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Effect of natural spices on the proximate composition and shelf life of smoke-dried African catfish (*Clarias gariepinus*) in Lafia, Nasarawa State

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ABSTRACT: The effect of natural species on the proximate composition and shelf life of smoke-dried African catfish in Lafia, Nasarawa State, was investigated. To determine the proximate composition of the muscle tissue of the products before and after storage, 42 kilograms of fresh *C. gariepinus* (500 g) average weight was distributed at 2 kg per treatment, and cured with T1 (Salt), T2 (Ginger), T3 (Garlic), T4 (Turmeric), T5 (mixed ginger and garlic), T6 (mixed ginger and turmeric) and T7 (mixed garlic and turmeric) at different levels (10, 20, and 30 g) respectively. The various treatment samples were smoked for 9 hours. The result obtained indicated; moisture was highest in T7 (16.33 ± 4.51) at 30 g and lowest in T1 (10.00 ± 3.00) at 30 g concentrations. Ether extract was highest at T5 (23.33 ± 1.53) at 10 g concentration and lowest in T1 (15.00 ± 5.00) at 10 g concentration. Protein was highest in T5 (43.67 ± 7.51) at 30 g concentration and lowest T2 (41.00 ± 5.00) at 10 g concentration. With high reduction in moisture contents and high protein values obtained before and after storage, it is recommended that *C. gariepinus* be cured using natural spices. These findings suggest that natural spices, as used in this study, are suitable for use as preservatives while enhancing the nutrient value of the product.

Keywords: Natural spices, proximate composition, *C. gariepinus*

INTRODUCTION

Nigeria and Ghana are some the African countries that lead in fish farming practices, 96% of the 389,302 tons of fish produced in 2016 positioned them as Economic Community of West African States largest fish exporters, estimated at 301,950 tons while imports amounted to 1,690,501 tons (ECOWAS, 2020), this must have motivated the production of smoked fish product which are perceived as excellent and harmless source of omega-3 fatty acids (Bienkiewicz *et al.,* 2022).

Aquaculture is important for Nigeria's economic development, considering movement into new fields; expansion of existing fish products, diversification of the sub-sector as the major solution that will put Nigeria economy on the path of growth given the recent fluctuation in global petroleum prices and consequent economic recession in the country (Ekelemu *et al.*, 2021).

Processing and preservation of fish is done in the most indigenous and traditional ways, with little or no attempt to add value or improve on the old practices through branding. Processed fish products are often prone to insect infestation, rodent invasion, and unappealing, considering that their quality is of concern to consumers who often have to trust fish handlers like the fisher folks, processors and traders with the healthy state of the fish they consume (Ghaly *et al.,* 2020). Maillet *et al.* (2021) indicated that smoking of fish can have a protective function against spoilage to increase the shelf-life of harvested fish. It is interesting to note also that seasonings such as cloves, cinnamon, black pepper, turmeric, ginger, garlic and onions in parts or in whole are used as therapeutic agents in a range of processed foods either as anti-inflammatory, anti-cancer and anti-microbial agents

nevertheless they are not fully exploited (Nikmaram *et al.,* 2018).

In addition to increasing shelf life, processing is carried out to enhance food value and improve merchandise quality. Fish handling activities, such as processing, are targeted at increasing value addition to make available a range of fishery products and impact the launch of an assortment of products that appeal to domestic as well as international consumers (Wicaksana *et al.,* 2022).

Determining the proximate composition of the muscle tissue of *C. gariepinus* processed using natural spices will enhance the nutritional value and prolong the shelf life of *C. gariepinus* in this study

Experimental procedures

Forty two kilogram (42 kg) samples of *C. gariepinus* were divided into seven treatments; T1 (salt), T2 (ginger), T3 (garlic), T4 (turmeric), T5 (combined ginger and garlic), T6 (combined ginger and turmeric) and T7 (Combined garlic and turmeric) in three levels; each treatment consisted of 2 kg *C. gariepinus* making a total of 42 kg table size (500 g average weight) *C. gariepinus.* Each level group of fish (2 kg) were gutted and cut into chunks of near equal sizes and washed thoroughly under clean tap water to remove fish slime and fish viscera.

The test spices were crispy dried, ground into powder, and placed in containers separately in preparation for the study, and thereafter, 10, 20, and 30 g of each of the ground spices were weighed using a sensitive scale (Atom A 122 Electronic kitchen digital weighing scale, model SF: 400A). Each of the weighed spices was mixed in a litre of water separately, and thereafter each fish treatment sample was immersed in the mixture for 2 hours, respectively and tagged. Smoking was carried out at the Processing Unit of the Department of Aquaculture and Fisheries Management, Nasarawa State University, Faculty of Agriculture, Shabu Campus, Lafia. The tagged cured fish were smoked in a gas kiln for 9 hours under low heat to reduce the water activity, after which the smoked fish products were left to cool inside the smoking kiln for 2 hours; and thereafter, the cooled smoked product was packed and labelled respectively. The first sample treated with brine solution served as the control.

RESULTS

Proximate composition of variously cured smoked *C. gariepinus* before storage

Table 1 present the results of a two-way ANOVA for various nutritional parameters of *C. gariepinus* across treatment groups (T1 to T7) at different concentrations (10, 20, and 30 g) which are T1 (salt), T2 (ginger), T3 (garlic), T4 (turmeric), T5 (mixed ginger and salt), T6 (mixed ginger and turmeric), and T7 (mixed garlic and turmeric). The moisture content did not show significant differences across treatment groups or concentrations, as indicated by the F and P values ($p>0.05$ for all). Crude protein content did not significantly vary across treatment groups or concentrations ($p>0.05$ for all). No significant differences in ether extract content were observed across different treatments or concentrations ($p>0.05$ for all). Significant differences in crude fibre content were noted at the 10 g concentration ($F=15.18$, $p<0.001$), but not at higher concentrations ($p>0.05$ for 20 and 30 g). No significant differences were found in NFE content across treatments or concentrations, except at 30 g, where a significant interaction was observed ($F=2.91$, $p>0.005$).

Proximate composition of variously cured smoked *C. gariepinus* after storage

Proximate compositions of the variously cured smoked catfish samples after storage are presented in Table 2. The cured samples of *C. gariepinus* smoked at different concentrations across treatments presented in this study showed proximate analysis carried out gave some variation. *C. gariepinus* cured using mixed garlic and turmeric (T7) gave the highest moisture (16.33 ± 4.51) and the lowest in ginger (T2), as well as in ginger and turmeric T6 (9.20 ± 1.00), respectively. Samples cured with ginger and garlic (T5) presented the highest crude protein values (43.67±7.51), and the lowest in the ginger cured sample at 30 g (41.00±5.00). Again, the highest ash content was recorded in the sample cured with combined ginger and turmeric at 30 g (13.00±3.000 and the lowest in ginger ginger-treated sample at 10 g (7.00±1.00), respectively. However, the sample cured with combined ginger and turmeric at 10 g recorded the highest ether extract (23.33±1.53), which was lowest in salt salt-cured sample again at 10 g (15.00 ± 5.00). Nitrogen free extract (NFE) recorded its highest value in T6 at 20 g (11.00±1.00) and lowest in T5 at 10 g (3.67±0.58).

DISCUSSION

Proximate composition of variously cured and smoked *C. gariepinus* samples

The proximate composition of the various treated samples in the present study revealed that increased concentration of salt was responsible for reducing moisture to 10%, this reduction conforms to Codex Alimentarius Standard (2013) for smoked fish. This finding agrees with those of Ajai *et al. (*2019) that salt, together with smoking, could significantly reduce moisture as well as spoilage, and the result also agrees with the finding of Al Ghabshi *et al.* (2011) who reported low moisture content in smoked-dried fish.

Table 1. Proximate composition of variously cured smoked *C. gariepinus* before storage.

Parameters	N	T_1 (Mean ± SD)	T_1 (Mean ± SD)	T_1 (Mean ± SD)	T_1 (Mean ± SD)	T_1 (Mean ± SD)	T_1 (Mean ± SD)	T_1 (Mean ± SD)	F	P
Moisture										
10 g	3	11.67 ± 4.51	13.00 ± 3.00	13.00 ± 4.00	11.00 ± 3.00	11.00 ± 3.00	13.00 ± 4.00	14.33 ± 4.51	0.91§	0.497
20 g	3	12.00 ± 4.00	11.00 ± 2.00	13.00 ± 3.00	11.33 ± 3.51	12.33 ± 3.51	11.33 ± 2.52	15.00 ± 5.00	1.21•	0.309
30 g	3	10.00 ± 3.00	13.00 ± 3.00	14.00 ± 4.00	14.00 ± 5.00	15.00 ± 6.00	15.67 ± 5.51	16.33 ± 4.51	0.29‡	0.998
Ash										
10 g	3	9.33 ± 4.51	8.00 ± 2.00	8.00 ± 2.00	9.00 ± 2.00	10.67 ± 2.52	10.67 ± 3.06	9.33 ± 2.52	3.51§	**0.007**
20 g	3	8.00 ± 2.00	7.00 ± 1.00	7.67 ± 2.08	10.00 ± 3.00	12.00 ± 4.00	11.67 ± 3.51	10.00 ± 2.00	0.74•	0.483
30 g	3	6.00 ± 1.00	9.00 ± 3.00	8.33 ± 1.53	12.00 ± 5.00	12.67 ± 3.51	13.00 ± 3.00	11.00 ± 2.00	0.46‡	0.925
Crude protein										
10 g	3	41.33 ± 8.51	41.00 ± 5.00	42.67 ± 7.02	42.00 ± 4.00	41.00 ± 7.00	42.00 ± 5.00	42.33 ± 3.06	1.01§	0.432
20 g	3	41.00 ± 7.00	42.00 ± 4.00	42.00 ± 5.57	41.00 ± 5.00	43.00 ± 8.00	42.67 ± 2.52	43.33 ± 4.04	0.20•	0.816
30 g	3	41.33 ± 6.51	42.00 ± 6.00	41.00 ± 7.00	42.67 ± 6.51	43.67 ± 7.51	42.00 ± 6.00	42.00 ± 3.00	0.21‡	0.997
Ether extract										
10 g	3	15.00 ± 5.00	18.00 ± 4.00	18.00 ± 5.00	19.00 ± 4.00	23.33 ± 1.53	18.67 ± 5.51	19.00 ± 3.00	2.22§	0.060
20 g	3	16.00 ± 3.00	19.00 ± 4.00	18.00 ± 3.00	16.00 ± 7.00	21.00 ± 1.00	20.33 ± 3.51	18.33 ± 3.51	0.07•	0.935
30 g	3	18.00 ± 3.00	17.00 ± 5.00	17.67 ± 2.08	15.67 ± 6.03	22.00 ± 1.00	21.00 ± 2.00	16.67 ± 4.51	0.34‡	0.977
Crude fibre										
10 g	3	17.67 ± 4.51	10.00 ± 5.00#	10.00 ± 5.00#	8.00 ± 3.00#	7.00 ± 3.00#	4.67 ± 2.52#	4.00 ± 1.00#	15.18§	**<0.001**
20 g	3	17.67 ± 4.51	10.00 ± 5.00#	9.33 ± 2.08#	12.00 ± 5.57#	8.00 ± 1.00#	4.00 ± 1.00#	5.00 ± 1.00#	0.97•	0.387
30 g	3	17.00 ± 5.57	11.00 ± 6.00#	9.33 ± 3.06#	7.00 ± 2.00#	2.00 ± 1.73#	1.33 ± 0.58#	7.67 ± 1.53#	0.81‡	0.634
NFE										
10 g	3	5.00 ± 0.00	10.00 ± 1.00	8.33 ± 1.16	11.00 ± 0.00	7.00 ± 0.00	11.00 ± 1.00	11.00 ± 0.00	1.16§	0.347
20 g	3	5.33 ± 0.58	11.00 ± 0.00	10.00 ± 1.73	9.67 ± 0.58	3.67 ± 0.58	10.00 ± 1.00	8.33 ± 0.58	2.32•	0.110
30 g	3	7.67 ± 0.58	8.00 ± 1.00	9.67 ± 0.58	8.67 ± 0.58	4.67 ± 0.58	7.00 ± 0.00	6.33 ± 0.58	2.91‡	**<0.005**

Statistical significance were expressed (#p<0.005 for pairwise comparison of treatment groups (T_n) with T1 as the comparator (reference group).

Moisture content in other treatments (T2, T4, T5, and T6) were within the standard. The present study agrees with the findings of Ndife *et al.* (2022) who recorded 10-13% moisture content of cured smoked fish under similar study; an indication that the use of natural spices in the present study impacted on the moisture content of the products, however there was high moisture recorded in T3 (garlic) and T7 (combined garlic and turmeric) compared to the recommended standard, the high moisture recorded in these treatments could lead to proliferation of microorganisms, this is further

Table 2. Proximate composition of variously cured smoked *C. gariepinus* after storage.

Parameters	N	T_1 Mean ± SD	T_2 Mean ± SD	T_3 Mean ± SD	T_4 Mean ± SD	T_5 Mean ± SD	T_6 Mean ± SD	T_7 Mean ± SD	F	P
Moisture										
10 g	3	9.67 ± 2.51	9.20 ± 1.00	9.20 ± 2.00	9.4.00 ± 1.00	9.40 ± 1.00	9.20 ± 1.00	9.33 ± 1.51	0.91§	0.427
20 g	3	10.00 ± 4.00	9.80 ± 2.00	9.80 ± 3.00	9.31 ± 3.51	10.13 ± 3.51	10.33 ± 2.52	12.00 ± 5.00	1.21•	0.319
30 g	3	10.00 ± 3.00	13.00 ± 3.00	14.00 ± 4.00	14.00 ± 5.00	15.00 ± 6.00	15.67 ± 5.51	16.33 ± 4.51	0.29‡	0.938
Ash										
10 g	3	8.00 ± 2.00	7.00 ± 1.00	7.67 ± 2.08	10.00 ± 3.00	12.00 ± 4.00	11.67 ± 3.51	10.00 ± 2.00	0.74•	0.423
20 g	3	9.33 ± 4.51	8.00 ± 2.00	8.00 ± 2.00	9.00 ± 2.00	10.67 ± 2.52	10.67 ± 3.06	9.33 ± 2.52	3.51§	**0.007**
30 g	3	6.00 ± 1.00	9.00 ± 3.00	8.33 ± 1.53	12.00 ± 5.00	12.67 ± 3.51	13.00 ± 3.00	11.00 ± 2.00	0.46‡	0.915
Crude protein										
10 g	3	41.33 ± 6.51	42.00 ± 6.00	41.00 ± 7.00	42.67 ± 6.51	43.67 ± 7.51	42.00 ± 6.00	42.00 ± 3.00	0.21‡	0.917
20 g	3	41.00 ± 7.00	42.00 ± 4.00	42.00 ± 5.57	41.00 ± 5.00	43.00 ± 8.00	42.67 ± 2.52	43.33 ± 4.04	0.20•	0.826
30 g	3	41.33 ± 8.51	41.00 ± 5.00	42.67 ± 7.02	42.00 ± 4.00	41.00 ± 7.00	42.00 ± 5.00	42.33 ± 3.06	1.01§	0.412
Ether extract										
10 g	3	15.00 ± 5.00	18.00 ± 4.00	18.00 ± 5.00	19.00 ± 4.00	23.33 ± 1.53	18.67 ± 5.51	19.00 ± 3.00	2.22§	0.070
20 g	3	16.00 ± 3.00	19.00 ± 4.00	18.00 ± 3.00	16.00 ± 7.00	21.00 ± 1.00	20.33 ± 3.51	18.33 ± 3.51	0.07•	0.915
30 g	3	18.00 ± 3.00	17.00 ± 5.00	17.67 ± 2.08	15.67 ± 6.03	22.00 ± 1.00	21.00 ± 2.00	16.67 ± 4.51	0.34‡	0.977
Crude fibre										
10 g	3	17.67 ± 4.51	10.00 ± 5.00#	10.00 ± 5.00#	8.00 ± 3.00#	7.00 ± 3.00#	4.67 ± 2.52#	4.00 ± 1.00#	15.18§	**<0.001**
20 g	3	17.00 ± 5.57	11.00 ± 6.00#	9.33 ± 3.06#	7.00 ± 2.00#	2.00 ± 1.73#	1.33 ± 0.58#	7.67 ± 1.53#	0.81‡	0.624
30 g	3	17.67 ± 4.51	10.00 ± 5.00#	9.33 ± 2.08#	12.00 ± 5.57#	8.00 ± 1.00#	4.00 ± 1.00#	5.00 ± 1.00#	0.97•	0.327
NFE										
10 g	3	5.33 ± 0.58	11.00 ± 0.00	10.00 ± 1.73	9.67 ± 0.58	3.67 ± 0.58	10.00 ± 1.00	8.33 ± 0.58	2.32•	0.120
20 g	3	5.00 ± 0.00	10.00 ± 1.00	8.33 ± 1.16	11.00 ± 0.00	7.00 ± 0.00	11.00 ± 1.00	11.00 ± 0.00	1.16§	0.317
30 g	3	7.67 ± 0.58	8.00 ± 1.00	9.67 ± 0.58	8.67 ± 0.58	4.67 ± 0.58	7.00 ± 0.00	6.33 ± 0.58	2.91‡	**<0.005**

Statistical significance were expressed (#p<0.005 for pairwise comparison of treatment groups (T_n) with T1 as the reference group).

supported by Ndife *et al.* (2022) who stated that moisture had been as an important attribute in food processing and preservation because many biochemical and physiological changes depend on it. Protein content documented in this study indicates that nutritional parameters of *C. gariepinus* were affected by smoking rather than antimicrobial treatments; these findings align with some studies while contradicting others. For instance, this result agrees with findings of Oparaku and Mgbenka (2012), who reported that smoke drying, affects protein concentration. The findings also agree with

the findings of Oyeleye (2003), who reported that post-harvest handling using ginger, garlic, and turmeric has some anti-oxidative effects on rancidity manifestations of smoked *C. gariepinus,* as evident in the current study, which is further sustained by Akintola *et al.* (2013) that lipid increases with heat processing resulting from reduction in moisture content.

Lipid levels reported in this study were lower in salt-cured samples (15.00 ±5.00) than those reported by Ogbonnaya and Shaba (2009), who reported 21.2% lipid for *C. gariepinus*. However, Treatments 5 and 6 presented values 21.00±1.00 and above 20 and 30 g concentration, which is considered high according to Ndife *et al.* (2019).

The use of various spices in this study at 20 g concentration combined with smoking in T1, T2, T3, T4, T5 significantly reduced moisture to 9% with no significant differences after storage; the result corresponded with the acceptable level as prescribed by Codex Alimentarius Standard (2013), which also indicated that storage did not affect the nutrient composition with the use of spices.

The high ash value of smoked *C. gariepinus* in the current study may be due to the low moisture recorded, which may be connected to the heating effect of the smoking process. This account agrees with those of Ndife *et al.* (2022), who reported that smoking significantly increased ash in sun-dried *C. gariepinus.*

Fish species with more than 20% lipid content are considered lipidic (high lipid value) (Ndife *et al.,* 2019). Reports have it that lipid increases with heat processing, resulting from a reduction in moisture content (Akintola *et al.,* 2013). Lipid levels reported in the current study (18 to 19%) were lower than those reported for *C. gariepinus*; for instance, Ogbonnaya and Shaba (2009) reported 21.2% lipid content for *C. gariepinus.*

The significant ash content at lower concentrations could be due to mineral-rich components in treatments like turmeric and ginger.

Conclusion

To prevent post-harvest losses, the effectiveness of natural spices as preservatives on the proximate quality of smoked *C. gariepinus* was investigated, and the result indicated that moisture was highest in T7 at 30 g and lowest in T1 at 30 g concentrations, and ether extract was highest in T5 at 10 g concentration. Protein was highest in T5 at 30 g concentration, while the highest NFE was recorded in T6 at 10 g. Therefore, the treatments as used in the present study did improve the proximate composition of smoked *C. gariepinus*, however, T1 performed better considering its moisture reduction capability, while T5 had better performance considering the high protein value effect.

Recommendations

With high reduction in moisture contents and high protein values observed in this study, it is therefore recommended that *C. gariepinus* be cured using natural spices. These findings suggest that spices (ginger, garlic, and turmeric as well as combined ginger and turmeric) are suitable for use as value added enhancer in the processing and preservation of *C. gariepinus* post-harvest.

1. It is recommended that fish post-harvest handlers use ginger at 20 g concentration to achieve a firm texture as well as better taste enhancement.
2. For low moisture content as well as slowed spoilage, salt should be used at 30 g concentration per one litre of water for curing per 5 kg *C. gariepinus,* while spices (ginger and turmeric) should be used at 20 g concentration.
3. Awareness programme on beneficial uses of these spices for public use should be funded by the Government through the extension officers in government parastatals or non-governmental organisations (NGOs).
4. Fish post-harvest handling should be taken seriously by fish handlers in order to prevent wastage and economic loss.
5. Further research should be conducted on the phytochemical and therapeutic properties of these spices on fish post-harvest handling, as well as an investigation of factors and their combinations in order to attain an established microbial quality of smoked fish under similar settings.
6. Further research on the effectiveness of canning the products to create an assorted range of smoked fish products on the shelves should be conducted.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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