



Storage Stability of Smoked Mackerel Fish (*Scomboromorus scombus*) as Affected by Selected Packaging Materials

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To cite this article:

Agomuo Jude Kelechi, Ehirim Fidelis, Onugha Fidelis Chimezie. Storage Stability of Smoked Mackerel Fish (*Scomboromorus scombus*) as Affected by Selected Packaging Materials. *World Journal of Food Science and Technology*. Vol. 1, No. 1, 2017, pp. 22-27.

doi: 10.11648/j.wjfst.20170101.14

Received: April 21, 2017; Accepted: May 2, 2017; Published: June 26, 2017

Abstract: In this study, Smoked mackerel fish (*Scomboromorus scombus*) was stored under ambient conditions ($30\pm 2^{\circ}\text{C}$) in selected local packaging materials namely: Aluminium foil (AF), High density polyethylene (HDP), Low density polyethylene (LDP) and Cartons (CT) were determined. Results obtained showed that proximate composition of the samples were significantly affected ($P\leq 0.05$) by the packaging materials at the 9th week of storage. The protein content of sample AF (45.28) was higher followed by sample CT (47.02), then sample HDP (45.65) while sample LDP (45.35) was lowest. Moisture content did not follow the same trend as protein. The carbohydrate and ash contents of sample CT were generally higher than the other samples. There was gradual decrease in with storage time. On the other hand, Peroxide values increased significantly with storage time, and sample AF showed the lowest increase. Sample AF had lower total plate count that ranged from 1.6×10^3 to 1.1×10^4 cfu/g, while sample LDP had the highest values (1.6×10^3 to 1.6×10^5 cfu/g) the yeast and mould counts showed low visible growth (<28) in sample AF at the 9th week of storage, and the highest growth was seen in sample LDP. Results of the sensory analysis showed that smoked mackerel packaged and stored in aluminium foil had highest degree of general acceptability. This study recommends aluminium foil as the best packaging material for smoked mackerel followed by High and Low density Polyethylene while carton which is generally most used in Nigeria gave the least performance.

Keywords: Mackerel, Fish, Storage Period, Packaging, Materials

1. Introduction

Fish is an important food item which contains a lot of nutrients that are vital to the human body. Generally, fishes are good sources of high quality animal protein as well as essential and non-essential amino acids [3]. Mackerel (*Scomboromorus scombus*) fish is one of the most common species of fish in Nigeria because it is hardy and prolific in production [23]. Fresh Mackerel (*Scomboromorus scombus*) fish is highly susceptible to deterioration immediately after death [24]. Therefore, to reduce postharvest and economic losses, fresh fish should be processed immediately after capture or left alive for a reasonable period [6].

Several chemical and biological changes take place in the dead fish which can ultimately lead to rejection for human consumption because of spoilage. The postharvest changes

results in spoilage, which affect sensory properties of the dead fish [15]. To combat this, there is the need for processing and preservation of fish to ensure longer shelf life. Fish processing involves primarily the application of preservation techniques in order to retain quality and increase shelf life.

Common preservation techniques include freezing, smoking, drying and heat treatment [12]. Smoked fish is much appreciated by Africans because of its unique characteristics. Smoking is a method that utilizes smoke to introduce flavour, taste, colour and preservative ingredients into the fish. In developing countries, this method is used as a means of preservation [6], while in developed countries, it is used to insert smoke flavour on the product [12].

According to a study sponsored by the Food and Agricultural Organization of the United Nations, the quantity

of dried and smoked mackerel and other types of fish exported from West Africa to the United Kingdom was estimated at over 500 tonnes per year, with a retail value of nearly \$20 million [6]. Nigeria alone exports about 5 tonnes of smoked mackerel per month, via air freight [15]. The huge trade in smoked-dried fish is a consequence of growing demand by increasing number of Africans living in the diaspora. As a result of this transcontinental migration, and a growing appreciation for African flavours and food, the demand for dried and smoked mackerel fish appears to be going through the roof [18]. However with strict regulations on imported foods in the US and Europe, Africans are finding difficulties to exploit the million dollar foreign market for smoked and dried fish. According to [1] and [8], up to 40% of smoked fish exported from Africa is detained or destroyed at US and European ports due to improper packaging, labelling, insect infestation and mould growth on the products.

To figure out this problem, the use of the right packaging material is imperative. This can be achieved by ensuring that smoked fish does not contain considerable amount of moisture, which could attract insects and foment moulds growing, what significantly affects the quality of the products [6]. Furthermore, to ensure that packaged smoked mackerel fish meets the international standards, one of the needs is to evaluate the chemical and microbiological quality of the product as well as sensory changes during storage with different materials, intending the recommendation of the most appropriate material for longer storage. Therefore, the objective of this work is to evaluate the storage stability of smoked (common name, mackerel or catfish?) fish (*Scomboromorus scombus*) in selected packaging materials.

2. Materials and Methods

2.1. Sample Procurement

Mackerel (*Scomboromorus scombus*) were purchased from a fish pond in Owerri, Imo State, Nigeria. The fishes were transported alive to the laboratory in a container with fresh tap water. Hard wood used for the smoking of the fish were purchased from timber shade at timber market, Owerri, Nigeria. Packaging materials including cartons, aluminium foil, high and low density polyethylene, used for storing the smoked fish, were also purchased from Eke Onuwa market, Owerri.

2.2. Sample Preparation

The fishes were eviscerated and properly washed in clean water according to method of [16] with slight modification. Each fish was coiled using pieces of sticks. The mackerel were smoked using a smoking kiln from the Department of Food Science and Technology of the Imo State University following the procedure reported by [3]. After the smoking period, the freshly smoked mackerel samples were taken to the laboratory for analysis, before being wrapped with the selected packaging materials then stored in a room at ambient

temperature, and analysed at three weeks interval for a period of nine (9) weeks.

2.3. Proximate Composition Analysis of Samples

2.3.1. Total Protein Determination

The Kjeldahl method was used for the determination of total protein as described by [4]. The samples (1.0g each), was first digested in a Kjeldahl digesting system. The digested samples were allowed to cool and then distilled into 2% boric acid solution containing methyl orange indicator, after being appropriately diluted with water and the introduction of 40% sodium hydroxide solution. The distilled sample was titrated against 0.1N HCl solution. A blank titration was similarly carried out and the protein percentage content was estimated as percentage Nitrogen x 6.25.

2.3.2. Fat Determination

The Soxhlet method outlined in [4] was used. Two gram samples were weighed (A) into the extraction thimble which was fitted with cotton wool and placed back in the Soxhlet apparatus, attached to a weighed flat bottom flask (B) which was filled to about three quarter of its volume with petroleum ether of a boiling point of 40 – 60°C. The extraction was carried out for a period of 4 – 8 hours after which complete extraction was made. The petroleum ether was removed by evaporation on the water bath, and the remaining portion in the flask was dried in an oven at 80°C for 30 minutes, cooled in a desiccator and weighed (C).

$$\% \text{ Fat Content} = \frac{C-B}{A} \times \frac{100}{1} [1]$$

Where,

A = Weight of Sample

B = Weight of empty flask

C = Weight of flask + oil

2.3.3. Ash Determination

The ash content of the sample was determined by the method described by [4]. A silica dish was heated to 600°C, cooled in desiccators and weighed. Then 5g of the sample were weighed into the silica dish and transferred to the furnace. The temperature of the furnace was allowed to reach 525°C before placing the dish. The temperature was maintained until whitish grey colour was obtained, indicating that all the organic matter content of the sample had been destroyed. The dish was then brought out from the furnace and placed in the desiccator, cooled and re-weighed.

$$\% \text{ Ash Content} = \frac{C-A}{B-C} \times \frac{100}{1} [2]$$

Where,

A = Weight of empty dish

B = Weight of empty dish + sample before ashing

C = Weight of dish + ash

2.3.4. Moisture Content Determination

Moisture content was determined by the air-oven method as described by [4]. Two grams of the samples were weighed

in duplicate into petri dishes of known weight and covered immediately. This was transferred to an oven, uncovered, and left at $103 \pm 2^\circ\text{C}$ for 3 – 5 hours. The samples were then removed from the oven and placed in the desiccator to cool for 15 minutes, then the constant weight were recorded. The loss in weight from the original weight was reported as the moisture content.

$$\% \text{ Moisture Content} = \frac{\text{Weight loss}}{\text{Weight of sample}} \times \frac{100}{1} [3]$$

2.3.5. Carbohydrates Determination

Carbohydrate was determined by difference as reported by [25].

$$\text{Carbohydrate} = 100 - (\% \text{ Moisture, Protein, Fat and Ash})$$

2.4. Sensory Evaluation

The organoleptic quality assessment of the four samples were evaluated using a 7-point hedonic scale (7 = like extremely to 1 = dislike extremely) as described by Iwe, 2002. The evaluation was based on Appearance, Flavour, Texture and General acceptability. It was done by a 15 member semi trained panellists comprising staffs and students of the Department of Food Science and Technology, Imo State University, Owerri.

2.5. Microbiological Analysis

The microbiological analysis carried out on these samples includes yeast and mould count as well as Total plate count. It was carried out at week 0, 3, 6 and 9 respectively. Method described by [22] was adopted.

2.5.1. Preparation of Media for Total Plate Count

About 5g of plate count agar (PCA) was weighed and added to 250ml distilled water in a conical flask and then mixed thoroughly. It was heated to boiling and then sterilized in an autoclave at 15 psi at 121°C for 15 minutes.

2.5.2. Preparation of Media for Yeast and Mould Count

Potato Dextrose Agar (PDA) was prepared for the determination of yeast and mould. 14g of the PDA was suspended in 250 ml of distilled water in a conical flask. It was swirled to ensure thorough mixing. This was then sterilized by an autoclave for 15 minutes at 121°C . After sterilization, 10% tartaric acid was added into it.

2.5.3. Preparation of Media for Serial Dilution

Test tubes were sterilized, arranged and labelled appropriately (10^{-1} – 10^{-4}) according to the number of samples. It was added 9.0 mL of distilled water in each test tube, then it was mixed 2g of each finely mashed sample with 250 mL of distilled water. The mixture was properly stirred to give a homogeneous mixture. 1ml of the sample was taken from the solution and introduced into the first test tubes labelled 10^{-1} . 1ml of the first dilution was transferred to the second test tube and labelled 10^{-2} and this was done until it reached 10^{-4} .

2.5.4. Total Plate Count

The method reported by [22] was adopted. About 9ml of diluent (distilled water) was measured into test tubes. Known quantity of nutrient agar was weighed in a 250 ml conical flask and diluted to mark. Both the diluent and the nutrient agar were put into autoclave and sterilized. Then 1g of the sample was weighed and used to prepare a homogeneous solution with distilled water. Serial dilutions of the resultant homogenates were made to obtain 10^{-1} , 10^{-2} , 10^{-3} and 10^{-4} . About 0.1ml of each diluted solution was transferred to sterile petri-dishes and the cool nutrient agar poured and gently swirled. The Petri dishes were allowed to solidify and transferred to an incubator at 37°C for 18-24 hours. Total viable count (cfu/g) was counted using colony counter and recorded.

2.5.5. Mould and Yeast Count

The method described by [22] for total yeast and mould counts was used. Distilled water (9ml) was pipette into ten test tubes and sterilized in an autoclave. The sterilized potato dextrose agar was acidified with 10% tartaric acid to a pH of 3.5 ± 0.1 immediately before use. Pouring was done and the petri dishes swirled and allowed to solidify. The hardened agar was incubated at 37°C for 3 – 5 days in an inverted form and the number of colony counted.

2.6. Determination of Storage Parameters

The smoked Markerel fish samples were stored at room temperature, chemical analysis such as pH and Peroxide value were carried out at intervals of 0, 3, 6 and 9 weeks..

2.6.1. pH Value

The pH measurement was done according to the procedures described by [17]. About 5g of the smoked fish samples were homogenized with 50ml of distilled water in a beaker to form a homogeneous solution. It was allowed to stand for 30 minutes in a 40°C water bath. It was then mixed thoroughly and the pH was measured using a pH meter.

2.6.2. Peroxide Value (PV)

This was done as described by [17]. 1g of the sample was weighed into a clean and dry boiling tube and 1g of powdered potassium Iodide and 20ml of solvent mixture (2 vol. glacial acetic acid + 1 vol. Chloroform) was added. The tube was placed in boiling water and allowed to boil for 30 seconds. The solution was filtered and the filtrate was transferred to a flask containing 20 ml of potassium iodide solution (5%) the tube was washed out twice with 25 ml distilled water and filtered with 0.002 m sodium thiosulphate solution using starch. A blank was also prepared.

$$\text{Peroxide Value (PV)} = \frac{V - V_0}{M} \times 10^3 \text{ mEq/kg} [4]$$

Where:

V_0 = Volume of blank titrated

V = Volume of sample titrated

M = Weight of sample

2.7. Statistical Analysis

The data obtained from the sensory analysis were all subjected to Analysis of Variance (ANOVA); T-test. The tests of significance were done at probability of 95% [25].

3. Results and Discussion

3.1 Proximate Composition

The result of proximate composition of the stored smoked mackerel fish using selected packages is shown in Table 1. The results showed that crude protein formed the highest percentage of the dry matter in all the four samples. This is in line with reports of [2, 22]. At the end of 9 weeks of storage, the protein content of samples HDP (45.28%) and LDP (45.65%) were lower than samples AF (47.28%) and CT (47.02%). These differences could be due to the more gradual degradation of the initial crude protein to volatile products

Table 1. Proximate Composition of Smoked Catfish Packaged in selected materials at the 9 weeks (values are presented as g/100g) of storage.

Parameters	Samples				
	AF	HDP	LDP	CT	LSD
Moisture	9.60 ^a ±0.02	10.10 ^a ±0.01	10.00 ^a ±0.12	9.70 ^{bc} ±0.01	0.20
Ash	7.20 ^a ±0.15	7.10 ^a ±0.02	7.01 ^b ±0.01	7.20 ^a ±0.11	0.17
Fat	14.80 ^a ±0.02	16.32 ^a ±0.10	16.31 ^a ±0.02	14.87 ^{bc} ±0.14	0.24
Protein	47.28 ^a ±0.01	45.65 ^{bc} ±0.11	45.35 ^c ±0.01	47.02 ^{ab} ±0.02	1.57
Carbohydrate	12.90 ^a ±0.01	12.80 ^a ±0.12	12.93 ^a ±0.02	13.50 ^a ±0.15	1.24

Values with same superscripts within the same rows are not significantly different ($P \leq 0.05$).

Key: AF = Aluminum Foil, HDP = High Density Polyethylene, LDP = Low Density Polyethylene, CT= Carton, LSD = Least Significant Difference.

The lipid content of samples AF and CT were significantly ($p \leq 0.05$) lower than that of HDP and LDP, attributable to oxidation of polyunsaturated fatty acids (PUFA) in the fish tissues to products such as peroxides, aldehydes, ketones and free fatty acids [10]. The greater the degree of unsaturation of fatty acids, the greater would be the tendency for fat rancidity [20].

Samples AF, HDP and LDP were low in carbohydrate content compared to sample CT, attributable to decomposition of carbohydrate. [15] stated that during storage, some proteolytic microbes produce acid after decomposition of carbohydrate, thereby reducing the carbohydrate contents

3.2. Peroxide and pH

The peroxide and pH values during the period of storage are presented in Table 2. Peroxide value which is a primary indicator of oxidation of fat (rancidity) increased weekly from 7.02 at the 0th week to 38.03 at the 9th week for all packing materials. The peroxide values are usually in the order of 20-40mEq of oxygen per kg of sample. However, [8] reported that when peroxide value exceeds is above 10-20, fish develop rancid taste and smell. Thus, it can be concluded that the values from this work indicated that the sample packaged in Aluminium foil (AF) remained acceptable until the 6th week of storage, while samples packaged in High (HDP), and Low (LDP) as well as carton (CT) began to spoil

such as Total Volatile Bases (TVB), Hydrogen Sulphide and Ammonia in samples HDP and LDP compared with samples AF and CT, according to [15]. Changes observed in protein and lipid content of the samples may also have been due to leaching out of some extractable soluble protein fraction and hydrolysis of some lipid fractions [11]

There was higher moisture content in sample HDP (12.02%) and LDP (12.01%) compared to samples AF (9.60%) and CT (9.70%). Therefore, it may be assumed that the mackerel fish absorbed more moisture when stored in High and Low Density Polyethylene than in Aluminium Foils and Cartons, indicating greater moisture permeability in High and Low Density Polyethylene than Aluminium Foils. [20] reported that fish with 10 – 15% moisture content had a shelf life of 3 – 9 months, while fish with higher water activity had lower shelf-life. The moisture content of the samples in this work indicates that they can retain good microbiological quality up to 9 months of storage

at the 4th of storage.

Table 2 also shows that the pH values decreased within the period of storage. The pH values, however, did not show significant change ($p < 0.05$) during the storage period. Decrease in pH level is due to the fact that there was gradual fermentation of carbohydrate of the fish to acid during the storage period [15]. He further opined that pH is an indicator of the extent of microbial spoilage in fish and that some proteolytic microbes produce acid after decomposition of carbohydrate, thereby increasing the acid level of the medium. The pH value is a reliable indicator of the degree of freshness or spoilage. Decrease in pH corresponded to the decrease in shelf life of samples with storage time.

Table 2. pH and Peroxide values of the Stored Smoked mackerel using selected packages.

Parameters	Storage time (weeks)	Samples			
		AF	HDP	LDP	CT
pH values	0	5.80	5.80	5.80	5.80
	3	5.73	5.72	5.76	5.78
	6	5.62	5.60	5.70	5.72
	9	5.50	5.40	5.62	5.65
Peroxide Values (mEq/kg)	0	7.02	7.02	7.02	7.02
	3	9.01	10.00	10.22	11.40
	6	18.20	23.52	27.03	29.40
	9	28.01	34.25	41.03	38.03

Key: AF=Aluminium foil, HDP=High Density Polyethylene, LDP=Low Density Polyethylene, CT=Carton

3.3. Microbiological Count

The results of the microbiological analysis (Total Plate Count as well as Yeast and Mould Count) are presented in Table 3. From the results obtained, the total plate count of all the smoked catfish samples at week zero was 1.6×10^3 . At week 9 of storage, Sample LDP had the highest total plate count of 1.6×10^5 . In comparison, sample AF had 1.1×10^4 , while both samples HDP and CT had 1.4×10^4 . No yeast and mould count were found week zero. At week 3, there was no

visible growth in sample AF, while there was growth in HDP, LDP and CT but less than 28 (.28). At week 6, there was an increase in the yeast and mould count for Sample LDP (4.4×10^1), whereas samples AF, HDP and CT recorded > 28 . At week 9, the highest yeast and mould count increased in sample LDP to 2.0×10^2 . The highest values for yeast and mould count were within the acceptable limit of less than 10^6 [16]. [19] reported an increase in total plate count as well as in yeast and mould count during prolonged storage of fish.

Table 3. Microbiological results of Smoked Catfish stored in selected packaging materials.

	Samples				Parameters
	Storage Time (weeks)	AF	HDP	LDP	
Total Plate Count (Cfu/g)	0	1.6×10^3	1.6×10^3	1.6×10^3	1.6×10^3
	3	1.1×10^3	1.4×10^3	0.9×10^4	0.9×10^4
	6	0.9×10^4	1.0×10^4	1.0×10^4	1.0×10^4
	9	1.1×10^4	1.4×10^4	1.6×10^5	1.4×10^4
Yeast and Mould Count (Cfu/g)	0	NVG	NVG	NVG	NVG
	3	NVG	< 28	< 28	< 28
	6	< 28	< 28	4.4×10^1	< 28
	9	< 28	< 28	2.0×10^2	< 28

Key: AF = Aluminium Foil, HDP = High Density Polyethylene, LDP = Low Density Polyethylene, CT = Carton, NVG = No Visible Growth

3.4. Sensory Evaluation

The result of the sensory evaluation of stored smoked mackerel fish using selected packages is presented in Table 4. The sensory attributes evaluated were appearance, texture, flavour and general acceptability. Samples AF and HDP showed no significant difference in terms of appearance, texture, as well as Flavour, likewise samples LDP and CT. Though all the four samples were generally acceptable, but Sample AF had the highest degree of acceptability, which was followed by sample HDP, LDP and CT respectively. The flavour of Sample LDP and CT had lower degree of acceptability compared to Sample AF and HDP, this could be attributed to the pungent smell and resin odour compared to the other samples [6].

Table 4. Mean sensory scores for smoked catfish stored using selected packages.

Attributes	Samples				
	AF	HDP	LDP	CT	LSD
Appearance	3.57 ^a	3.37 ^a	2.43 ^b	2.23 ^b	0.24
Texture	3.50 ^a	3.23 ^a	2.76 ^b	2.13 ^b	0.32
Flavour	3.30 ^a	3.10 ^a	2.83 ^b	2.43 ^b	0.32
General Acceptability	3.57 ^a	3.10 ^b	2.43 ^c	2.17 ^c	0.33

Values with same superscripts within the same rows are not significantly different ($P \leq 0.05$)

Key: AF = Aluminium Foil, HDP = High Density Polyethylene, LDP = Low Density Polyethylene, CT = Carton

4. Conclusion

The proximate compositions were generally affected by the package material used to the product storage. The microbial load (bacteria and mold) of the stored mackerel fish packaged in the using selected packages generally had

lower values than the recommended maximum limit of 10^6 cfu/g, independent of the material used. Also, all the four samples were generally accepted by the sensory analysis evaluation, but smoked mackerel fish packaged in Aluminium foil (AF) had a greater degree of acceptability.

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