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COMPARATIVE ASSESSMENT OF THE EFFECT OF SOME LOCALLY AVAILABLE SPICES IN EXTENDING THE SHELF LIFE OF SMOKED CATFISH *(Clarias gariepinus)* IN MAKURDI, NIGERIA

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Abstract

A comparative assessment of the effect of three locally available spices - garlic (*Allium sativum*), uziza seeds (*Piper guineense*) and ginger (Zingiber *officinale*) - on the sensory quality, microbial load and nutritional quality of smoked *Clarias gariepinus* was conducted in this study. Fifty fresh catfish were obtained from Wadata market in Makurdi, cleaned, degutted and divided into four treatments: T1 (control), T2 (garlic), T3 (uziza) and T4 (ginger). Each spice (50g) was grinded, mixed with 1 litre of water and used to soak the fish for 1 hour before smoking in a drum kiln. The smoked samples were packaged in polythene materials and stored for eight weeks. Sensory evaluation was carried out by a ten-member panel using a 5-point hedonie scale. Microbial assessment was done through total viable, coliform and fungal counts using pour plate techniques. Proximate analysis was conducted using standard AOAC methods. Data were analyzed using ANOVA at $P > 0.05$. Results showed that spice treatments significantly improved sensory qualities compared to the control, ginger having the highest score for all attributes except flavor (4.40±1.4), while uziza ranked first in flavor (4.90±0.94). Microbial counts increased in all treatments after storage, but garlic (T2) recorded the lowest total viable (14.00±0.11d*), coliform (6.00±0.38h*) and fungi counts (0.00±0.00*), indicating superior antimicrobial activity. Proximate composition showed increase in moisture content in all treatments after storage. There was no significant change in protein, ether extract and NFE in the treated samples compared to the control. In conclusion, ginger, garlic and uziza seeds significantly improved the nutritional quality, sensory attributes and shelf life of smoked *C. gariepinus*. Ginger is recommended for overall acceptability and quality retention, while garlic is recommended for microbial control.

Keywords: *Clarias gareipinus*, Local spices, Proximate composition, Shelf life

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INTRODUCTION

Fish is globally recognized as one of the most valuable sources of animal protein, supplying not only high-quality protein but also essential fatty acids, vitamins and minerals that are critical for human growth and health (Hosseini *et al*., 2021). Among the different species of fish, the African catfish (*Clarias gariepinus*) is very popular because it grow fast, can survive in many environments, and is affordable for consumers (Adeyeye, 2015). It also provides a good source of income for farmers and traders. However, one major problem with catfish and other fish is that they spoil very quickly after been harvested. This is because fish has a lot of water, soft tissue and unsaturated fats, which make an ideal environment for bacteria, enzymes and chemical reactions that cause spoilage (Adeyeye, 2015; Ayeloja *et al*, 2020).

Fish processing and preservation is a critical intervention aimed at extending the storage life of fish and transforming it into forms that are appealing to customers (Tawari and Abowei, 2011). There are several preservation methods widely utilized, notably those involving the control of temperature through chilling or freezing, the reduction of water activity via drying, salting, and smoking, as well as the application of preservatives.

In Nigeria, smoking is the most common preservation method particularly among artisanal processors who lack access to cold storage facilities (Obi and Oke 2019). Smoking reduces the moisture in fish, adds flavor, and helps to slow down spoilage. It also makes transportation and storage easier. Even though smoking improves the shelf life of fish, smoked fish can still spoil, especially when it is stored for long periods in hot and humid conditions. Microbial contamination, rancidity of oils, reabsorption of moisture and loss of nutrients still occur (Adeyeye, 2015; Ayeloja *et al*., 2020), compromising product safety and consumer acceptability (Effion and Abaye, 2020; Nwiyi *et al*., 2021). These challenges have pushed researchers and processors to look for additional methods that can support smoking and make smoked fish last longer while keeping it quality.

In recent years, there has been growing interest in the use of natural preservatives from plants as alternatives to synthetic chemicals, which are often associated with health concerns and reduced customer acceptance. Plant-derived spices such as garlic (*Allium sativum*), ginger (*Zingiber officinale*), cloves (*Syzygium aromaticum*), uda (*Xylopia aethiopica*) and uziza seeds (*Piper guineense*) has long been recognized for their antimicrobial and antioxidant properties making it a promising natural preservative (Nwachukwu *et al*., 2020) and safer alternatives (Ubadire-Agua *et al*., 2023). They are rich in phytochemicals such as alkaloids, flavonoids, tannins, polyphenols, essential oils (Okeke *et al*., 2021; Eze and Agbo, 2018), offering potential benefits in extending the shelf life of food products and improving their oxidative stability (Patciro *et al*., 2021). This study investigated the effect of using ginger, African black pepper and garlic in extending the shelf life of smoked *C. gariepinus* in laboratory condition.

MATERIALS AND METHODS

Collection and Processing of *Clarias gariepinus*

Fifty (50) fresh samples of *Clarias gariepinus* were purchased from fishmongers in Wadata Market, Makurdi. All samples were transported in an ice-packed to the zoology laboratory of the Department of Biological Sciences, Rev. Fr. Moses Orshio Adasu University, Makurdi. The fish samples collected were weighed to determine its average mean weight, washed in clean water to eliminate traces of sand and dirt, degutted (Olopade *et al.*, 2023) and divided into respective treatments. Each treatment contained 10 samples of fish and was replicated twice.

Preparation of Spices and Application

Natural fresh garlic (*Allium sativum*), uziza seeds known as African black pepper (*Piper guineense*) and ginger (Zingiber *officinale*) were purchased from Wadata Market in Makurdi, Benue state. The spices were washed with clean water, sun-dried for 7 days and grounded into powder using a mortar and pestle according to Fauzlyya *et al*., 2024. Fifty grams (50 g) of each spices was weighed using a digital weighing balance and assigned as treatments: T_2 (garlic), T_3 (uziza), and T_4 (ginger). T_1 (0 g) was represented as the control in which no spice was used. Each of the weighed spices were mixed separately with 1 liter of water to form aqueous solutions of the different treatments. The fish were submerged into the solution of the different treatments with each treatment consisting of 10 pieces of fish. They were allowed to stand for 1 hour before transferring to the Kiln for processing.

Fish Processing Procedure

The fish samples were processed using Drum Kiln. The drying rate or moisture loss was measured at the end of the dying process, there was frequent checking of the fish in other to take precaution against charring of the fish product until the fish was completely smoked and dried. The fish were then allowed to cool at an ambient temperature before they were packaged using a polyethylene leather for preservation. The samples were stored for eight weeks.

Organoleptic/Sensory Evaluation

Samples for organoleptic test were taken from each treatments and subjected to panel tests. A panel of 10 judges, where selected at random to assess the samples. The performance of judges towards these products was tested using hedonic scale. The qualities assessed were: color, odor, taste, flavor and acceptability. A 4-point hedonic Scale (5 = excellent, 4 = very good, 3 = good, 2= fair, 1 = poor). Each quality attribute was evaluated separately.

Proximate Analysis of samples

The proximate analyses of all the samples for crude protein, crude fiber, ether extracts, moisture, ash contents and nitrogen free extract were determined as described by AOAC (2015).

Microbial Analysis

One gram of the sample from each treatment was cut and weighed using a digital weighing balance (Metler, PM4800). Each weighed sample was transferred into a sterile mortar and pestle. They were separately macerated and put into the sterile test tubes containing sterilized water (10 ml). The samples were homogenized to prepare the stock suspension. 1 ml of the stock was serially transferred to six test tubes each containing 9 ml diluents of peptone water, one at a time of repeated succession up to the sixth test tube to obtain 10^{-7} dilution. Dilutions of 10^{-2}, 10^{-4} and 10^{-5} were selected for each of the fish treatments. A pour plate method was used for each of the serially diluted sample and was also prepared by using approximately 20.0ml of nutrient agar. Samples were incubated at 370C for 24 hours. The colonies were counted for total viable counts and was recorded as log 10 Colony Forming Units, CFU/g (Olusola, 2021). Potatoes Dextrose Agar was used for total fungi count while Macon key Agar was used for the total coliform count.

Data Analysis

Data collected was subjected to ANOVA. Results were presented using mean and standard error of means and expressed in figures. A P-value of less than 0.05 was considered statistically significant.

RESULTS

Sensory Evaluation of *Clarias gariepinus* smoked with garlic, uziza seeds (African black pepper) and ginger.

The result revealed significant differences in most sensory attributes, including appearance, taste, flavor, smell, and general acceptability. However, texture showed no significant difference **(P>0.05)**. The appearance of the smoked fish significantly

differed among treatments (**P<0.05**). The highest was recorded for **T4 (5.80±0.97)**, followed by **T2 (5.10±1.27)**, while **T3 (4.40±0.70)** had a moderate score. The lowest appearance was for **T1 (3.20±1.03)**.

Taste was significantly influenced by ginger extract concentration **(P<0.05)**. The best taste was observed in T4 **(5.00±0.85)**, followed by **T3 (4.10±2.00)**. The lowest was recorded in **sample T1 (control)**. Flavor was significantly affected **(P<0.05)**. **Sample with ginger extracts** had the best flavor, followed by **uziza**, while garlic had a moderate rating. The lowest flavor was recorded in **T_1**. The smell of the smoked fish also showed significant differences among treatments (**P<0.05**). The best was observed in **T_4** followed by T_3 while the lowest smell rating was recorded in T_1. Texture did not show a statistically significant difference (**p>0.05**), indicating that the application of ginger extract had minimal impact on the smoked fish. General acceptability, which represents the overall preference for the smoked fish, varied significantly among treatments (**P<0.05**). The most accepted sample was T_4, followed by T_3 **while the** lowest was T_1 (Table 1).

Microbial Counts of *Clarias gariepinus* Smoked with Garlic, Uziza Seeds and Ginger.

The total viable count (TVC), total colony count (TCC) and total fungi count (TFC) of fish samples smoked with different treatments of garlic, uziza seeds and ginger showed a significantly higher TVC, TCC and TFC after storage at the different treatments (P<0.05). It was also observed that lower microbial growth was significantly noted at T_2 (garlic) treatment compared to the other treatments at P<0.05 (Table 2).

Proximate Composition of *Clarias gariepinus* smoked with Garlic, Uziza Seeds and Ginger

The proximate composition of *Clarias gariepinus* fish smoked with spices before and after storage showed the moisture content was significantly higher after storage across all treatments (P<0.05) (Table 3). T4 was also observed to have significantly lower moisture content after storage (P<0.05).

The protein content was observed to decrease significantly after storage at T1 (P<0.05). No significant difference was however observed both before and after storage at T2, T3 and T4 (P>0.05). Similar results were observed for the ether and NFE parameters respectively. The result further showed that fish smoked with ginger had higher protein and NFE contents, higher ash content at T1 and higher ether at T2.

Table 1 Sensory Evaluation of *Clarias gariepinus* Smoked with Garlic, Uziza Seeds and Ginger

Treatment	Appearance	Taste	Flavor	Smell	Texture	General acceptability
T1(control)	3.20 ± 1.03^{a}	3.50 ± 1.08^{c}	2.90 ± 0.99^{d}	2.70 ± 0.82^{d}	4.70 ± 0.95	2.10 ± 0.74^{d}
T2(garlic)	5.10 ± 1.27	3.20 ± 1.14^{c}	3.50 ± 1.18^{c}	3.20 ± 1.03^{c}	4.40 ± 1.07	3.70 ± 0.67^{c}
T3(uziza)	4.40 ± 0.70^{a}	4.10 ± 2.00^{b}	4.90 ± 0.94^{b}	4.10 ± 1.75^{b}	4.30 ± 1.16	4.10 ± 1.60^{b}
T4(ginger)	5.80 ± 0.97^{a}	5.00 ± 0.85^{a}	4.40 ± 1.4^{a}	5.00 ± 0.84^{a}	4.40 ± 0.97	5.30 ± 0.95^{a}
P-Value	0.090^{NS}	0.001	0.003	0.010	0.100^{NS}	0.000

Values are mean ± standard deviation. Means in the same column with different superscripts differ significantly* (p<0.05**)

NS = No significant difference

Table 2: Microbial Load of *Clarias gariepinus* Smoked with Garlic, Uziza seeds and Ginger

	TVC		TCC		TFC	
Treatment	**Before storage**	**After storage**	**Before storage**	**After storage**	**Before storage**	**After storage**
T_1(control)	31.00±0.44*	165.00±3.30**	22.00±0.72*	46.00±0.76^{e}**	2.00±0.07**	12.00±0.03^{i}*
T_2 (garlic)	7.00±0.47**	14.00±0.11d*	0.00±0.00**	6.00±0.38^{h}*	0.00±0.00*	0.00±0.00*
T_3 (uziza)	22.00±0.59*	34.00±0.81^{b}*	10.00±0.08	19.00±0.3^{f}**	2.00±0.13*	8.00±0.13^{j}**
T_4 (ginger)	12.00±0.07*	32.00±0.78^{c}**	6.00±0.20*	10.00±0.38^{g}*	0.00±0.00*	6.00±0.25^{k}*
P- value		0.000		0.000		0.000

Values are Mean ± Standard Deviation. Mean Values with similar alphabets in a column, and similar superscripts at each treatment for each parameter are not significantly different.

KEY:
TVC = Total viable count
TCC = Total coliform count
TFC = Total fungal count

Table 3: Proximate Composition of *Clarias gariepinus* Smoked with Garlic, Uziza seeds and Ginger

Treatment	Moisture		Protein		Ash		Fiber		Ether		NFE	
	BS	AS	BS	AS	BS	AS	BS	AS	BS	As	BS	AS
T_1(Control)	9.42±0.64*	14.67±0.55**	42.38±0.91**	33.20±1.00^{de}*	8.74±0.18*	12.80±0.58g*	0.00±0.00	0.00±0.00	14.18±0.00**	12.54±0.01i*	25.17±50*	21.89±0.51m*
T_2 (garlic)	10.42±0.55**	13.67±16ab*	41.78±0.51*	37.20±0.99d*	6.74±0.66**	11.23±1.00h*	0.00±0.00	0.00±0.00	12.29±0.84*	12.89±0.37i*	12.89±0.24*	27.01±0.47n*
T_3 (uziza)	10.86±0.17**	12.85±0.14b*	39.65±0.27*	36.66±0.58^{e}*	8.90±0.31	9.06±0.48f*	0.01±0.00	0.01±0.00	11.64±0.56**	10.76±0.11j*	28.95±0.37	30.66±0.14l*
T_4 (ginger)	9.06±0.27*	10.67±0.42c*	43.63±.017	40.45±1.07e*	7.66±0.14**	9.10±0.11f*	0.01±0.00	0.01±0.00	9.09±0.20*	8.98±0.14k*	30.56±0.42*	30.79±0.27l*
P-Value		0.00200		0.019		0.002				0.000		0.000

* Values are Mean ± Standard Deviation. Mean Values with similar alphabets in a column, and similar superscripts at each treatment for each proximate parameter are not significantly different.

KEY:
BS = before storage
AS = after storage
NFE = Nitrogen Free Extract

DISCUSSION

The Sensory Evaluation revealed that ginger (*Zingiber officinale*), uziza and garlic were more acceptable in terms of appearance, taste, flavor smell and general acceptability than the control. However, texture remained unaffected. The high value in appearance at T_4**,** agrees with the findings of Venkateshwarlu et al., (2014)**,** who reported that natural plant extracts, particularly ginger, enhance the coloration and surface texture of smoked fish, making it more visually appealing. Ginger contains antioxidants that may help in preserving the color of smoked products, preventing excessive darkening due to oxidation (Daramola *et al*., 2007). The lower appearance score in the control sample suggests that the absence of ginger may lead to excessive oxidative browning, as observed by Akinwumi (2011)**.** Taste was significantly enhanced by all the spices, with the ginger sample having the highest value. This agrees with Ime-Ibanga and Fakunle (2008)**,** who reported that gingerol, the active compound in ginger, imparts a characteristic spicy-sweet taste that enhances the palatability of food products. Flavor, which is a key determinant of consumer preference, significantly influenced by *uziza.* This is consistent with the findings of Negbenebor (1999)**,** who observed that *uziza* enhances the flavor and taste of *C. anguillaris*. The moderate flavor rating in the 50g sample suggests that a lower concentration may not be sufficient to impart a distinct flavor improvement.

The lower value in **smell** and flavor at T_2 compared to the ginger and *uziza* treatments may be due to strong garlic flavor, which some consumers may find overpowering. Similar observations were reported by Ogunleye and Akinyemi (2020), who noted that excessive use of spices can affect taste preference. The lowest smell rating in the control sample suggests that the absence of spice allows for stronger undesirable odors. Akinwumi, (2011), reported that ginger extract helps in masking fishy odors by reacting with trimethylamine (TMA), a compound responsible for the characteristic fishy smell.

The result of the microbial assessment showed increase in microbial load after storage across all treatments. This may be attributed to the fact that low concentration of the spices may not be sufficient to inhibit microbial load. This observation supports the work of Ibrahim *et al*. (2020), who reported that inadequate spice concentration leads to weak antimicrobial action. This also agrees with reports that natural spices reduce microbial loads in stored smoked fish, with higher concentrations or more effective systems giving stronger inhibition (Abdullahi and Bello, 2023; Olusola, 2021; Oshimagye *et al*., 2023). The lowest microbial count recorded in garlic samples indicated garlic was more effective in reducing microbial growth. This agrees with the findings of Adegoke *et al*., (2019), who reported that garlic significantly reduces bacterial and fungal growth in smoked fish due to the presence of allicin, a natural antimicrobial compound.

The general pattern of high protein as the dominant dry matter agrees with findings for smoked *C. gariepinus* and related products (Abdullahi and Bello, 2023; Ajibare *et al*., 2023). The slight protein decrease at some treatments after storage resembles previous observations where storage of certain botanical reductions, often linked to denaturation or oxidative and handling changes (Abdullahi and Bello, 2023). In this study, the relative stability of protein at T_3 and T_4 parallels reports in which spices or extract treatments did not drastically compromise protein content, thereby preserving nutritional quality (Abdullahi and Bello, 2023; Ajibare *et al*., 2023; Olusola, 2021). The increase in ash content at some treatments after storage is compatible with reports that plants extract or spice treatments can slightly increase ash content by contributing minerals (Ndoye, 2024). Ether extract and NFE showing limited change or slight increase with storage also echoes results where spice-treated smoked fish retained acceptable lipid and carbohydrate fractions over several weeks (Ajibare

et al., 2023; Dawi *et al*., 2025; Olusola 2021; Oshimagye *et al*., 2025).

CONCLUSION

This study assessed the effect of garlic (*Allium sativum*), *uziza* seeds (*Piper guineense*) and ginger (*Zingiber officinale*) in extending the shelf life of smoked African catfish (*Clarias gariepinus*) stored under ambient conditions. The findings from the sensory evaluation revealed that smoked fish treated with spices was generally acceptable to consumers compared to the control. Ginger treated samples recorded the highest for appearance, taste, smell and general acceptability. *Uziza* seeds treatment ranked second, and was particularly noted for enhancing flavor. The low scores observed in the untreated samples confirmed that the absence of spices resulted in poorer sensory qualities and development of fishy odors. Of the spices evaluated, garlic had the higher potential to extend shelf life of smoke fish, though the difference was not statistically significant. The microbial assessment demonstrated that total viable count, total coliform count and fungal count increased in all the treatments after storage. However, fish treated with spices had lower microbial loads compared to untreated sample (control). Garlic was the most effective in inhibiting microbial growth, indicating the strong antimicrobial phytochemicals present in garlic. Ginger and uziza also suppressed microbial growth compared to the control, but were less potent than garlic. This confirms that natural preservatives can slow down spoilage and extend shelf life. The proximate composition showed that moisture content increased significantly after storage in all treatments, but ginger treated samples had the lowest moisture uptake, suggesting better resistance to reabsorption. Protein content decreased significantly in the control after storage, while ginger, garlic and *uziza* samples maintained relatively stable protein levels, indicating a protective effect against protein denaturation and oxidation. Overall, the study finds that adding spices considerably increases the shelf life, enhances quality and preserves the nutritional content of smoked catfish.

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