Assessment of Onion Juice and Chaff as Preservative Efficiency on Smoked *Clarias gariepinus*

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Abstract

Onion (Allium cepa) derivatives contain bioactive compounds with antioxidant and antimicrobial properties that may improve product quality. This study evaluated the effects of onion juice (OJ) and onion chaff (OC) on the sensory, proximate, and microbial characteristics of smoked Clarias gariepinus to assess their performance in enhancing fish quality. Onions weighing 1kg were washed and blended to a paste, the pulp was transferred through a muslin cloth (1mm mesh-size) to obtain the juice by squeezing, leaving the chaff as a waste residue Thirty freshly harvested C. gariepinus (average weight 1kg) were divided into three groups of ten fish, each treated with OJ, OC, and untreated controls. All samples were smoked using a modified smoking kiln and stored at room temperature for eight weeks. Proximate composition, microbial characteristics and sensory attributes were analysed using standard procedures. Results indicated that OC-treated fish recorded higher proximate values, which differed significantly ($p<0.05$) from those of OJ-treated samples. Protein content decreased slightly across treatments, from 62.38% to 60.25% (OC), 60.09% to 58.05% (OJ), and 59.43% to 55.84% (control), while ash and moisture contents increased. Sensory evaluation revealed higher scores for OJ-treated fish in taste (7.90), appearance (8.05), aroma (7.80), texture (7.80), and overall acceptability (8.10) compared to OC-treated fish. Microbial organisms isolated showed varied characteristics. These findings suggest that onion derivatives enhance the sensory, nutritional, and microbial properties of smoked fish. Onion juice performed slightly better than onion chaff, suggesting its potential as a natural quality enhancer for smoked C. gariepinus.

Keywords:
Fish-preservative, Microbial isolates, Onion-chaff, Onion-juice.

Introduction

The preservation of perishable foods, particularly fish, remains a significant concern, as fish begin to deteriorate almost immediately after being harvested from their natural environment. According to Zolfaghari et al. (2010), consumers are now opposing the use of synthetic compounds in the preservation of fish products. Plants are excellent sources of phytochemicals, which can serve as replacements for synthetic additives (Haghparast et al., 2011). Processing fish with food-grade spices can increase the storage period and improve fish acceptability in the market (Sotolu et al., 2017). Demir et al. (2018) reported that onions are consumed globally and widely used in various cuisines for food preparation.

The preservation of fish after harvest remains a lingering challenge. Available local methods may be utilised to prevent postharvest losses in fish (Onuoha, 2018). The non-affordability of modern fish processing in Nigeria has led fisherfolk to use smoking and drying methods, which have helped reduce postharvest losses and enhance the storage of fish for marketing and consumption (Jega et al., 2018). Plants, especially vegetable spices, possess natural preservatives with antimicrobial and antioxidant properties that can be used as functional food in the shelf-life extension of products with high moisture

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content, serving as alternatives to synthetic preservatives (Jega et al., 2018; Mei et al., 2019).

Value addition through fish smoking is a vital strategy for improving the fisheries sector and the overall economy. It increases income for fish producers, creates employment opportunities, reduces losses, and enhances export potential. By investing in improved smoking technologies, packaging, and market linkages, countries can transform fish processing from a subsistence activity into a profitable and sustainable enterprise that drives economic growth, enhances food security, and promotes rural empowerment. According to the FAO (2023) and NBS (2023), Nigeria produces between 1.4 and 1.8 million metric tons of onions annually from an estimated 150,000 to 200,000 hectares of cultivated land.

Onion (*Allium cepa*) has been considered a good source of functional, healthy food with various medical benefits. Its leaves (Jega et al., 2018), skin peel (Ifesan, 2017; Berdenicek et al., 2019), and juice are also beneficial. Marination of meat products in OJ for value addition has proven to be a preservative with microbial and retardation of biochemical changes of fresh product, thus enhancing shelf-life extension (Demir et al., 2020), which could be adopted for preservation of fish products (Ige et al., 2021). Onion skins and chaff are rich in phenolics and flavonoids (much higher concentration than edible bulb), so they're widely studied for conversion into value-added extracts such as antioxidants, antimicrobials, nutraceutical ingredients, and natural colourants (Celano et al., 2021; Paesa et al., 2022). Onion juice and extracts exhibit antimicrobial and antioxidant properties that have been tested in food preservation and as food-grade additives. Balogun et al. (2023).

According to Haghparast et al. (2011), sensory analysis is consumer-centred in determining the acceptability of food products. Ali et al. (2022) posited that fish preservation is inherently important if fish product freshness is to be sustained over a period, while any technique used should prevent microbial spoilage, delay the deterioration process, and enhance nutritional content with improvements in sensory characteristics. Sule et al. (2023) noted that waste from onion marketing and processing can be put to functional utilisation in food preservation. Previous studies have primarily focused on techniques for extracting onion oil from onion skins, the utilisation of raw, dried onion skins (Sule et al., 2023), and the application of conventional refrigeration methods. However, these approaches are not commonly practised in Africa, where fish preservation is predominantly achieved through smoking. This statement is crucial because it helps identify the research gap, as it highlights that most existing studies have explored other preservation techniques (such as onion oil extraction and refrigeration), rather than the method relevant to the African context. The present study justifies this by pointing out that fish smoking is a standard preservation method in Africa, which establishes the need for a study that aligns with local practices. This research assessed the proximate composition of onion juice and chaff, identified the microbial flora on smoked *C. gariepinus* processed with onion juice and chaff, and its effect on nutritional and sensory quality characteristics.

Materials and Methods

Fish processing

The processing was conducted in line with the method described by Sule et al. (2022), with slight modifications. Thirty samples of fresh farmed *C. gariepinus*, each weighing 1kg, were purchased from IDIPR Eriwe, Ijebu Ode, Ogun State, Nigeria. The fish were divided into three treatments, with 10 fish per treatment. The fish were degutted, washed off their slime, and drained. Onions weighing 1kg were purchased from the Oke Aje market in Ijebu Ode, washed, and blended into a paste using an electric kitchen blender (Binatone: BLG 699) with no addition of water. The juice from the blended onion was obtained by transferring it to a muslin cloth with a 1mm mesh size, and the juice was squeezed out, leaving the chaff as a waste residue. The fish were gutted, and one treatment was dipped into the juice for 10 minutes. The chaff was rubbed on other treatments, while the third group served as the control without a preservative. The three treatments were smoked using a metallic drum smoking kiln for 8 hours, and stored for 8 weeks at room temperature.

Laboratory analysis

The smoked fish were taken to the Animal Biochemistry Laboratory at the University of Ibadan for analysis. In the laboratory, the following analyses were conducted: proximate analysis (crude protein, ash, ether extract, crude fibre, and carbohydrate), assessment of antinutritional factors in onion juice and chaff, and determination of the proximate composition of the initial and final fish samples, following the official methods of analysis as outlined by the AOAC (2000).

Determination of protein content

Protein was determined using the Kjeldahl method, as described by AOAC (2000). Two milligrams of each sample was weighed into a Kjeldahl flask, and 5 grams of anhydrous sodium sulfate was added. Also, 1 g of copper sulfate and selenium was added. Twenty-five millilitres of concentrated sulfuric acid and five glass beads were introduced. The sample was heated gently at first; the heating was increased with occasional shaking until the solution assumed a green colour. Distilled water was used to wash down the mouth and neck of the flask after cooling. The solution was reheated gently at first, and then the heating was increased until the assumed green colour disappeared. It was then allowed to cool.

Determination of ash content

The procedure involves weighing 2 g of a dried sample into a previously dried and weighed dish. The sample was placed on a plate with the crucible in the fume cupboard to char the organic matter. The dish was transferred into a muffle furnace maintained at 600 °C for 6 hours to completely ash the samples. The dish was directly transferred to a desiccator, cooled, and weighed immediately.

Ether extract

A dried sample (2 g) was extracted with petroleum ether (4 - 60 °C) in a Soxhlet apparatus to remove the ether-soluble component present in it. The extracted material was dried to a constant weight in an oven at 70 ^{o}C.

Determination of crude fibre content

Two grams of sample and one gram of asbestos were put into 200 mL of 1.25% H_2SO4 and boiled for 30 minutes. The solution and the content were poured into a Buchner funnel equipped with muslin cloth and secured with an elastic band. This was allowed to filter, and the residue was then put into 200 mL of boiled NaOH, and boiling continued for 30 minutes. It was transferred to a Buchner funnel, filtered, and then washed twice with petroleum ether. The residue obtained was put in a clean dry crucible and dried in the moisture extraction oven to a constant weight. The dried crucible was removed, cooled, and weighed. The difference in weight (i.e., loss in ignition) was recorded as crude fibre and expressed as the percentage crude fibre.

Determination of carbohydrate

The carbohydrate content was determined by difference. This was done by subtracting the total of (100 – (% M + % CP + % EE + % CF + % Ash).

M= Moisture content
CP= Crude protein content
EE= Ether extract
CF=Crude fibre content
Ash=Ash content

Antinutritional analysis

Analysis of anti-nutrients in the juice and chaff was conducted according to the following methods of Marcano & Hasenawa (1991), listed below:

Phenols: Distilled water 2 mL to which extract of 1 mL is added along with ferric chloride (10%) in 5 drops. The formation of blue or green colour indicated the presence of phenols.

Flavonoids: 1 mL NaOH aqueous solution to which the extract of 1 mL was incorporated, with observation for the yellow-orange formation.

Tannin content: Acetone (70%) was used to extract the sample. An aliquot of extract was mixed with Folin-Ciocalteau reagent, Na_2CO3 (10%), and incubated at room temperature for 40 minutes. Extract was measured at 700 nm for absorbance, while Tannic acid equivalents were used to express tannin content as g/100 g.

Saponin content: Extract 1 mL of the sample into a graduated flask, adding 5-10 mL of distilled water with agitation for 15 minutes. Saponin is said to be present in the solution when a 1 cm layer of foam is formed.

Glycosides: Extract of 2 mL is mixed with glacial acetic acid (1 mL) and $FeCl_3$ (5%) with the addition of 3 drops of conc. H_2SO_4. A greenish-blue colour indicated the presence of glycosides.

Oxalate determination by the titration method

A 250 mL flask with a sample of 2 g in 190 mL of distilled water suspension, to which was added 10mL of 6M HCl and digested at 100 °C for 1 hour, followed by cooling and filtration after it was made up to the volume of the flask. Filtrates in duplicate beakers, portions with the addition of 4 methyl red indicator drops. With the addition of NH_4OH in a dropwise manner, the solution changes from a pink colour to a faint yellow. Both portions were heated to 90 °C, allowing the ferrous ion precipitate to be removed after cooling and filtration. Filtrates were again heated to 90 °C with the addition of 5% $CaCl_2$ in a 10 mL solution

under constant stirring. The solution was heated to 25 °C and left overnight; then, it was centrifuged for 5 minutes at 2500 rpm. The supernatant was decanted, and the precipitate was entirely dissolved in 10 mL of a 20% H_2SO_4 solution.

Terpenoids: Extract sample (5 mL) to which $CHCl_3$ (2 mL) is added in a test tube, and

Followed by careful addition of concentrated H_2SO_4 (3 mL) to the mixture to form a layer of reddish-brown colouration, which indicates that a terpenoid constituent was present.

Phytates: Extract 1 g of sample with 10 mL of TCA (3%) and precipitate phytate as ferric phytate with 0.1% ammonium ferric sulfate. The ferric phytate is converted to ferric hydroxide and sodium phytate with the addition of 10 mL of 0.5M sodium hydroxide. The solution is then boiled. Precipitate is dissolved with dilute acid.

Microbial isolates identification

The method of Afolabi et al. (2020) was adopted for microbial identification and characterisation. Nutrient agar and commercial media solution prepared according to the instructions were autoclaved for 15 minutes at 121 °C to sterilise the media solution. Separately weighed fish samples of 1 g were aseptically macerated. Samples were placed in a test tube with 9 mL of distilled, sterile water to a dilution of 10^{-1} and mixed thoroughly by shaking. The solutions were further diluted to 10^{-3}. Samples of 1 mL of the 10-3 solution were pipetted with syringes into petri dishes containing molten agar media with inocula. The petri dishes were then evenly swirled to mix the agar and the organism. The media plates were left to solidify, then inverted and incubated for 24 hours at 27 °C. Obtained colonies were further sub cultured to get a pure culture of the organism using freshly prepared nutrient agar, mannitol salt agar, and cetrimide agar media. The colonies were further incubated for 24 h at 37 °C to obtain a pure culture, which was then identified accordingly.

Organoleptic analysis

A total of twenty (20) well-trained panelists were randomly selected, as per Sule et al. (2023b). The samples were prepared and served. A hedonic scale, ranging from 1 to 9, was used to score samples for sensory quality, where a score of 9 represented "extremely liked" and a score of 1 represented "extremely dislike". (9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely)

Statistical analysis

The experiment employed a Completely Randomised design with three treatments, and one-way analysis of Variance (ANOVA) was used for data analysis. A significant difference was identified using the Duncan Multiple Range Test in SPSS (version 23) for all indices obtained.

Results and Discussion

Proximate analysis of onion juice and onion chaff.

The proximate analysis of onion juice and onion chaff (Table 1) differed significantly ($p<0.05$) in the analysed parameters. All parameters analysed were higher in OC than in OJ.

Table 1: Proximate analysis and anti-nutrients of onion juice and onion chaff.

Variables	Onion juice (%)	Onion chaff (%)
Crude protein	1.29±0.02^b	4.84±0.08^a
Ash	0.65±0.02^b	2.65±0.05^a
Ether extract	0.14±0.01^b	1.71±0.03^a
Crude fibre	0.00±0.00^b	11.08±0.27^a
Moisture content	83.08±0.14^a	33.18±0.22^b
Carbohydrate	14.84±0.05^b	46.54±0.34^a
Antinutritional Factors (%)		
Phenol	0.009±0.00^b	0.012±0.00^a
Flavonoid	0.002±0.00^b	0.003±0.00^a
Tannin	0.001±0.00^b	0.002±0.00^a
Saponin	0.009±0.00^b	0.013±0.00^a
Glycoside	0.006±0.00^b	0.014±0.00^a
Oxalate	0.006±0.00^b	0.011±0.00^a
Xanthone	0.003±0.00^b	0.007±0.00^a
Terpenoid	0.002±0.00^b	0.003±0.00^a
Coumarin	0.003±0.00^b	0.008±0.00^a
Phytate	0.009±0.00^b	0.012±0.00^a

The values are the means ± SD, with different notation (a and b) along the same column indicating a significant difference at the 5% level of significance.

The use of any plant or animal sample for food-grade inclusion must be preceded by an analysis of its composition, including nutritional status, phytochemical parameters, amino acid profile, mineral and vitamin content, and fatty acid profile. This will enable the best judgment to be made regarding its utilisation as a functional food, without any health implications for humans and livestock. Haghparast et al. (2011) noted that the concentration of phenolic compounds in onion juice increased with increasing concentration of the onion juice. According to Mei et

al. (2019), who reported that plant extracts possess antimicrobial activities with combined effects in crude extracts that contain polyphenols and flavonoids, which disrupt the cellular content and membranes of microorganisms. The antinutritional factors reported here are lower than the reported values by Sule et al. (2023a) for onion peel waste. Sule et al. (2023b) reported crude protein, 4.40%; fibre, 11.45%; and ether, 1.15% in onion peel waste, similar to onion chaff. Likewise, antinutritional factors in juice and chaff are lower compared to the values reported for two varieties of onion peel (Sule et al., 2025), while protein, carbohydrate, and fat are higher than for red onion peel; fibre and ash are lower than those reported by Sule et al. (2025). This revealed that the different parts of a plant will possess different nutritional parameters.

Proximate analysis of smoked *C. gariepinus* specimen

The results of proximate analysis of smoked *C. gariepinus* preserved with onion juice and onion chaff are presented in Table 2 below. The initial fish samples analysed revealed that, in their fresh state, the composition was superior to the final composition.

Table 2: Proximate analysis of Smoked *C. gariepinus* Preserved with Onion Juice and Onion Chaff

Variables	Initial fish			Final fish		
	Control	Fish with OJ	Fish with OC	Control	Fish preserved with OJ	Fish preserved with OC
Crude protein %	59.43±0.93^{c}	60.09±0.01^{b}	62.38±0.17^{a}	55.84±0.37^{e}	58.05±0.49^{d}	60.25±0.21^{b}
Ash %	12.08±0.27^{b}	11.07±0.05^{c}	10.20±0.14^{d}	12.41±0.04^{a}	11.65±0.07^{bc}	10.97±0.09^{cd}
Ether extract %	8.63±0.02^{a}	8.06±0.22^{b}	8.50±0.14^{ab}	7.64±0.08^{bc}	7.25±0.07^{c}	7.80±0.14^{b}
MC %	15.32±1.08^{c}	15.14±1.20^{c}	12.20±0.42^{d}	18.99±0.24^{a}	15.83±5.56^{b}	12.20±0.42^{d}

The values are the means ± SD, with different notation (a and b) along the same column indicating a significant difference at the 5% level of significance. OJ: Onion juice, OC: Onion chaff, MC: Moisture content

In this study, onion juice and chaff were used as fish preservatives in smoked *Clarias gariepinus.* Variations in the nutrient composition of fish, as noted in Table 2, agree with Ayandiran et al. (2021), who observed that such variations are common even within the same fish species, while noting that fish protein content is high. According to Rathod and Pagarkar (2013), processing methods decrease the protein content due to changes in the physical and chemical nature of the fish, thereby resulting in protein denaturation. Onuoha (2018) also reported a reduction in moisture content during hot smoking. There was a drop in the protein content of the fish in the course of the experiment. This reduction in protein content could be due to the action of enzymes and heat, which alter or denature the protein content of the fish. It is noted that protein decreases with increasing storage time. Furthermore, Berdenicek et al. (2019) demonstrated that yellow and red onion skin waste reduces ether extract in raw and cooked pork, accompanied by a decrease in moisture as the concentration increases from 10% to 20%. While Mei et al. (2019) stated that smoke treatment could stabilise fish muscle during frozen storage.

Masood et al. (2020) noted that a high concentration of onion powder increased the fibre, protein, and ash content of bread, with a trend. The proximate analysis result from the current study was higher than that reported by Olanrewaju et al. (2022) when the smoked catfish was initially analysed. This might be due to the extent of smoking, which reduced the moisture content to 15.32% compared to 23.49% in Olanrewaju et al. (2022). Additionally, when catfish was treated with onion oil (1.5 mL/kg), a commercially marketed product was used. In another study, Sule et al. (2023b) reported a decrease in protein while ash increased. Nurhayati et al. (2024) reported that, after fermentation with onion powder, pepper, and lime juice, the protein, fat, and ash content of the experimental shrimp decreased in all samples. In contrast, carbohydrate and ash increased after a 10-day fermentation period, with the red pepper powder treatment having the best nutrient composition among the treatments.

Organoleptic scores of smoked *C. gariepinus* specimen

Assessment of the organoleptic scores (Table 3) revealed that, despite storage, the control fish was preferred over the fish preserved with onion chaff. Organoleptic indices showed a range of (5.65 and 8.10), showing panelists accepted the samples with a significant difference ($p<0.05$) noticed between fish samples. It is worth noting that fish preserved with onion juice had the highest score compared to other samples.

Table 3: Organoleptic scores of smoked *C. gariepinus* preserved with onion juice and onion chaff.

Sample	Taste	Appearance	Aroma	Texture	Acceptability
Control fish sample	7.60±1.10[a]	7.70±1.17[a]	7.55±1.32[a]	7.85±1.18[a]	7.80±1.01[a]
Fish with onion juice	7.90±1.86[a]	8.05±0.89[a]	7.80±1.61[a]	7.80±1.36[a]	8.10±1.17[a]
Fish with onion chaff	5.75±2.34[b]	6.30±1.75[b]	5.85±1.81[b]	6.05±1.82[b]	5.65±1.93[b]

The values are the means ± SD, with different notation (a and b) along the same column indicating a significant difference at the 5% level of significance. (9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely)

Panelists' reports revealed the acceptability of both products, with a mean score of at least 5.65 for the examined indices. Comparatively, the sensory assessment qualities of fish samples revealed that fish preserved with onion juice were preferred over fish preserved with onion chaff and control fish with respect to the assessed indices. This agrees with Oyewole et al. (2006), who noted that brining fish and applying heat from wood to smoke fish increases the shelf life. Zolfaghari et al. (2010) studied the use of onion juice and reported that organoleptic characteristics decrease with time. The application of 4% onion juice concentration showed the best result, followed by lower concentrations up to 18 days at 4 °C in refrigerated storage. Similarly, Haghparast et al. (2011) reported refrigeration at 4 °C of onion juice and tea extract on fish fillets, stored at 5% for up to 8 days. Sensory analysis revealed that the addition of a high volume of onion juice (>1%) gained the interest of the panelists. Furthermore, Shinde et al. (2015) reported that the acceptability of pomegranate peel extract was 17 days, green tea extract 16 days, and untreated fish acceptability at 8 days. They also stated that even in cold storage, changes in the physical and sensory quality of fish occur.

Ucak et al. (2019) noted that extracts from onion peel (OPE) can enhance the storage of rainbow trout in refrigerated conditions. Onuoha (2018) stated that treatment with a higher level of spice resulted in more extended storage with better shelf life and sensory qualities compared to lower juice concentration. In their experiment with Onion top leaf extract (OTLE), Jega et al. (2018) found that sensory evaluation indicated a significant effect ($P<0.05$) of OTLE on all sensory indices tested, except for consumer acceptability, after the third week of storage. The sensory analysis results of this study were comparable to those of pork patties, with no significant difference between the control fish and fish preserved with onion juice (Berdnicek et al., 2019). Ucak et al. (2019) noted that 10% OPE gave the best sensory analysis, followed by 5%, and the least was in the control. This indicates that with an increase in OPE, the sensory quality and storage period of rainbow trout fillets were extended to 6-8 days. The values obtained for taste and overall acceptability are similar to those reported by Demir et al. (2020), who noted that onion juice has a tenderising effect on food hardness due to the presence of proteolytic enzymes in the juice.

Masood et al. (2020) incorporated OPE and onion powder into bread. Extract of onion peel at 1% scored best in all sensory characteristics, while 7% powder scored the least. The assessment in our study was higher in all treatments for sensory quality than that reported by Olanrewaju et al. (2022), who reported lower values for sensory parameters. The difference between the two studies was due to the nature of the product experimented with, as Olanrewaju et al. (2022) studied the effect on fresh smoked fish, while our study focused on smoked dried fish stored for 8 weeks. Sensory analysis of control and onion juice in this study aligned with control of onion peel waste (OPW) (Sule et al., 2023b), but was different from onion chaff, with the lowest score, but not below the score of 5.

Microbial characteristics and Isolates

The characteristics of microbes on smoked *C. gariepinus*, as presented in Table 4, included Gram stain, shape, and various identification tests that were used to identify these bacterial species. *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Micrococcus acidophilus* bacterial isolates were obtained from *C. gariepinus* in control fish samples, fish preserved with onion juice, and fish preserved with onion chaff, respectively. The identification tests showed that all bacterial isolates produced methyl Red, hydrolysed gelatin, and hydrolysed starch. The *S. aureus* and *P. aeruginosa* isolates were found to be catalase-positive, but *M. acidophilus* was found to be coagulase-negative. The result also revealed that *S. aureus* and *P. aeruginosa* exhibited a positive reaction to the coagulase test. In contrast, the *M. acidophilus* isolate was negative for the coagulase test. Moreover, *S. aureus, P. aeruginosa,* and *M. acidophilus* were found to be negative to the Urease test.

Table 4: Characteristics of microbes on smoked *C. gariepinus.*

TREATMENTS		Gram Stain	Shape	Motility	Catalase	Oxidase	Coagulase	Urease	Indole	Methyl Red	Voges-Proskaer	Gelatin [illegible]	Starch Hydrolysis	Casein Hydrolysis	Citrate Hydrolysis	Pigmentation	H_2^S production	O_2 Relationship	Fructose	Sucrose	Lactose	Mannitol	Arabinose	Xylose	Dulcitol	Raffinose	Glucose	Maltose	Adonitol	Saccharose	Probable Identification (see Table 5)
Week 0	TRT 0	+	C	–	+	–	–	–	–	–	+	+	+	+	+	+	+	AN	A	A	A	A	A	A	A	A	A	A	A	A	*E. coli .....*
	TRT 1	+	R	–	+	–	–	–	–	–	+	+	+	+	+	+	+	A	A	A	A	A	A	A	A	A	A	A	A	A	*S. faecium ....*
	TRT 2	+	SR	–	–	+	–	+	–	–	+	–	–	+	–	–	–	AN	A	A	A	A	A	A	A	A	A	A	A	A	*Aeromonad spp*
Week 8	TRT 0	+	S	+	+	+	–	–	+	+	–	+	+	–	–	–	–	A	A	A	A	A	A	A	A	A	A	A	A	A	*S. aureus .....*
	TRT 1	+	R	–	+	–	+	–	–	+	+	+	+	+	+	+	+	A	A	A	A	A	A	A	A	A	A	A	A	A	*P. aeruginosa ...*
	TRT 2	+	C	–	–	+	–	–	+	+	+	+	+	+	+	+	+	A	A	A	A	A	A	A	A	A	A	A	A	A	*M. acidophilus ..*

Where: TRT = Treatment, TRT0 = Control fish sample, TRT1 = Fish preserved with onion juice, TRT2 = Fish preserved with onion shaft AN = Anaerobic organism, C = cocci, A = Aerobic organism, R = rod, S = spherical

Table 5 presents the microbial diversity found in smoked *C. gariepinus* in various samples.

Table 5: Microbial isolates on smoked *C. gariepinus*

Sample ID	Microbial isolates
Control fish sample	*Aeromonas spp, Pseudomonas aeruginosa, Bacteroides amylophilus, Staphylococcus aureus, E. coli, Micrococcus spp, and Streptococcus faecium.*
Fish with OJ	*Staphylococcus aureus, Penicillium spp, Aeromonas spp, Proteus vulgaricus, Streptococcus faecium, Klebsiella aerogens.*
Fish with OC	*Pseudomonas aeruginosa, E. coli, Bacillus subtilis, Aspergillus tamarind, Staphylococcus aureus, Clostridium welchi.*

Afolabi et al. (2020) reported that the microbial flora of importance is abundant in the culture media and persists on the fish at harvest and throughout the value addition process. The microbial identification test (Table 4) conducted on the test fish revealed the presence of various microbial flora, as reported by Osakue et al. (2016). Accordingly, the detection of pathogenic spoilage microbes is a significant health concern to consumers, as it can lead to foodborne diseases. CFS (2014) reported the occurrence of *P. aeruginosa*, indicating that contamination might have originated from water or during packaging. When *E. coli* is present in high levels in a food product, it may be a result of inadequate hygiene during handling and storage, or both. While the occurrence of *P. vulgaris* is associated with inadequate cooking or contamination after processing (CFS 2014).

In ice storage, Shinde et al. (2015) reported that Indian mackerel treated with pomegranate peel and green tea contained *E. coli* and *S. aureus* in the samples. When Ifesan (2017) stored meat for 9 days using OPW, it was reported that the extract possessed an antibacterial effect against the proliferation of isolates. Onuoha (2018) stated that garlic allowed for the expression and absence of certain microorganisms on fish. It revealed that the presence of *E. coli, Klebsiella spp.,* and *Fusarium spp*. was absent after the application of garlic treatment, while *Aspergillus spp.* Increases in percentage during storage, which lasted for 28 days. Moosazad et al. (2019) revealed the inhibitory effect of OPE on the bacterial growth of *S. aureus* and *E. coli* at increasing concentrations. While Sagar & Pareek (2020) noted that onion peel (both white and red) inhibits the growth of bacteria, including both gram-positive and gram-negative flora, on fish. Similarly, Phan et al. (2021) reported that onion juice inhibited bacterial growth, and that 3% OPE reduced lipid oxidation in refrigeration at 4 °C and -18 °C for 4 weeks, while the extract was not effective on samples without temperature reduction.

In comparison with improved smoked catfish, Ige et al. (2021) found *S. aureus, A. niger,* and *A. flavus* among the organisms isolated. Durojaiye et al. (2021) identified *S. aureus* in marketed smoked frozen fish, indicating that spoilage microbes can be present in any processed fish. According to Ali et al. (2022), the use of cinnamon oil at a 0.1% immersion concentration and pure lemon oil on fish muscle decreases microbial flora and increases shelf life, as well as quality. Sule et al. (2022) noted that onion chaff was more effective in reducing microbial load than onion juice. This can be attributed to the chaff's ability to serve as a barrier to the proliferation of microbes on the fish. At the same time, the juice has undergone a chemical reaction within the fish, allowing some microbes to grow. Sule et al. (2023a) reported that OPW reduced the microbial load on smoked catfish over an eight-week period. The similar microbial flora isolated in this research corroborated those reported by the authors mentioned, except for *C. botulinum*, which Zolfaghari et al. (2010) stated to be the most feared microorganism in fish. Balogun et al. (2023) reported that Onion extract reduced the growth of the tested microorganism on meat, noting that Gram-positive bacteria are more susceptible to onion and garlic extract than Gram-negative strains.

Conclusion

The study demonstrated that the application of onion juice and chaff significantly influenced the quality performance of smoked *Clarias gariepinus*. Both treatments improved the proximate composition and enhanced sensory attributes compared to the untreated control. Among the two forms, onion juice showed slightly superior effects on nutritional and sensory qualities, while onion chaff also produced acceptable results. Therefore, onion by-products can serve as effective natural enhancers of the nutritional and

organoleptic quality of smoked fish, indicating the potential use of Onion juice and chaff as a functional food for marketing.

References

Afolabi, O. J., Oladele, O. O., & Olususi, F. C. (2020). Assessment of bacterial loads of *Clarias gariepinus* (Burchell, 1822) obtained from cultured and natural habitats. *The Journal of Basic and Applied Zoology, 81*, 32. https://doi.org/10.1186/s41936-020-00168-w

Ali, A., Wei, S., Ali, A., Khan, I., Sun, Q., Xia, Q., Wang, Z., Han, Z., Liu, Y., & Liu, S. (2022). Research progress on nutritional value, preservation and processing of fish—A review. *Foods, 11*, 3669. https://doi.org/10.3390/foods11223669

AOAC. (2000). *Official methods of analysis* (18th ed.). Association of Official Analytical Chemists.

Ayandiran, T. A., Ogundiran, M. A., Ajala, O. O., Opasola, O. A., & Olanipekun, A. S. (2021). Comparative assessment of the nutritional fitness of wild and cultured African catfish (*Clarias gariepinus*). *Annual Research and Review in Biology, 36*(2), 96–106.

Balogun, M. A., Sobande, O. S., & Oyeyinka, S. A. (2023). Antimicrobial properties of onion and garlic extract in beef and chicken. *Food Chemistry Advances, 3*, 100519.

Bedrníček, J., Laknerová, I., Linhartová, Z., Kadlec, J., Samková, E., Bárta, J., Bártová, V., Mráz, J., Pešek, M., Winterová, R., Vrchotová, N., Tříska, J., & Smetana, P. (2019). Onion waste as a rich source of antioxidants for meat products. *Czech Journal of Food Sciences, 37*(4), 268–275.

Celano, R., Docimo, T., Piccinelli, A. L., Gazzerro, P., Tucci, M., Di Sanzo, R., Carabetta, S., Campone, L., Russo, M., & Rastrelli, L. (2021). Onion peel: Turning a food waste into a resource. *Antioxidants, 10*, 304. https://doi.org/10.3390/antiox10020304

Centre for Food Safety (CFS). (2014). *Microbiological guidelines for food: For ready-to-eat food in general and specific food items* (p. 46).

Demir, H., Yildiz, M. K., Becerikli, I., Unluturk, S., & Kaya, Z. (2018). Assessing the impact of non-thermal and thermal treatment on the shelf-life of onion juice. *Czech Journal of Food Sciences, 36*, 1–7.

Demir, H., Yıldız, M. K., Becerikli, I., Unluturk, S., & Kaya, Z. (2020). Impact of pasteurisation process on the quality and marination properties of onion juice. *Turkish Journal of Agriculture - Food Science and Technology, 8*(3), 531–537.

Durojaiye, A. F., Sule, S. O., Bassey, O. B., Olorunshola, S. J., & Ogunkelu, D. F. (2021). Microbial risk assessment of smoked fish products in Yewa North, Ogun State, Nigeria. *FUTO Journal Series, 7*(1), 17–24.

Food and Agriculture Organization (FAO). (2023). *FAOSTAT: Onion production in Nigeria (2020–2023).* Rome: FAO. https://www.fao.org/faostat

Fawole, M. O., & Oso, B. O. (1995). *Laboratory manual on microbiology* (2nd ed., pp. 77–78). Spectrum Books Limited.

Haghparast, S., Kashiri, H., Alipour, G., & Shabanpour, B. (2011). Evaluation of green tea (*Camellia sinensis*) extract and onion (*Allium cepa* L.) juice effects on lipid degradation and sensory acceptance of Persian sturgeon (*Acipenser persicus*) fillets: A comparative study. *Journal of Agricultural Science and Technology, 13*, 855–868.

Ifesan, B. O. T. (2017). Chemical composition of onion peel (*Allium cepa*) and its ability to serve as a preservative in cooked beef. *International Journal of Science and Research Methodology, 7*(4), 25–34.

Ige, I. M., Nwaehujor, I., Dada, O. A., Adediji, A. Y., Adebayo, O. B., & Oyebanji, A. O. (2021). Microbial studies of dried catfish (*Clarias gariepinus*) from some markets in Ilorin, Kwara State. *Nigerian Journal of Postharvest Research, 3*(1), 46–55.

Jega, I. S., Michael, P., & Ribah, I. M. (2018). Effect of onion top leaves extract on the quality of smoked *Heterotis niloticus* (Cuvier, 1829). *Research in Agriculture, Livestock and Fisheries, 5*(2), 241–248.

Marcano, M. H., & Hasenawa, D. (1991). Analysis of phytochemicals in leaves and seeds. *Agronomy Journal, 83*, 445–452.

Masood, S., Attiq ur Rehman, Bashir, S., Imran, M., Khalil, P., Khursheed, T., Iftikhar, F., Jaffar, H. M., Farooq, S., Rizwan, B., & Javaid, N. (2020). Proximate and sensory analysis of wheat bread supplemented with onion powder and onion peel extract. *Bioscience Research, 17*(4), 4071–4078.

Mei, J., Ma, X., & Xie, J. (2019). Review on natural preservatives for extending fish shelf life.

Foods, 8, 490. https://doi.org/10.3390/foods8100490

Moosazad, S., Ghajarbeigi, P., Mahmoudi, R., Shahsavari, S., Vahidi, R., & Soltani, A. (2019). Antibacterial and antioxidant properties of colorant extracted from red onion skin. *Journal of Chemical Health Risks, 9*(3), 235–243.

National Bureau of Statistics (NBS). (2023). *Agricultural performance survey report for Nigeria (2022–2023).* Abuja: NBS.

Nurhayati, Y., Mat Rahim, N. N., Mohd Juhari, N. I., & Tang, J. Y. H. (2024). Physicochemical and proximate composition of cincalok (fermented shrimp) mixed with red onion powder, red chilli pepper and musk lime juice. *IOP Conference Series: Earth and Environmental Science*, *1413*, 012071.

Olanrewaju, A. N., Agbelege, O. O., & Ibrahim, U. A. (2022). Effect of onion and garlic oils on proximate composition and organoleptic characteristics of smoked African catfish (*Clarias gariepinus* Burchell, 1822). *Proceedings of the 37th Annual Conference of the Fisheries Society of Nigeria (FISON)*, 520–523.

Onuoha, P. C. (2018). Comparative study on graded brine solution and spice juice (*Allium sativum*) on the nutritive value and shelf life of *Clarias gariepinus*. *International Journal of Agriculture and Earth Science, 4*(5), 13–22.

Osakue, O. P., Igene, J. O., Ebabhamiegbebho, P. A., & Evivie, S. E. (2016). Proximate analysis and microbial quality of ready-to-eat (RTE) fried chicken parts. *Journal of Food and Industrial Microbiology, 2*(1), 1–8.

Oyewole, B. A., Agun, B. J., & Omotayo, K. F. (2006). Effects of different sources of heat on the quality of smoked fish. *Journal of Food, Agriculture and Environment, 4*(2), 21–29.

Paesa, M., Nogueira, D. P., Velderrain-Rodríguez, G., Esparza, I., Jiménez-Moreno, N., Mendoza, G., Osada, J., Martin-Belloso, O., Rodríguez-Yoldi, M. J., & Ancín-Azpilicueta, C. (2022). Valorisation of onion waste by obtaining extracts rich in phenolic compounds and feasibility of its therapeutic use on colon cancer. *Antioxidants, 11*, 733. https://doi.org/10.3390/antiox11040733

Phan, T.-H.-A., Nguyen, T.-P., & Tran, T.-T.-A. (2021). Extracting and evaluating biological activities of phenolic compounds from yellow onion peels (*Allium cepa* L.) and their applicability for fish preservation. *IOP Conference Series: Earth and Environmental Science, 947*, 012042.

Rathod, N., & Pagarkar, A. (2013). Biochemical and sensory quality changes of fish cutlets made from pangasius fish (*Pangasianodon hypophthalmus*) during storage in refrigerated display units at −15 to −18°C. *International Journal of Food, Agriculture and Veterinary Sciences, 3*(1), 1–8.

Sagar, N. A., & Pareek, S. (2020). Antimicrobial assessment of polyphenolic extracts from onion (*Allium cepa* L.) skin of fifteen cultivars by sonication-assisted extraction method. *Heliyon, 6*, e05478.

Shinde, P. A., Reddy, V. K., Patange, S., & Patange, S. B. (2015). Quality of Indian mackerel as affected by pomegranate peel and tea leaf extracts during ice storage. *SAARC Journal of Agriculture, 13*(1), 109–122.

Sotolu, A. O., Abdulateef, M. M., & Sule, S. O. (2018). Proximate composition and organoleptic assessment of *Kilishi* made from *Clarias gariepinus* and *Mormyrus rume*. *Proceedings of the 1st Conference of the Association of Nigerian Fisheries Scientists (ANIFS)*, University of Ibadan, Nigeria, July 10–12, 2018, 189–195.

Sule, S. O., Ashley-Dejo, S. S., Oyetunji, O. T., Olaniyi, S. E., & Adeyemi, A. Y. (2023a). Effect of onion peel waste on microbial load of smoked *Clarias gariepinus* fish. *Proceedings of the 9th Regional Food Science and Technology Summit (ReFoSTS)*, Abeokuta, Ogun State, Nigeria, June 5–8, 2023, 368–374.

Sule, S. O., Ashley-Dejo, S. S., Oyetunji, O. T., Olaniyi, S. E., Adeyemi, A. Y., & Abdullahi, U. U. (2023b). Effect of onion peel waste on nutritional and organoleptic quality assessment of smoked *Clarias gariepinus*. *Journal of Aquatic Sciences, 38*(2), 253–261.

Sule, S. O., Oguntade, O. A., Oduntan, O. B., & Yusuf, S. A. (2025). Proximate and phytochemical analysis of two onion peel varieties. *Scientia Africana, 24*(2), 1–10.

Sule, S. O., Sadiq, H. O., Durojaiye, A. F., Ojetayo, T. A., & Sotunbo, A. F. (2022). Effect of onion juice and onion chaff waste as preservative on microbial load of smoked *Clarias gariepinus*. *Proceedings of the 37th Annual Conference of the Fisheries Society of Nigeria (FISON),*

Modibbo Adama University, Yola, Adamawa State, Nigeria, October 30–November 4, 2022, 549–552.

Ucak, İ., Khalily, R., Abuibaid, A. K., & Ogunkalu, O. A. (2019). Maintaining the quality of rainbow trout (*Oncorhynchus mykiss*) fillets by treatment of red onion peel extract during refrigerated storage. *Journal of Progress in Nutrition, 20*(4), 672–678.

Zolfaghari, M., Shabanpour, B., & Fallahzadeh, S. (2010). Quality preservation of salted, vacuum packaged and refrigerated mahi sefid (*Rutilus frisii kutum*) fillets using an onion (*Allium cepa*) extract. *Aquaculture Research, 41*, 1123–1132