plate, then cooled. The residue was then re-dissolved with 10 ml of 0.1 M nitric acid and the solutions were left standing for 2 hrs then transferred to 50 ml volumetric flasks, topped with ultra-pure water [10] for determination of calcium, magnesium, zinc and iron. Phosphorus was analysed using the UV spectrophotometer using a colorimetric method at 823 nm, according to an AOAC method [10].

Statistical Analysis

Data were entered into Microsoft Excel (Microsoft Windows, USA) spreadsheet and analysed using SPSS for Windows Statistical Software Program version 16 (Microsoft Windows) (SPSS Inc, USA). Means for treatments: crude protein, crude fat, moisture, ash, energy and minerals, were compared using one-way analysis of variance (ANOVA) at a 5% level of confidence. Significantly different means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

Results for proximate and mineral composition of Lake Malawi tilapia (*O. karongae*) processed using different methods are presented in Tables 1 and 2, respectively. Fish that were processed in the fireless cooker had significantly more proteins and moisture than those processed using the other cooking methods ($P<0.05$) but not significantly different ($P\geq0.05$) with values for fresh fish. Apart from samples that were pan fried and fresh fish, values for crude fat in the fireless cooker samples were also significantly higher ($P<0.05$). The highest and lowest ash values were observed in fresh (uncooked) and pan

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fried fish, respectively. Fish that were pan-fried had the most calories while fish prepared in the fireless cooker had the least.

Calcium content for the whole fish was high in all the cooked fish although these were not significantly different ($P<0.05$). Fresh (uncooked) fish had the highest levels of magnesium with the lowest amounts being in fish that were roasted. No traces of zinc and iron were recorded. Fish prepared in the fireless cooker had the highest levels of phosphorus while the lowest levels were observed in fresh uncooked fish.

DISCUSSION

Values for nutrient composition of the fresh fish in this study were close to those reported earlier by Kapute *et al.* [7] for fresh Lake Malawi tilapia confirming that the fish is rich in protein. Significant changes in the nutrient values of the fish after being subjected to different types of cooking methods were observed, and these, therefore, echo many earlier reports that processing compromises the nutritional quality of fish [2, 4, 5]. Proximate composition is both an indicator of fish nutrition and fish quality [11].

The high protein in samples prepared in the fireless cooker could be due to the fact that proteins thermally denatured during cooking were not necessarily lost [12]. Fish proteins are more easily denatured than those of meats [13]. Al-Jedah *et al*. [14] also reported that fish muscle is more digestible than other animal protein due to lower amounts of connective tissue. For the pan fried fish, higher protein could be explained by the higher loss of moisture [13]. Since protein is the most needed dietary macro-nutrient in fish because of the need for essential amino acids [15], the higher protein content in fish processed in the fireless cooker suggests its superiority over the rest of the methods assuming consumption of an equal weight of fish.

Significantly higher levels of fat ($P<0.05$) in pan fried fish has been previously reported [2, 16] due to absorption of fat during cooking [1, 17]. Saguy and Dana [18] suggested that fat can penetrate into the food after water is partially lost by evaporation. Although Lake Malawi tilapia is considered to be a lean (not fatty) fish, processing by pan frying may not be a good cooking method for those who are overweight and/or have cardiovascular problems although people who expend a lot of energy each day might benefit from the extra calories.

The fireless cooker and roasting methods showed significantly higher and lower moisture content, respectively, compared to fresh fish. The higher moisture content in fish from the fireless cooker could be attributed to the extended contact with both boiling water and steam [8].

High ash values in all the cooking methods except for the pan fried fish suggests that Lake Malawi tilapia is a mineral rich food fish. Generally, minerals are not destroyed by heating [19]. A possible explanation for the low mineral content for the pan fried fish is that the frying extracted some minerals (from the scales and the backbone) into the fat [20, 21]. The observation by Devi and Sarojnalini [13] that most of the calcium in large fish with hard bones is lost may also be relevant for this study. In smaller fish, which are consumed whole, all of the minerals in the bone would be consumed. Results for calcium reported in this paper are within the range for those reported earlier for several species of fish including freshwater fish such as tilapia [22, 23, 24, 25]. The lowest phosphorus content was observed in fresh then pan fried fish while phosphorus values in boiled, roasted and the fireless cooker fish, although higher, were not significantly different. This may suggest that cooking increases phosphorus content in fish. However, many studies suggest that processing and cooking methods do not affect minerals in fish [1, 20, 26, 27]. As with other minerals, there were no traces of zinc and iron in fish across all the cooking methods.

CONCLUSION

The fish processed using the fireless cooker had the highest nutrient content mainly protein that may suggest its superiority in terms of producing food with better nutrient content. However, higher moisture content in cooked fish may decrease shelf life as moisture favours microbial growth. Fish oil is very good and healthy and as such, highest fat content in pan fried fish is desirable coupled with the lowest moisture content indicative of longer storage though poor in minerals. Boiled and roasted fish did not differ generally in mineral content except for the lower moisture content in the latter suggestive of a product with a better shelf life.

Insignificant changes of the minerals may suggest that cooking does not necessarily affect mineral content in the fish. With an exception of the fireless cooker, all the processing methods caused reduction in nutrient content suggesting the need for a caution when processing fresh fish.

RECOMMENDATIONS

Although fishes are nutrient-rich foods, the most sought after component of fish for most consumers is protein. The choice of a cooking method should, therefore, target those methods that conserve protein. The fireless cooker should, therefore, be adopted and its use encouraged. Another advantage of the fireless cooker is that the technology used in its construction is affordable using locally available materials. It is also an energy saving cooking medium. Many people in Malawi rely on wood fuel for cooking hence its adoption could reduce dependence on wood fuel and consequently prevent deforestation which is already a serious environmental issue in the country.

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Table 1: Mean proximate composition of Lake Malawi tilapia (*Oreochromis karongae*) processed using different cooking methods

Cooking method	Parameter			
	Protein (%)	Fat (%)	Moisture (%)	Ash (%)
Boiling	61.3±0.2[a]	12.1±0.2[a]	10.2±0.1[a]	15.2±0.1[a]
Roasting	59.9±0.4[a]	12.6±0.1[a]	6.8±0.4[b]	18.0±2.0[a]
Fireless cooker	64.3±0.2[b]	15.3±0.1[b]	10.6±0.1[a]	17.1±0.3[a]
Pan frying	60.1±0.1[a]	25.5±0.1[c]	4.0±0.4[c]	12.6±0.1[b]
Fresh	64.4±0.3[b]	20.5±0.3[d]	10.7±0.2[a]	18.0±3.0[a]
P-value	0.0	0.0	0.0	0.1

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

Table 2: Mineral composition of Lake Malawi tilapia (*Oreochromis karongae*) processed using different methods

Cooking method	Mineral				
	Ca (μg/g)	Mg (μg/g)	Zn (μg/g)	Fe (μg/g)	P (%)
Boiling	55.0±3.0[a]	0.6±0.0[b]	0.0±0.0[acd]	0.0±0.0[abc]	2.0±0.0[abc]
Roasting	53.0±3.0[a]	0.4±0.1[e]	0.0±0.0[b]	0.0±0.0[abc]	2.0±0.1[abc]
Fireless cooker	54.0±7.0[a]	0.5±0.0[c]	0.0±0.0[acd]	0.0±0.0[abc]	2.6±0.0[abc]
Pan frying	44.8±0.1[a]	0.5±0.0[d]	0.0±0.0[acd]	0.0±0.0[d]	2.0±0.1[d]
Fresh	55.0±5.0[a]	0.7±0.1[a]	0.0±0.0[e]	0.0±0.0[e]	2.0±0.1[e]
P-value	0.0	0.0	0.0	0.0	0.0

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

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