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Original Article

Proximate composition and cost benefit analysis of smoked *Clarias gariepinus* and *Oreochromis niloticus* treated with some natural spices

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A B S T R A C T

This study evaluated the impact of smoking combined with natural spices (salt, clove, garlic, and ginger) on the nutritional value and profitability of Clarias gariepinus and Oreochromis niloticus. The fish samples undergo hot smoking after treatment with the spices, and data were analyzed using one-way ANOVA at a significance level of $p<0.05$. Result from proximate composition of Clarias gariepinus showed a moisture range of 4.59-57.20%, ash 7.32-16.08%, fat 7.61-13.94%, crude protein 25.72-53.13%, nitrogen-free extract 2.15-17.26%, and dry matter 42.80-95.41%. Similarly, the result obtained from Oreochromis niloticus showed a moisture range of 3.57-55.5%, ash 9.39-17.96%, fat 6.30-10.27%, crude protein 24.62-49.25%, nitrogen-free extract 5.14-23.46%, and dry matter 44.50-96.43%. The profitability results of Clarias gariepinus and Oreochromis niloticus indicated the total variable cost of production for all items incurred is ₦13,650 and ₦10,650, respectively. The total revenue generated per 1 kg of smoked Clarias gariepinus ranges from ₦10,000-₦10,630 (T1-T4), while ₦7,500-₦8,050 (T1-T4) were generated from the price of smoked Oreochromis niloticus. The benefit cost ratio (BCR) obtained from the treatment was 3.278 T1, 2.912 T2, 3.156 T3, 3.181 T4, and T1 ₦3.260, T2 ₦2.775, T3 ₦3.128, T4 ₦3.163. Return on investment (ROI) for Clarias gariepinus ranges from ₦1.912-₦2.278 per ₦1 invested, whereas for Oreochromis niloticus it was ₦1.775-₦2.260 per ₦1 invested, respectively. Conclusively, incorporating spices before smoking enhances both the nutritional quality and profitability of Clarias gariepinus and Oreochromis niloticus. While salt yielded the highest profit, ginger and garlic offered better nutrient profiles.

K E Y W O R D S : *African catfish, Nile tilapia, Profitability, Proximate analysis, Smoking, Spices*

INTRODUCTION

Fish is a relatively affordable source of protein and vital nutrients needed in human diets. It serves as a source of animal protein for numerous Nigerians, with an estimated annual per person fish consumption of 13.3 kg in 2013 (FAO, 2017). Fish is prone to spoilage at room temperature, which often encourages bacterial activity, enzymes, and chemical fat oxidation post-capture (Nur *et al.*, 2020). Nigeria makes up approximately 30-50% of fish postharvest losses due to inadequate handling (Kuley *et al.*, 2017). Spices are consumable plant substances that have anti-oxidant, antiseptic, and bacteriostatic qualities. They are incorporated into foods to postpone the onset of spoilage, like rancidity, and serve as seasonings to enhance the flavor of the foods (Kefas *et al.*, 2022).

African catfish is one of the popular freshwater fish in the world (Marimuthu *et al.*, 2017; Ayoola & Bamiro, 2017), and this species has been cultured intensively and extensively in Nigeria

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(Adeniyi *et al.,* 2021). In Nigeria tilapia is one of the most important cultured fish. Today, *Oreochromis niloticus* has become the shining star of aquaculture with many farms beginning and others expanding as consumption rate increases across the globe (Fitzsimmons, 2005; Ogello *et al.,* 2014). Due to high rate of post-harvest loses caused by biochemical processes and improper handling, adequate studies on post-harvest and effective handing methods are essential to reduce the spoilage rate and increase profitability, hence this study was conducted to evaluate the effect of some spices on the nutrient composition of smoked African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus)* and its profitability. The study therefore seeks to answer the following research question.

Is there any difference in nutrient composition between and treated and untreated smoked fish?

What is the difference in profitability between smoked fish treated with different spices

MATERIALS AND METHODS

Study Area

The study was conducted at the teaching and research fish farm of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Federal University Dutse, Jigawa state which is located on the latitude 11° 42' North and longitude 9° 22' East and altitude of 436m above sea level (Compass, 2024). It is within the Sudan Savannah agro-ecological zone of Nigeria and is characterized by dry climate which starts from October to May; cold dry climate starting from November to February and hot dry climate during March to May. The rainy season usually begins from June to September with mean annual rainfall of 638mm per annum (Climate-data, 2024), relative humidity of 15 to 20% (City-population, 2024) and atmospheric temperature of 27.1ºC and can reach up to 41ºC during April and May and may fall below 20ºC during December and January (Climate-data, 2024).

Fish Sample Collection and Preparation

A total of 43 and 52 fresh samples of each *Clarias gariepinus* and *Oreochromis niloticus* with average body weight of 268g for *C. gariepinus* and 108g for *O. niloticus* and average standard length of 25.7cm and 12.4cm were procured from the landing site of Kafin Gana reservoir, Birnin Kudu Local Government Area, Jigawa state in the early morning hours (8am) in two different icebox containers and transported to the laboratory of teaching and research fish farm of the Department of Fisheries and Aquaculture, Federal University Dutse, Jigawa state were gutted, cut along side by side, washed to remove external dirt. The fish samples were then soaked in a saline solution for about 30 mins after which the solution was drained out and the samples fish where then divided into treatments respectively.

Spices Preparation and Application

The natural spices; clove, garlic and ginger were purchased from Dutse Ultra-Modern Market, Jigawa State. The spices were crushed into powdered form using local mortar and pestle. Twenty grams (20g) of each grounded spices were weighed using a sensitive scale (Digital pocket scale BP-N Series, with 7 weighing modes), and added to the already brined fish treatments namely: T1 salt (control), T2 (clove), T3 (garlic) and T4 (ginger) respectively. The samples were mixed properly and allowed to stand for 30 minutes on a wire mesh sieve before smoking, this is to enable ample time for the penetration of the treatments into the fish samples. Each batch of the treatments was smoked differently in a smoking kiln. The departmental traditional smoking kiln was used for the smoke-drying process, it was made from a 400l drum with 90cm length and 58 cm diameter. The drum was midway cut and the base was used as a combustion chamber with a fire fox of 22 × 22 cm². It has four chambers with carrying capacity of 30-50 fish. The firing section of the kiln was filled with hardwood to produce smoke. The stem of Ebony (*Diospyros ebenum*) tree was use as firewood. Fish sample was then introduced into the smoke house. The temperature of the smoking chamber was maintained between 60 and 70°C by adjusting the firewood burning in the earth. The treated fish was smoked for 4 to 5 hours and allowed to cool overnight (Iheanacho *et al.,* 2017).

Samples for proximate composition, organoleptic tests and microbial load was selected from each treatment and separately packaged in polyethylene bags, labelled according to their respective treatments T1, T2, T3 and T4, sealed (to prevent dust, dirt and flies) and stored under a room temperature for six (6) months.

Experimental Design

The experiment consisted of four (4) treatments, namely: T1 (salt as control), T2 (clove), T3 (garlic), and T4 (ginger), with three (3) replicates each and allocated in a completely randomized design (CRD).

Determination of Proximate Composition

Proximate composition was carried out before and after processing according to the standard methods described by the Association of Official Analytical Chemist (AOAC, 2006).

Cost and Benefit Analysis of the Study

Cost Benefit Analysis (CBA) which assesses the profitability of production system was used to CBA estimates profits that can reasonably be expected or accrued from a unit of investment. A comparative assessment was estimated for the cost and benefits accruable from smoked fish that is not treated with spices and smoked fish that is treated with spices. The analysis was estimated using the following relation;

Gross Margin = TR – TVC (1)

Where; TR = Total Revenue, TVC = Total Variable Cost;

The cost components included were; cost of smoked fish, cost of packaging, cost of firewood, transportation cost, cost of ginger, cost of garlic, and cost of clove.

Profitability index

$$\text{Gross ratio} = \frac{Total\ variable\ cost}{Total\ revenue} \quad (2)$$

$$\text{Benefit Cost Ratio} = \frac{Total\ revenue}{Total\ variable\ cost} \quad (3)$$

BCR is break even, > than 1 indicate profitable venture, < one indicates loss

$$\text{Return on invested (ROI)} = \frac{Gross\ margin}{Total\ cost} \quad (4)$$

Statistical Analysis

Data obtained were subjected to a one-way analysis of variance (ANOVA) using SPSS (Statistical Package for Social Science version 27.0). Duncan's multiple range test was used to compare the differences among individual means at P= 0.05.

RESULTS AND DISCUSSION

Proximate Composition of *Clarias gariepinus*

Table1 presents the proximate composition of *Clarias gariepinus*, showing a significant difference ($p<0.05$) between the means across the parameters. Moisture content was highest in the fresh sample (57.20±0.26%) and lowest in T4 (ginger) at 4.59±0.03%. Ash content was highest in T1 (salt) at 16.08±0.19% and lowest in the fresh sample (7.32±0.43%). Lipid content reached its maximum in T2 (clove) with 13.94±0.23%, while the fresh sample recorded the lowest fat content (7.16±0.04%). The crude protein percentage was significantly ($p<0.05$) highest in T1 (salt) at 53.13±0.88% and lowest in the fresh sample (25.72±0.76%). The maximum nitrogen-free extract (NFE) value was recorded in T4 (ginger) at 17.26±0.05%, whereas the minimum NFE percentage was observed in the fresh sample (2.15±0.02%). Overall, the results indicate a significant ($p<0.05$) difference across the four treatments.

Table1: Proximate composition of fresh and smoked *Clarias gariepinus*

	Treatments				
Parameters	**Fresh**	**T1 (Salt)**	**T2 (Clove)**	**T3 (Garlic)**	**T4 (Ginger)**
Moisture	57.20±0.26^{a}	6.03±0.11^{c}	6.77±0.06^{b}	4.79±0.03^{d}	4.59±0.03^{d}
Ash	7.32±0.43^{d}	16.08±0.19^{a}	15.15±0.99^{b}	14.67±0.27^{b}	13.44±0.32^{c}
Fat	7.61±0.04^{c}	13.84±0.11^{a}	13.94±0.23^{a}	12.11±0.18^{b}	12.21±0.29^{b}
Crude protein	25.72±0.76^{d}	53.13±0.88^{a}	50.31±0.00^{c}	51.41±0.00^{b}	52.50±0.00^{ab}
NFE	2.15±0.02^{d}	10.93±1.08^{c}	13.85±0.40^{b}	17.03±0.48^{a}	17.26±0.05^{a}
Dry matter	42.80±0.026^{d}	93.97±0.11^{b}	93.23±0.06^{c}	95.21±0.03^{a}	95.41±0.02^{a}

Mean value within the same row with similar superscripts are not significantly different ($p>0.05$).

Proximate Composition of *Oreochromis niloticus*

Table 2 indicates the proximate composition of *Oreochromis niloticus*, showing significant variations across the treatments. The highest moisture content was recorded in the fresh sample (55.55±0.62%), while the lowest was observed in T4 (ginger) at 3.57±0.04%. Ash content was significantly higher ($p<0.05$) in T1 (salt) at 17.96±0.26%, with the fresh sample recording the lowest value (9.39±0.24%). Lipid content was highest in T4 (ginger) at 10.27±0.20% and lowest in the fresh sample, which had a fat percentage of 6.30±0.10%. A significantly ($p<0.05$) higher crude protein concentration was observed in T3 (garlic) at 49.25±0.00%, while the lowest concentration was found in the fresh sample (24.62±0.79%). Nitrogen-free extract (NFE) was highest in T4 (ginger) at 23.46±0.41%, with the fresh sample showing the lowest percentage (5.14±1.44%). Dry matter content was also highest in T4 (ginger) at 96.43±0.04%, followed closely by T3 (garlic) at 96.22±0.14%, while the fresh sample recorded the lowest value (44.50±0.62%).

Table 2: Proximate composition of fresh and smoked *Oreochromis niloticus*

	Treatments				
Parameters	**Fresh**	**T1 (Salt)**	**T2 (Clove)**	**T3 (Garlic)**	**T4 (Ginger)**
Moisture	55.55±0.62^{a}	5.54±0.21^{b}	5.25±0.20^{b}	3.78±0.14^{c}	3.57±0.04^{c}
Ash	9.39±0.24^{d}	17.96±0.26^{a}	16.34±0.19^{b}	15.09±011^{b}	14.57±0.18^{c}
Fat	6.30±0.10^{d}	8.30±0.21^{c}	8.56±0.30^{c}	9.26±0.06^{b}	10.27±0.20^{a}
Crude protein	24.62±0.79^{c}	48.69±0.79^{b}	46.31±0.81^{b}	49.25±0.00^{a}	48.13±0.00^{a}
NFE	4.14±1.44^{c}	19.51±1.76^{b}	23.44±0.03^{a}	22.62±0.04^{ab}	23.46±0.41^{a}
Dry matter	44.50±0.62^{c}	94.46±0.21^{b}	94.75±0.20^{b}	96.22±0.14^{a}	96.43±0.04^{a}

Mean value within the same row with similar superscripts are not significantly different ($p>0.05$).

Cost benefit analysis of *Clarias gariepinus.*

The cost benefit analysis of the treated and untreated *Clarias gariepinus* was presented in Table 3. The results of the analysis shows that the total variable cost for the smoked fish was ₦13,650, with a total cost for untreated sample T1 (salt) ₦3,050 while for the treated samples, the total costs incurred were ₦3,650 for T2 (clove), ₦3,250 for T3 (garlic), and ₦3,200 for T4 (ginger). The variable costs of production included fish transportation, firewood, salt, packaging materials, clove, garlic, and ice (Table 3). The total revenue generated per kilogram of smoked *Clarias gariepinus* was ₦10,000 for T1, ₦10,630 for T2, ₦10,260 for T3, and ₦10,180 for T4. However, the gross margins were ₦6,950, ₦6,980, ₦7,010, and ₦6,980 for T1, T2, T3, and T4, respectively. The gross ratios were computed also as follows: 0.305 for T1, 0.343 for T2, 0.316 for T3, and 0.314 for T4. The Benefit-Cost Ratio (BCR) for each treatment was ₦3.278 for T1, ₦2.912 for T2, ₦3.156 for T3, and ₦3.181 for T4. These values indicate that fish processing is profitable across all treatments. Nevertheless, Treatment 1 (T1) recorded the highest profit ratio (₦3.278), while T2 (clove) had the lowest profit ratio (₦2.912). The result shows that to every ₦1 invested in treated smoked *Clarias gariepinus* business, ₦2.278, ₦1.912, ₦2.156 and ₦2.181 were received as profit respectively.

Table 3: Cost benefit Analysis of *Clarias gariepinus*.

Item ₦	**Cost ₦**	**T1 (Salt)**	**T2 (Clove)**	**T3 (Garlic)**	**T4 (Ginger)**
African catfish	10,000	2500	2500	2500	2500
Cost of salt	200	50	50	50	50
Package	200	50	50	50	50
Firewood	500				
Transportation	1400	350	350	350	350
Cost of ginger	150	-	-	-	150
Cost of garlic	200	-	-	200	-
Cost of clove	600	-	600	-	-
Cost of ice	400	100	100	100	100
Total cost	**13650**	**3050**	**3650**	**3250**	**3200**
Weight of smoked dried fish (kg)	4.0	1.0	1.0	1.0	1.0
Total revenue of smoked fish at ₦ 10,000 per kg	**41,070**	**10,000**	**10,630**	**10,260**	**10,180**
Gross margin	27,420	6950	6,980	7010	6980
Gross ratio	0.332	0.305	0.343	0.316	0.314
Benefit cost ratio	3.008	3.278	2.912	3.156	3.181
ROI	**2.008**	**2.278**	**1.912**	**2.156**	**2.181**

Source: Field survey, 2024

Cost benefit analysis of *Oreochromis niloticus*

Table 4 shows the profitability of treated and untreated *Oreochromis niloticus*. The analysis reveals that the total variable cost for the untreated smoked *Oreochromis niloticus* (T1, control) was ₦2,300. The treated samples incurred total costs of ₦2,900 for T2 (clove), ₦2,450 for T3 (garlic), and ₦2,500 for T4 (ginger), with a total cost of ₦10,650. The variable costs included the cost of fish, transportation, firewood, salt, packaging, ginger, clove, garlic, and ice. The gross margin for all treatments was ₦20,470. Additionally, the total production costs were ₦5,200, ₦5,150, ₦5,320, and ₦5,300 for T1, T2, T3, and T4, respectively. The total revenue generated from the market price of smoked *Oreochromis niloticus* was ₦7,500, ₦8,050, ₦7,820, and ₦7,750 for every 1 kg of T1, T2, T3, and T4, respectively. The gross ratios were calculated as 0.306 for T1, 0.360 for T2, 0.319 for T3, and 0.316 for T4. The Benefit-Cost Ratio (BCR) for each treatment was ₦3.260 for T1, ₦2.775 for T2, ₦3.128 for T3, and ₦3.163 for T4. Also, the result of Return on Investment (ROI) indicated that T1 (salt) had the highest ROI wit ₦2.260 followed closely by T4 with ₦2.163 meanwhile T3 had an ROI of ₦2.128 while T2 recorded the lowest ROI of ₦1.775, making it the least profitable treatment.

Discussion

Proximate Composition of *Clarias gariepinus* and *Oreochromis niloticus*

The results of proximate composition shown in table 1 and 2 showed that there is significant difference (p>0.05) between the treatments. Moisture content decrease after the fish sample undergo the addition of some spice and smoking process. This agrees with the work of Tahiluddin *et. al.*, (2022) who reported that Nigerian smoked catfish species has 7.16-10.71% moisture content, 33.66-66.04% protein, 1.58-6.09% fat and about 9.12-12.16 % ash content. This report was within the range in terms of moisture and protein content and differ with the range of fat and ash content.

Table 4: Cost benefit analysis of *Oreochromis niloticus*

Item ₦	Cost ₦	T1 (Salt)	T2 (Clove)	T3 (Garlic)	T4 (Ginger)
African catfish	7,000	1750	1750	1750	1750
Cost of salt	200	50	50	50	50
Package	200	50	50	50	50
Firewood	500	-	-	-	-
Transportation	1400	350	350	350	350
Cost of ginger	150	-	-	-	150
Cost of garlic	200	-	-	200	-
Cost of clove	600	-	600	-	-
Cost of ice	400	100	100	100	100
Total cost	**10,650**	**2,300**	**2,900**	**2,500**	**2,450**
Weight of smoked dried fish (kg)	4.0	1.0	1.0	1.0	1.0
Total revenue of smoked fish per kg	**31,120**	**7500**	**8050**	**7820**	**7750**
Gross margin	20,470	5,200	5,150	5,350	5,300
Gross ratio	0.342	0.306	0.360	0.319	0.316
Benefit cost ratio	2.922	3.260	2.775	3.128	3.163
ROI	**1.922**	**2.260**	**1.775**	**2.128**	**2.163**

Source: Field survey, 2024

The high protein contents and high fat contents obtained in this study concurs with the study of Oromadike (2015), who reported high protein contents and semi high oil contents in wild African catfish *Chrysichthys nigrodigitatus* (Lacepede, 1802). The finding of this research is also in accordance with the reports of Ayeloja *et al.,* (2015) who stated that there was significant difference ($p<0.05$) in the percentage of crude protein contents of the differently spiced hot-smoked catfish. The control (smoked catfish without spices) recorded the highest protein content with a mean value of 79.44%. The garlic ginger spiced smoked catfish had the lowest percentage crude protein content of 75.69%. This result showed clear reduction of moisture content from the fresh sample as compared to the treated samples ($P< 0.05$) due to smoking process, which is in line with the findings of Ajai *et. al.,* (2019), who reported the use of salt together with either sun drying or smoking could significantly reduce moisture as well as spoilage of fish and from the action of enzymes and bacteria. Moisture content is an important attribute in food processing and preservation because many biochemical and physiological changes depend very much on it (Ndife *et al.,* 2022). The ash content of the smoked dried sample increased as compare to unsmoked sample which is similar to the works of Paul *et. al.,* (2021). Chibuezeh *et al.,* (2022) stated that fat increases with heat processing resulting for reduction in moisture content, this is in line with the finding of the present study, which also shows an increment in fat content from fresh to smoked untreated and treated sample. Chukwu (2009) reported fat level as 28.0% while Chukwu & Shaba, (2009) reported 21.2% fat for Kiln dried Tilapia (*Oreochromis niloticus*) and Catfish (*Clarias gariepinus*) respectively. This differs with the level fat in this study which reported 13.94 for catfish and 10.27 for tilapia. Msusa *et al.,* (2017) reported (49.5%) for whole fish and sundried catfish (57.43-62.34 %) this varied slightly with finding of this report (53.13±0.88) for smoked *Clarias gariepinus* (49.25±0.00) for smoked *Oreochromis niloticus*. It is widely reported by (Oparaku and Mgbenka, 2012) that smoke drying increases protein, attributed to concentration in the proteins resulting from dehydration, these is in consonant with this study. Meanwhile, Jummai (2016) reported that the proximate composition of *Clarias gariepinus* as follows; moisture content of the smoked samples as 66.8%, ash content which ranged from 5.7% to 5.9%, fat content from 4.5% to 4.8% and crude protein which also ranged from 22.8% to 24.8%. This disagrees with the finding of this research which show the moisture content from 6.77% to 4.59%, ash 16.08% to 13.44%, fat 13.94% to 12.11% and crude protein 50.31% to 53.13%. According to the finding of Gaber (2000), the normal ash, moisture, and lipid content of *Oreochromis niloticus* meat should be 2.6%,78.9 ± 0.5%, giving a dry matter value of 21.1 ± 0.5% and 2.75 ± 0.16%, this was not in line with this study. Base on the report of Aberoumad & Pourshafi (2010) they stated that the lower the percentage of water, the greater the lipid content on the species, and it's agreed with the end result of this finding. Bolawa *et al.,* (2011) documented the proximate composition of *Oreochromis niloticus* as follows; lipid content 18.6%, protein content 38.19%, moisture content 27.66%, ash content 1.76%, carbohydrate content 10.41 %, and crude fibre content 3.38 %. This disagreed with the finding of this study. The investigation of Olapade *et al.* (2013) shows the proximate composition of crude protein of *Oreochromis niloticus* as 47.69%, lipid content 10.21%, ash 1.53%, moisture 38.36%, this finding slightly agreed with this study on the percentage of crude protein 49.25%, lipid 10.27% and significantly differenced on ash content14.57% and moisture 5.54%.

Cost benefit analysis of *Clarias gariepinus* and *Oreochromis niloticus*

The cost benefit analysis of the treated and untreated *Clarias gariepinus* and *Oreochromis niloticus* is presented in (Table 3 and 4). The result of the analysis shows that *Clarias gariepinus* incurred a total cost of ₦13,650 and a total revenue of ₦40,000. Similarly, for *Oreochromis niloticus* the total cost was ₦10,650 while the total revenue realized was 30,000. These result shows that although all the species are profitable but *Clarias gariepinus* was more profitable based on ROI of 2.008 which is greater than that obtained from *Oreochromis niloticus* 1.922. This reveal that the fish processing business generates enough revenue in excess of operating cost used in the business. This result agrees with the finding of Musa and Ala (2013), in their research they reported that respondents consume any form of catfish of their choice regardless of their income. However, the processing and distribution activities of smoke-drying catfish were found to be profitable as estimated. This result is in agreement with the findings of Kwaghe, (2008) who opined that profitability of business is one driving motivational factors that attract people to any particular venture. The result on ROI presented in (Table 3), indicates that for every ₦1 invested in the smoking business of *Clarias gariepinus* generated ₦2.278, ₦1.912, ₦2.156 and ₦2.181 for T1, T2, T3 and T4 respectively were received as profit and, ₦2.260 T1, ₦1.775 T2, ₦2.128 T3 and ₦2.163 T4 from the business of *Oreochromis niloticus* as presented in Table 3 and 4 respectively. This finding is slightly lower than that of Onogwu *et al*., (2019) who reported ROI of 3.06, this result is plausible because Singh and Bagga, (2019) posited that the capital structure of a firm has a significant and positive impact on the level of profit realized; hence, a higher investment in assets will result to higher output with a resultant increase in net-income. This result corroborates with the findings of Olaleye *et al.,* (2019) who also stated that smoked fish is highly profitable if efficiently managed.

CONCLUSION AND RECOMMENDATION

The study concluded that the addition of the spices (clove, garlic, ginger) prior to smoking affect the nutrient composition of the fish sample species by enhancing the nutrient content and also have the potency of decreasing moisture content which in turn can delay spoilage. Spices used in this study shows positive result but garlic proof to be more effective. This is followed by ginger and clove with least effect. The findings also concludes that the additions of spices to the smoking process is profitable with great return. The use of natural spices particularly ginger should be recommended to fish processors because of its advantage in nutritional value and cost effectiveness. Furthermore, analyzing consumer preference, among different kind of fish treated with spices should be conducted to observe the most preferred spice by the consumer.

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Authors' Contributions

FH managed data collection, interpretation of data, writing of manuscript, MAH conceived the idea, provided material support, and review of the manuscript, AHW managed the literature searches, and development of methodology, UBZ provided support on data analysis, MMA managed profitability analysis, UY provided support on data collection. All authors read and approved the final manuscript.

Ethical Statement

This research was approved by the institutional Animal care and use committee (IACUC) of Federal University Dutse. The approval was based on the approved scientific research protocols of the National Veterinary Research Institute (NVRI) and the Federal Ministry of Agriculture and Rural Development (FMARD), and all the local and/or international animal welfare laws, guidelines and policies for the care and use of animal.

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