International Food Research Journal 24(4): 1507-1512 (August 2017)
Journal homepage: *http://www.ifrj.upm.edu.my*

Nutritional quality of *Barbus paludinosus* (matemba) smoked using traditional and improved smoking methods

Lipato, I. and *Kapute, F.

Mzuzu University, Department of Fisheries Science, Faculty of Environmental Sciences, P/Bag 201, Luwinga, Mzuzu 2, Malawi

Article history

Received: 15 June 2016
Received in revised form: 28 June 2016
Accepted: 15 July 2016

Keywords

Nutrient quality
Barbus paludinosus
Traditional smoking
Improved smoking

Abstract

Proximate composition (crude protein, moisture, crude fat and ash) and calcium of *Barbus paludinosus* locally known as matemba, smoked in traditional and improved smoking kilns was compared. This species makes the most important fishery in Lake Chilwa, Malawi. Matemba is also highly nutritious because it is consumed whole due to its small size. Most of the catch is either sun dried or smoked. However, knowledge that heat processing compromises nutrient content in food products, underpins the need for assessing the magnitude of nutrient changes or losses in the respective processed products. In this study, freshly caught fish samples were obtained from Lake Chilwa (Southern Malawi), smoked and analysed for proximate composition. Crude protein significantly increased (61.00 ± 0.02) ($P<0.05$) and decreased (59.50±0.03) ($P<0.05$) from the normal (fresh samples – 60.50 ± 0.01) in fish processed using the improved and traditional smoking kiln respectively. Fish smoked in the traditional kiln showed higher amount of moisture (19.00 ± 0.02) than the improved kiln (18.00 ± 0.03) ($P<0.05$). Higher amount of crude fat, ash and calcium were retained in fish smoked in the traditional smoking kiln compared to the improved smoking kiln ($P<0.05$). Summary results suggest that the improved smoking kiln is better in preserving nutrients in fish over the traditional smoking kiln. Of much interest in the improved smoking kiln, is the higher protein and lower moisture retention. This suggests that fresh fish smoked in the improved kiln is more nutritious but also may have a longer shelf life due to lower moisture which is a medium for microbial growth responsible for fresh food spoilage. The improved smoking kiln should therefore be recommended also because it uses less firewood than the traditional smoking kiln. However, the traditional smoking kiln may not be eliminated completely owing to products with higher fat content which is also required by the human body.

Introduction

Fish remain a good and rich source of important nutrients like high quality proteins, vitamins and minerals (Ojutiku *et al*., 2009). Fish has received increased attention as a source of dietary animal protein (Fawole *et al*., 2007). In fact, many nutritional studies recommend that fish should be part of the daily meal (Blanchet *et al*., 2000; Balk *et al*., 2004). In Malawi, over 40% of the total consumed dietary animal protein is obtained from fish – lower than the previous 70% due to decline of fish stocks in the natural waters (Banda *et al*., 2005). Small sized fish species such as *Barbus paludinosus* (local name: matemba) which are consumed whole, are a good source of calcium - one of the principal micro-nutrients required by the human body (Effiong and Fakunle, 2011; Jiang *et al*., 2015). Matemba is one of three most harvested and commercial fish species in Lake Chilwa (Chiwaula *et al*., 2012). As a highly perishable product, fish are always processed or preserved after catch to prevent spoilage. Smoking is one of the preferred methods of fish preservation in most rural areas and riverine fishing communities in Malawi which includes the matemba fishery of Lake Chilwa, southern Malawi (FAO, 2005). Smoking is actually, the oldest and commonest method in fish preservation in many developing countries of the tropics (Kumolu-Johnson *et al*., 2010; Petridis *et al*., 2012; Aremu *et al*., 2013). In Lake Chilwa, the traditional fish smoking is characterized by open fire smoking kilns which are constructed from mud.

*Corresponding author.
Email: *fkapute@gmail.com*

Figure 1. Traditional (L), and Improved Smoking kiln (R) at Lake Chilwa, Malawi

Figure 2. Lake Chilwa fresh (L) and smoked (R) *Barbus paludinosus*

However, fish smoked in the traditional kiln are exposed to dust and uncontrolled fire temperature. There is also high uncontrolled smoke production and inefficient use of fuel wood (Wood and Balwin, 1985). To prevent or minimise such problems, an improved version of the traditional smoking kiln has been introduced for the processing of matemba in Lake Chilwa and other areas along Lake Malawi. The improved smoking kiln has demonstrated to be fuel wood efficient, clean and well aerated, and producing high sensory quality smoked fish products.

However, many studies have shown that most processing methods especially those involving addition of heat, affect the chemical composition of the processed fish by altering its nutrient levels (Saliu, 2008; Oluwanyi and Dosumu, 2009; Ahmed *et al*., 2011; Oparaku and Mgbenka, 2012; Makawa *et al*., 2015). Fawole *et al*. (2007) reported that determining proximate profiles such as protein content, lipid, ash and other nutrients is indispensable to ensure that they are within the range of dietary requirement and commercial specifications. The objective of this study was therefore to determine the effect of the traditional and improved smoking kiln on the proximate composition of *Barbus paludinosus* (matemba) from Lake Chilwa, Malawi.

Materials and Methods

Fish sample collection and processing

Fresh *Barbus paludinosus* fish samples were collected from Lake Chilwa – an inland drainage lake in southern Malawi. The samples were divided into three portions (treatments) of about 9 kg each in triplicates. Two portions were processed using the traditional and improved smoking kilns respectively (Figure 1) and the third portion was kept fresh (unprocessed). Fish were then washed with clean water before being put on trays in the smoking kilns for smoking. The smoked and fresh fish (Figure 2) were analysed for proximate composition following the procedure by (AOAC, 2005) to determine crude protein, crude fat, Ash, moisture and calcium. Crude protein content was determined as nitrogen by the Kjeldahl procedure and multiplied by 6.25 (Protein contains 16% nitrogen thus 6.25 is 100/16.). Moisture content was determined by hot air oven method at 105^{o}C; the loss in weight was expressed as moisture content.Fat content was determined by soxhlet extraction using the formula: % crude lipid = (wt of residue/original wt of sample) x 100. The free fatty acid (FFA) was expressed as percent oleic acid equivalent. Determination of ash content involved putting the fish samples into a muffle furnace at 550^{o}C

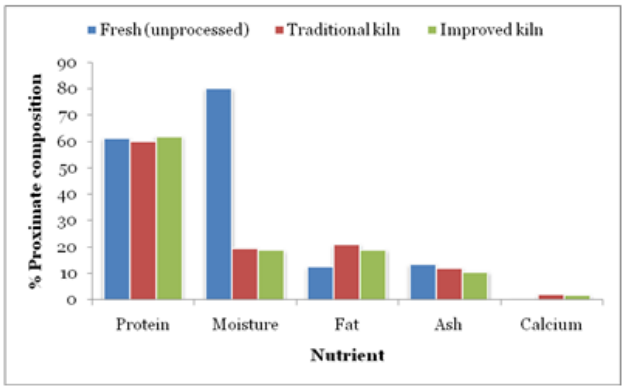

Figure 3. Proximate composition for *Barbus paludinosus* smoked in a traditional and improved smoking kiln

Table 1. Proximate composition results (%) for *Barbus paludinosus* smoked in a traditional and improved smoking kiln

Processing method	Nutrient				
	Crude protein	Moisture	Crude fat	Ash	Calcium
Traditional	60.04±0.03^{c}	19.52±0.02^{b}	20.84±0.01^{a}	11.93±0.01^{b}	1.95±0.01^{a}
Improved	61.85±0.02^{a}	18.66±0.03^{c}	18.88±0.00^{b}	10.51±0.02^{c}	1.71±0.06^{b}
Fresh	60.17±0.01^{b}	79.94±0.05^{a}	12.45±0.02^{c}	13.49±0.04^{a}	0.10±0.05^{c}
P value	0.00	0.05	0.01	0.03	0.04

Values with different superscript in a column are significantly different (P<0.05).

for 16 hours then, calculating ash values by dividing the weight of ash by the weight of the sample.

Calcium was determined by heating 1g of sample on a hotplate until it was charred. The sample was then was transferred into a muffle furnace and heated at 500°C – 600°C for 2 – 4 hours to obtain a clear carbon free ash. 10ml of 1N Hydrochloric acid was added and dissolved ash by heating cautiously on a hotplate. Later the sample was put into into a 25 ml volumetric flask, cooled and diluted with the Hydrochloric acid. Value was read on the Microwave Plasma Absorption Emission Spectrophotometer (MPAES) and expressed in mg/g sample. All the proximate values were reported in g/100 g of the fish sample.

Statistical analysis

Data for proximate composition were analysed using SPSS version 16.0. One way analysis of variance (ANOVA) was performed to compare the treatment means at 0.05 level of confidence. Significantly different treatments were separated using Duncan's Multiple Range Test (DMRT).

Results

Crude protein significantly increased (61.85 ± 0.02) (P<0.05) and decreased (60.04 ± 0.03) (P<0.05) from the normal (fresh samples – 61.17 ± 0.01) in fish processed in the improved and traditional smoking kiln respectively (Table 1). This suggests that fish processed in the improved smoking kiln retained more crude protein than those smoked in the traditionally. On the contrary, fish smoked in the traditional kiln showed higher amount of moisture (19.52 ± 0.02) than the improved kiln (18.66 ± 0.03) (P<0.05). Higher amount of crude fat, ash and calcium were retained in fish smoked in the traditional smoking kiln compared to the improved smoking kiln (P<0.05). The striking differences in nutrient content for fish samples processed in the two smoking kilns and fresh samples are presented in a graph (Figure 3) for more clarity. Although levels for Calcium (Ca) appear to be low, results show that processing improved the availability in the fish (Table 1 and Figure 3).

Discussion

Comparative studies in nutritional levels of fish processed in the traditional and improved smoking kilns have been previously carried out in other fish species (Okereke *et al*., 2014; Ezembu and Onwuka, 2015). Results in these studies agree with those from the present study pointing to the observation that smoking (irrespective of the type - traditional or improved), increases nutrient levels in the processed fish products. Other reports (Olayemi *et al*., 2011; Oparaku and Mgbenka, 2012; Makawa *et al*., 2014) on effects of processing on nutrient content of fish concluded the same.

Evaluation of proximate composition is an important and reliable indicator for determining nutritional quality of food fish (Hernandez *et al*., 2001; Sutharshiny and Sivashanthini, 2011). Results in this study suggest that *Barbus paludinosus* is a highly nutritious fish with crude protein content of 60.5% in freshly caught fish (Table 1; Figure 3). Superiority of the improved smoking kiln over the traditional is due to the fact that products produced are of high protein content - a nutrient much needed in every diet (Louka *et al*., 2004). A plausible explanation to the increase in protein in smoked fish could be due to dehydration which concentrates proteins thereby increasing the nutritional value of the processed fish product (Ahmed *et al*., 2011; Okereke *et al*., 2014). Associated heat, flow of gases and interaction of the smoke components with protein could be the reason for lower values of protein for fish processed

in the traditional smoking kiln (Morris, 2004). The traditional fish smoking kiln has uncontrolled fire temperatures, high uncontrolled smoke production and inefficient use of fuel wood which results into high nutritional and post harvest losses (Stolyhwo and Sikorski, 2005). Improved kilns on the other hand have heat and smoke regulatory mechanisms to ensure proper control of heat and smoke circulation in the kiln (Olayemi *et al*., 2013).

Decrease in moisture content with increasing protein levels in the smoked fish samples is supported by Aliya *et al*. (2012). Smoking decreases water activity in fish consequently concentrating the proteins (Ahmed *et al*., 2011). That is why moisture content in flesh is perceived as a good indicator of its relative values of protein, lipid and energy (Aberoumad and Pourshafi, 2010). Loss in moisture content in smoked products is also regarded as a gain in the other proximate constituents explaining high values of crude fat, ash and calcium earlier reported by Abdullahi (2001), Mumba and Jose (2005), Effiong and Mohammad (2008), and Aberoumad (2013). Similarly, lower crude fat content in improved kiln smoked fish may be due to the fact that fat exude with the moisture evaporation during the kiln oven drying (Chukwu, 2008). Though significantly different, Increase in calcium and ash content in tradition smoked could be due to susceptibility to breakdown of certain volatile mineral components such as chloride at increased temperature. Ali *et al*. (2011) observed that smoke-drying has a greater effect on raising most minerals due to loss of moisture.

Despite the superiority of the improved smoking kiln, higher fat content in fish processed in the traditional smoking kiln requires attention. Chang *et al.* (2009) reported that increased fat in human diets provides and sustains energy in the body. 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). Although nutritional requirements of the fishing communities around Lake Chilwa are not well documented, fish is by far the major source of a nutrient rich food consumed on a daily basis. Like most fishing communities in Malawi, prevalence of HIV and Aids is high due to among many reasons, widespread unprotected sexual acts known as "sex for fish or fish for sex", where women provide sexual services to fishermen in exchange for fish (Personal observation). The need for fat in diets especially for immune boosting can therefore not be underestimated.

Conclusions

The study has shown that fish processed in the improved smoking kiln retain more nutrients which are essential in human nutrition. The improved smoking kiln should therefore be recommended for adoption and out scaling to other areas in the processing of *Barbus paludinosus* for increased consumer nutritional benefit. However, fish processed in the traditional smoking kiln has more fat than the improved kiln. In view of the importance of fat in a diet, traditional smoking kilns cannot be eliminated completely.

Acknowledgements

Authors thank the Department of Fisheries Science at Mzuzu University for the moral support and staff in the Chemistry Department Laboratory at the Chancellor College (University of Malawi) for sample analysis.

References

Abdullahi, S. A. 2001. Investigation of nutritional status of *Chrysichthys nigrodigitatus, Barus filamentous* and *Auchenoghats accidentals*, family Bangdae. Journal of Arid Zone Fish 1: 39-50.

Aberoumad, A. 2013. Effect of processing on proximate composition and energy values of two less known selected fish species consumed in southern Iran. Indian Journal of Research 47(5): 417-420.

Aberoumad, A. and Pourshafi, K. 2010. Chemical and proximate composition properties of different fish species obtained from Iran. World Journal of Fish and Marine Sciences 2: 237-239.

Ahmed, A., Ahmadou, D. and Mohamadou, B. A. 2011. Influence of Traditional Drying and Smoke-Drying on the Quality of Three Fish Species (*Tilapia nilotica, Silurus glanis* and *Arius parkii*) from Lagdo Lake, Cameroon. Journal of Animal and Veterinary Advance 10: 301-306.

Ali, A., Ahmadou, D., Mohamadou, B. A., Saidou, C. and Tenin, D. 2011. Influence of Traditional Drying and Smoke-Drying on the Quality of Three Fish Species (*Tilapia nilotica, Silurusglanis* and *Arius parkii*) from Lagdo Lake, Cameroon. Journal of Animal and Veterinary Advances 10(3): 301-306.

Aliya, G., Humaid, K., Nasser, A., Sami, G., Aziz, K., Nashwa, M. and Ponnerassery, S. S. 2012. Effect of the freshness of starting material on the final product quality of dried salted shark. Advance Journal of Food Science and Technology 4(2): 60-63.

Aminullah-Bhugan, A. K. M., Ratnayake, W. M. N. and Ackman, R. G. 2006. Effect of smoking on proximate composition of Atlantic Mackerel. Journal of Food Science 51(2): 327-329.

Aremu, M. O., Namo, S. B., Salau, R. B., Agbo, C. O. and Ibrahim, H. 2013. Smoking methods and their effects on nutritional value of African Catfish *(Clarias gariepinus)*. The Open Nutraceuticals Journal 6: 105-112.

Association of Official Analytical Chemists (AOAC). 2005. Official Methods of Analysis. 18th ed. Gaithersburg, Maryland, USA: AOAC.

Balk, E., Chung, M., Lichtenstein, A., Chew, P., Kupelnick, B., Lawrence, A., De Vine, D. and Lau, J. 2004. Effects of omega-3 fatty acids on cardiovascular risk factors and intermediate markers of cardiovascular disease. Evidence Report/Technology Assessment (Summary) Journal 93: 1-6.

Banda, M., Jamu, D, Njaya, F, Makuwila, M. and Maluwa, A. 2005. The Chambo Restoration Strategic Plan. In WorldFish Center Conference, p. 112. Penang: Malaysia.

Black, P. N. and Sharpe, S. 1997. Dietary fat and asthma: is there a connection? European Respiratory Journal 10(1): 6-12.

Blanchet, C., Dewailly, E. Ayotte, P. Bruneau, S., Receveur, O. and Holub, B. J. 2000. Contribution of selected traditional and market foods to the diet of Nunavik Inuit women. Canadian Journal Dietetic Practice and Research 61: 50-59.

Chang, C. Y., Ke, D. S. and Chen, J. Y. 2009. Essential fatty acids and human brain. Chang Neurol Taiwan 18(4): 231-241.

Chiwaula, L., Jamu, D., Chaweza, R., Nagoli, J. 2012. The Structure and margins of the Lake Chilwa fisheries in Malawi: a value chain analysis. Project Report 2012-12. Penang: The WorldFish Center.

Chukwu, O. 2009. Influences of drying methods on nutritional properties of Tilapia fish *(Oreochromis niloticus)*. World Journal of Agricultural Sciences 5(2): 256-258.

Effiong, B. N. and Fakunle, J. O. 2011. Proximate and Mineral Composition of Some Commercially Important Fishes in Lake Kainji, Nigeria. Journal of Basic and Applied Scientific Research 1(12): 2497-2500.

Ezembu, E. N. and Onwuka, G. I. 2015. Effect of improved and traditional smoking on the storage life and nutritional quality of cat, croaker and sardine fishes. American International Journal of Contemporary Scientific Research 2(4): 12-27.

Effiong, B. N. and Mohammed, I. 2008. Effect of seasonal variation on the nutritional composition in selected fish species in Lake Kainji-Nigeria. Nature Science 6(2):25-28.

Fawole, O. O., Ogundiran, M. A. Ayandiran, T. A. and Olagunju, O. F. 2007. Mineral composition in some selected fresh water fishes in Nigeria. Journal of Food Safety 9: 52-55.

Hernandez, M. D., Martinez, F. J. and Garcia, B. 2001. Sensory evaluation of farmed sharp snout sea bream *(Diploduspuntazzo)*. Aquaculture International 9: 519-529.

Ighodaro, H. E. and Abolagba, O. J. 2010. Acceptance of packaged smoked-dried cured fish *(Clarias gariepinus)* in University of Benin, Benin City. Journal of Field Aquatic Studies 6: 141-144.

Jiang, J., Lu, S., Zhang, H., Liu, G., Lin, K., Huang, W., Luo, R., Zhang, X., Tang, C. and Yu, Y. 2015. Dietary intake of human essential elements from a Total Diet Study in Shenzhen, Guangdong Province, China. Journal of Food Composition and Analysis 39:1-7.

Kaunitz, H. and Dayrit, C. S. 1992. Coconut oil consumption and coronary heart disease. Philippine Journal of Internal Medicine 30: 165-171.

Kumolu-Johnson, C. A., Aladetohun, N. F. and Ndimele, P. E. 2010. The effects of smoking on the nutritional qualities and shelf-life of *Clarias gariepinus* (Burchell, 1822). African Journal of Biotechnology 9(1): 73-76.

Louka, N., Juhel, F., Fazilleau, V. and Loonis, P. 2004. A novel colorimetry analysis used to compare different drying fish processes. Journal of Food Control 15: 327-334.

Makawa, Z., Kapute, F., and Valeta, J. 2014. Effect of delayed processing on nutrient composition, pH and organoleptic quality of pond raised tilapia *(Oreochromis shiranus)* stored at ambient temperature. African Journal of Food, Agriculture, Nutrition and Development 14(3): 8872-8884.

Mumba, P. and Jose, M. 2005. Nutrient composition of selected fresh and processed fish species from lake Malawi: a nutritional possibility for people living with HIV/AIDS. International Journal of Consumer Studies 29: 72–77.

Ojutiku, R. O., Kolo, R. J. and Mhammed, M. L. 2009. Comparative study of sun drying and solar tent drying of Hyperopisus bebeoccidentalis. Pakistan Journal of Nutrition 8(7): 955-957.

Okereke, A. N., Okpara, J. Y. and Ogumuka, S. O. 2014. Comparative Nutritional Composition of Smoked Catfish *(Clarias gariepinus)* Produced from NIOMR Smoking Kiln and Local Cut Drum Oven. American Journal of Food Technology 9(7): 377:381.

Olayemi, F. F., Raji, A. O., Oyelese, O. A, Oyewole, S. N., Omodara, M. A. 2013. Effective Fish Smoking Kiln for Developing Country. International Journal of Scientific and Engineering Research 4(1): 1-7.

Oluwanyi, O. O. and Dosumu, O. O. 2009. Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. Biokemistri 21(1): 1-7.

Omodara, M. A. and Olaniyan, A. M. 2012. Effects of pre-treatments and drying temperatures on drying rate and quality of African catfish *(Clarias gariepinus)*. Journal of Biology, Agriculture and Healthcare 2(4): 1-11.

Oparaku, N. F. and Mgbenka, B. O. 2012. Effects of electric oven and solar dryer on a proximate and water activity of *Clarias gariepinus* fish. European Journal of Scientific Research 81(1): 139 -144.

Petridis, D., Zotos, A., Kampouris, T. and Roumelioti, Z. 2012. Optimization of a steaming with liquid smoke smoking process of Mediterranean mussel *(Mytilus galloprovincialis)*. Food Science and Technology International 19: 59–68.

Ryder, J. M., Fletcher, G. C., Stec, M. G. and Seelye, R. J. 1993. Sensory, Microbiological and chemical changes in hake stored in ice. International Journal of Food Science and Technology 28: 169-180.

Saliu, J. K. 2008. Effect of Smoking and Frozen Storage on the Nutrient Composition of Some African Fish. Advances in Natural Applied Science 2(1): 16-20.

Stolyhwo, S. and Sikorski, Z. E. 2005. Polycyclic aromatic hydrocarbons in smoked fish a critical review. Food Chemistry 91: 303-311.

Sutharshiny, S. and Sivashanthini, K. 2011. Proximate Composition of Three Species of Scomberoides Fish from Sri Lankan Waters. Asian Journal of Clinical Nutrition 3: 103-111.

Wood, T. S. and Baldwin, S. 1985. Fuel wood and charcoal use in developing countries. Annual Review of Energy and Environment 10: 407-29.