SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2018; 18(1): 13009-13018 DOI: 10.18697/ajfand.81.16960

EFFECT OF SMOKING AND SUN DRYING ON PROXIMATE COMPOSITION OF *Diplotaxodon* FISH SPECIES (NDUNDUMA) FROM LAKE MALAWI, MALAWI

Msuku L[1] and F Kapute[2]*

Louis Msuku

Fanuel Kapute

*Corresponding author email: fkapute@gmail.com

[1]Bachelors Degree Student, Department of Fisheries Science, Mzuzu University, P/Bag 201, Luwinga, Mzuzu, Malawi

[2]Associate Professor in Fish Quality Management, Department of Fisheries Science, Mzuzu University, P/Bag 201, Luwinga, Mzuzu, Malawi

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Processed fish and fish products have high nutritional value, longer shelf life and fetch better prices on the market in contrast to freshly caught fish which are highly perishable. Processing, however, alters nutrient composition of a product underpinning the need for caution when consuming processed products. The study analyzed the effect of traditional smoking and sun drying on proximate composition (moisture, protein, fat and ash) of *Diplotaxodon* species locally known as Ndunduma. This is an important commercial cichlid species harvested across the entire Lake Malawi by both artisanal and commercial fishers. Fresh *Diplotaxodon* fish samples were collected from fishers' boats in the south-western part of Lake Malawi, Malawi immediately after catch early in the morning. The fish were washed then weighed and thereafter, smoked in a traditional smoking kiln and sun dried on reed mats. Determined percent moisture, protein, fat and ash content for smoked fish were: 12.22±0.05, 55.30±1.67, 25.31±2.78 and 12.96±0.72, respectively, while corresponding values for fish that were sun dried were: 24.28±0.14, 52.80±1.28, 22.36±0.26 and 13.81±0.14, respectively. Overall, results show reduced protein content in processed fish (smoked and sun dried) ($P<0.05$) although not significantly different in smoked fish ($P>0.05$). Significantly low moisture content in smoked fish is indicative of a product with longer shelf life since moisture favours rapid microbial growth causing freshness quality deterioration. Although not significantly different, high fat ($P>0.05$) and ash ($P<0.05$) in smoked fish is consistent with a nutrient rich product. The study concludes that smoked *Diplotaxodon* species is more nutritious and may present better storage qualities than sun dried due to relatively low moisture. Caution should, nevertheless, be considered due to the high fat levels to prevent spoilage caused by breakdown of fats. Since smoked products are of high commercial value, fish processors should be encouraged to smoke fresh *Diplotaxodon* species other than sun drying.

Key words: *Diplotaxodon* species, Ndunduma, processing, proximate composition, Lake Malawi

DOI: 10.18697/ajfand.81.16960

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

INTRODUCTION

Diplotaxodon are an important offshore species widely distributed across the entire Lake Malawi in Malawi, Southern Africa. The species is probably the most abundant of the cichlids in the lake with high biomass in the pelagic zone alone and is exploited commercially by both artisanal and commercial fishers [1]. It is, therefore, one of the major food fish providing nutrition to many Malawians. Fish are critical for the health and nutrition of Malawians, especially for rural communities and those living around the lakes [2, 3]. Fatty acids found in oily fish are essential for the development of the brain and body and are particularly crucial in the diets of babies, children, and of pregnant and lactating women [4]. In fact, consumption of omega-3 fatty acids during pregnancy reduces the risk of low birth weight, which is a key factor in both maternal and child mortality [5]. Fish contains nearly all essential nutrients important for people living with HIV/AIDS and related diseases that need good amounts of protein and energy rich foods together with vitamins and minerals to build their muscle and stay health [6]. In Malawi, fish are usually processed to extend shelf life and improve quality using the two most common and very old fish processing methods of sun drying and smoking. Sun drying is common during dry periods when relative humidity is low, while smoking is carried out any period of the year. Smoking reduces food spoilage but also modifies appearance, taste and smell of foods [7]. Processing, however, alters the nutritional composition of foods [8, 9, 10] underpinning the need to understand its effects on processed products. This study was carried out to determine the effect of the traditional processing methods (smoking and sun drying) on the nutrient composition of *Diplotaxodon* species (Ndunduma) harvested from south-western Lake Malawi, Malawi.

MATERIALS AND METHODS

Collection and processing of fish samples

Freshly caught *Diplotaxodon* (Ndunduma) fish were bought from fishers at Malembo beach in the south western arm of Lake Malawi, Malawi, Southern Africa. Fish were washed and grouped into three batches for smoking, sun drying and fresh (control). Ndunduma is a small sized fish species and as such, the fish were processed whole as it is done by processors without gutting or skinning. Drying was done by exposing the fish in the open sun for three days (Figure 1A).

DOI: 10.18697/ajfand.81.16960

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

A B

Figure 1: Sun drying of the fish samples (A) and smoking in a traditional smoking kiln (B) Fish were smoked using the traditionally constructed smoking kilns (Figure 1B) that are commonly used by fish processors in the area. Both fresh and processed fish samples were then analysed for nutrient composition (moisture, protein, fat and ash) in the laboratory

Proximate analysis

Proximate composition (moisture, crude protein, fat and ash) of the processed (smoked and sun dried) and fresh fish samples was determined in triplicate following a procedure by AOAC [11]. Protein was determined using the semi-micro Kjeldahl method. One gram of ground sample from each of the two samples (smoked and sun dried) was digested in a Kjeldahl flask using 98% Sulphuric acid and a catalyst made from Potassium sulphate and Cupric sulphate. The samples were distilled and the distillate titrated using 0.05M Sodium hydroxide (NaOH). Crude protein content was then determined as nitrogen and multiplied by 6.25 (Protein contains 16% nitrogen thus, 6.25 is 100/16). 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. Fat content was obtained by subtracting the weight of the flask after drying from that before drying. To determine moisture, 1 gram sample of ground fish (for each of the two samples) 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. Ash was determined by grinding 2 grams sample (for each of the two samples) then placing it in a crucible. The samples were later 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.

DOI: 10.18697/ajfand.81.16960

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Data analysis
Data were analyzed in SPSS for Windows (Version 20.0). Treatment means for the fish processing methods were compared using one-way analysis of variance (ANOVA) at 95% level of significance. Significantly different treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

The results of the proximate composition of the fresh, smoked and sun dried Ndunduma are presented in Table 1 expressed as mean ± Standard Deviation (SD) of the triplicate determinations. There were significant differences ($P<0.05$) in the mean moisture content among the three samples of fish with the highest being in the fresh Ndunduma followed by the sun dried then smoked. A significantly lower crude protein content ($P<0.05$) was recorded in sun dried Ndunduma than in fresh Ndunduma though it was not significantly different ($P>0.05$) from smoked fish. No significant differences ($P>0.05$) were recorded in the crude protein content of fresh and smoked Ndunduma. Crude fat was not significantly different ($P>0.05$) in the fresh and processed Ndunduma although the highest value was recorded in smoked Ndunduma. The ash content increased significantly ($P<0.05$) with processing and the highest value was recorded in sun dried Ndunduma followed by smoked Ndunduma.

DISCUSSION

The recorded moisture content of fresh Ndunduma (72.9%) falls within the range reported by Davies and Davies [12] that fish are made up of 70-84% water which decreased with processing. Smoked Ndunduma retained the least moisture content than sun dried fish. This could be explained by the fact that during smoke drying, the flesh loses a lot of water and, in addition, a protective coating is formed due to partial carbonization of the tissues and other components by wood smoke [8]. On the contrary, sun dried fish tend to moisturize ambient air humidity, a situation which is restricted by the protective coating formed in smoked fish [8]. Adequate drying creates unfavorable conditions for growth of microorganisms [13], which would subsequently lead to prolonged shelf life of the fish.

Reduction in protein content during smoking in this study, although not statistically significant, has been reported by several authors [14, 15, 16]. Crude protein in fish is reduced by chemical reactions that occur during smoking [14]. In addition, the decrease in protein level in smoked fish could be as a result of the direct heat that was used to dry the fish (pers. obs.). According to Ravichandran *et al.* [17], protein forms the largest component of dry matter in fish. Fish is consumed as a major and valuable protein source in Malawi and as such, it is important that the protein content not be compromised during processing and preparation. In sun dried Ndunduma, the decrease in crude protein content could also be attributed to the time that the fish spends in the drying process, which could give chance to microbial contamination causing degradation of the protein molecules [18]. Apart from presenting favourable conditions for microbial growth, the

DOI: 10.18697/ajfand.81.16960

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 18 No. 1 April 2018 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

prolonged period that the fish spent during sun drying could also accelerate enzymatic breakdown of the proteins [8].

The increase in fat content after smoking could be due to the fact that fat content increases with drying of fish since the elimination of moisture due to heating concentrates ash and fat content in the fish [19]. The low value of fat content in sun dried Ndunduma can be attributed to oxidation due to the prolonged drying period [20]. Fish contains chiefly unsaturated fatty acids that are easily oxidized by atmospheric oxygen and high temperature or exposure to light can also increase the oxidation rate [21]. While smoked Ndunduma may present a product with a longer shelf life due to the low moisture content, the fish's high fat content, although nutritionally good, is a cause for concern. Fatty fish spoil rapidly due to fat oxidation thereby compromising the freshness quality of the product, hence caution needs to be exercised to prevent breakdown of the fats in storage [22, 23].

In this study, fresh Ndunduma recorded an ash content of 10.57±0.51%, an indication that it is a good source of minerals hence nutritious [24]. Ndunduma is among lean fish species which are generally considered to contain high ash levels [25]. Results generally showed an increase in the ash content of the processed samples agreeing with earlier studies [9] that ash content increases with dry processing in fish. The high ash values in the processed fish could also be due to contamination with sand and dirt during drying and transportation [13]. Fapohunda and Ogunkoya [26] reported that smoke drying methods increase ash and fat contents, which is also necessitated by the loss of humidity.

CONCLUSION

Based on this study results, it is concluded that processed Ndunduma (smoked and sun dried) retains nutrients the most and eliminates significant moisture which would provide an ideal substrate for microbial growth. As a major source of dietary animal protein, smoked Ndunduma should be promoted as a way to effectively increase the shelf life of the fish while enhancing the flavour.

ACKNOWLEDGEMENTS

We sincerely thank the Department of Fisheries Science at Mzuzu University, Malawi where this study was hosted. We also appreciate the people who assisted in processing of the fish at Malembo beach (southwest Lake Malawi) – thank you.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Mean percent values of proximate composition (moisture, protein, fat and ash) of smoked and sun dried *Diplotaxodon* species (Ndunduma)

Processing method	Nutrient (%)			
	Moisture	Protein	Fat	Ash
Fresh	72.91 ± 1.03^{a}	58.86 ± 2.84^{a}	24.18 ± 0.67^{a}	10.57 ± 0.51^{c}
Smoked	12.22 ± 0.05^{c}	55.30 ± 1.67^{ab}	25.31 ± 2.78^{a}	12.96 ± 0.72^{b}
Sun dried	24.28 ± 0.14^{b}	52.80 ± 1.28^{b}	22.36 ± 0.26^{a}	13.81 ± 0.14^{a}

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

DOI: 10.18697/ajfand.81.16960

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 18 No. 1
April 2018
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

REFERENCES

1. **Kanyerere G** Age, Growth and Yield-per-recruit analysis of Ndunduma, *Diplotaxodon limnothrissa* (Teleostei: Cichlidae), in the Southeast Arm of Lake Malawi. Rhodes University, South Africa, 2003.

2. **Food and Agriculture Organization.** Fisheries and Aquaculture Department, Summary tables of Fishery Statistics: Food Balance Sheets. 2011 Retrieved from: ftp://ftp.fao.org/FI/STAT/summary/default.htm, 2017.

3. **Phiri LY, Dzanja J, Kakota T and M Hara** Value chain analysis of Lake Malawi fish: A case study of *Oreochromis* spp. (Chambo). *International Journal of Business Social Science* 2013; **4(2)**: 170-181.

4. **World Fish Center.** Fish and Food Security in Africa. World Fish Center, Penang, Malaysia, 2005.

5. **Finegold C** The importance of Fisheries and aquaculture to development **In**: Wramner P, Cullberg M and Ackefors H. (Eds.). Fisheries sustainability and development. The Royal Swedish Academy of Agriculture and Forestry, Stockholm 2009; 353-364.

6. **Mumba PP and M Jose** 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* 2005; **29(1)**: 72-77.

7. **Ahmed EO, Adm HT and KE Mohammed** Investigating the quality changes of hot smoked *Clarias lazera* at refrigerated temperature (5±1°C). *Journal of Agriculture and Food Science* 2013; **1(3)**: 27-32.

8. **Ahmed A, Ahmadou D and BA Mohamadou** 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 Advances* 2011; **10**: 301-306.

9. **Oparaku NF and BO Mgbenka** Effects of electric oven and solar dryer on a proximate and water activity of *Clarias gariepinus* fish. *European Journal of Scientific Research* 2012; **81(1)**: 139-144.

10. **Makawa Z, Kapute F and J Valeta** 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* 2014; **14(3)**: 8872-8884.

11. **Official Methods of Analysis.** Association of Official Analytical Chemists. 18th Edition. Washington D.C., USA, 2005.

12. **Davies RM and OA Davies** Traditional and Improved Fish Processing Technologies in Values of Fish. *Tropical Science* 2009; **33**: 183-189.

13. **Islam TM, Ahmed S, Sultana A, Tumpa SA and FA Flowra** Nutritional and food quality assessment of dried fishes in Singra Upazila under Natore district of Bangladesh. *Trends in Fisheries Research* 2013; **2(1)**: 2319-4758.

14. **Ime-Ibanga U and J Fakunle** Effect of smoking and oven drying on the proximate composition and sensory qualities of salted and salt less *Clarias* species. Proceedings of the 23rd Annual Conference. FISON 2008; 71-74.

15. **Longwe P and F Kapute** Nutritional composition of smoked and sun dried pond raised *Oreochromis karongae* (Trewavas, 1941) and *Tilapia rendalli* (Boulenger, 1896). *American Journal of Food and Nutrition* 2016; **4(6)**: 157-160.

16. **Akinwumi FO** Effect of Smoking and Freezing on the Nutritive Value of African Mud Cat Fish, *Clarias gariepinus* (Burchell, 1822). *Journal of Agricultural Sciences* 2014; **6(11)**: 143-149.

17. **Ravichandran S, Kumaravel K and EP Florence** Nutritive composition of some edible fin fishes. *International Journal of Zoological Research* 2011; **7(3)**: 241-251.

18. **Ghaly AE, Dave D, Budge S and MS Brooks** Fish spoilage mechanisms and preservation techniques: Review. *American Journal of Applied Sciences* 2010; **7(7)**: 859-877.

19. **Aberoumand A** Preliminary studies on nutritive and organoleptic properties in processed fish fillets in Iran. *Journal of Food Science and Technology* 2014; **34(2)**: 287-291.

20. **Hoki M** Quality changes of fish from catch to processing and during storage with focus on cooling practices and practical application of Sierra Leone. United Nations University Fisheries Training Programme (UNU-FTP), Marine Research Institute (MRI), Reykjavik, Iceland, 2011.

21. **Gokoglu N and P Yerlikaya** Seafood chilling, refrigeration and freezing: Science and Technology, John Willey and Sons 2015; p 47.

22. **DeWitt CAM and ACM Oliveira** Modified Atmosphere Systems and Shelf Life Extension of Fish and Fishery Products. *Foods* 2016; **5(48)**: 1-27.

23. **Amuamuta A, Mekonnen Z and A Agazie** Extraction and analysis of oil/fat and fatty acids content from different indigenous fish of Lake Tana Source, Northwest Ethiopia. *World Journal of Fish and Marine Sciences* 2014; **6 (5)**: 417-423, 2014.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 18 No. 1 April 2018 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

24. **Huss HH** Quality and quality changes in fresh fish. FAO Fisheries Technical Paper. No. 348. FAO, Rome, 1995.

25. **Kapute F, Likongwe J, Kang'ombe J and C Kiiyukia** Shelf life of whole fresh Lake Malawi tilapia (*Oreochromis* species – *chambo*) stored in ice. *African Journal of Food, Agriculture, Nutrition and Development* 2013; **13(1)**: 7138-7156.

26. **Fapohunda OO and M Ogunkoya** Effect of smoke-drying on the proximate composition of *Tilapia zilli*, *Parachanna obscura* and *Clarias gariepinus* obtained from Akure, Ondo-State, Nigeria. *Animal Research International* 2006; **3(2)**: 478-480.

DOI: 10.18697/ajfand.81.16960