Effect of the Physical Properties of Composite Packaging Materials on Keeping Quality of Smoked Catfish

[1]Olayemi, Foline Folorunsho; [2]Raji, Abdulganiy Olayinka and [3]Bamishaiye, Eunice Iyabo

[1]Engineering unit, Nigerian Stored Products Research Institute, Kano, Nigeria.
[2]Dept. of Agricultural and Environmental Engineering, University of Ibadan, Ibadan
[3]Chemistry Unit, Nigerian Stored Products Research Institute, Kano, Nigeria. Corresponding Author: bamishaiyeeunice@yahoo.com

Abstract

Six different composite packaging materials were tested with the trades' practice of polythene bags in storing smoked catfish for a period of six months. The thickness of the packaging materials ranges from 0.23 to 046 mm with water and oil absorption rates of the packaging materials varies from 0.23 to 10.00 and 0.28 to 10.857 glcm^2/mm respectively. The impact resistance weight also varies from 25 to 50 gm. It was observed that the physical properties of the packaging materials are related to the keeping quality of the stored catfish. The two packaging with better engineering properties offered better barrier functionality that gave better keeping quality for the catfish. **[O, Foline Folorunsho et al. Effect of the Physical Properties of Composite Packaging Materials on Keeping Quality of Smoked Catfish. International Journal of Agricultural Science, Research and Technology, 2011; 1(3):127-131].**

Received: 2 September 2011, Reviewed: 26 September 2011, Revised: 30 September 2011, Accepted: 11 November 011

Key words: Packaging material, catfish, absorption rate, thickness, engineering properties

1. Introduction

The importance of fish in the developing world cannot be overemphasized as it is a source of food and income to many people. About 35 million of the people in Nigeria depend on artisarial fisheries for their livelihood. Fish production has been at increase in Nigeria because of expansion in freshwater aquacultures activities by various development program of the government of make fish protein available for the teaming populace. Furthermore, more various traditional methods have been employed to preserve and process fish for consumption and storage. These include smoking, drying, salting, frying, fermentation and combination of these. But in the country, fish smoking is mostly practiced method. Practically all species of fish available can be smoked and it has been estimated that 70-80% of domestic marine and freshwater catch are consumed in smoked farm. The advantages of smoking fish are manifold. Fish smoking prolongs shelf-life, enhanced flavor and increase utilization as ready to eat, soups and sauces. It reduce waste at times of bumper catches and permits storage from the lean season and makes fish easier to pack, transport and market.

Research and Development in the fishery sector in Nigeria are limited to production and processing with a little or no attempt on the packaging of the processed products. The packaging materials in use are still indegioes ones that are not attractive, prone to easy enjoy of insect band rodents commanding no international appeals. The packaging materials only serve to hold the fish products during handlings, transportation and microbial, chemical moisture intake, dusk and products from microbial, chemical, moisture intake, dusts and insect pests (Okonkwo et al, 1991; Enenwaji, 1977). Since dry fish are highly prone to rapid deterioration due to the permeability of the atmospheric conductions by fesses such as oxygen, nitrogen, carbon dioxide, light and water vapor; these have exposed the fish consumers to health hazard while the marketers suffers monetary losses. Furthermore, this inadequate packaging has limited the shelf-life of fish product thereby making smoked fish production to remain a small scale business in the country.

Many, countries producing processing fish have tried to develop effective packaging material using the available material that will provide the two main function of advertising the food product at the point of sale and protecting it to a pre-determined degree for the expected shel-life.(Namsai et al, 2008) for Nigerian to fully develop her fishery activities and leave her share in the international market all chains leading from production to consumption must be fully identified and developed packaging which is an end and seal to value addition in the food supply system must be giving the necessary consideration and attention for proper development of our fisheries business.

The study was carried on to develop composite packaging materials and to use them to access their effectiveness of strong smoked dried catfish under ambient conditions.

2. Materials and methods

2.1 Construction of packaging material

A survey on the packaging materials available in Nigeria for smoked dried fish was carried out. The survey was conducted by administering questionnaires in two states Agricultural Development Program in each of the six zones in Nigeria. The outcome of the survey was used for selection of materials to be used in this study. The selections were based on the analysis of field report obtained from questionnaires administered, flexibility, availability and cost of the materials. Those that ranked high were selected for this study and composite materials were developed from them. The composite materials produced were:

(a) Cardboard lined with polythene materials (CN) – Double layered structure
(b) Polythene lined cardboard material (PN) - Double layered structure
(c) Polythene-cardboard-polythene materials (NCN) - Triple layered structure
(d) Paper lined with polythene materials (PN) - Double layered structure
(e) Polythene lined with paper materials (NP) - Double layered structure
(f) Polythene-paper-polythene materials (NPN) - Triple layered structure
(g) thick guage polythene (farmers practice) as control (C) – single layered structure

Each of the samples were laminated and formed into an A4 size.

From the result of a preliminary study on commonly used packaging materials for smoked fish, Paper, cardboard, polythene and nylon materials of thickness 0.18, 0.35, 0.05 0.27 (mm) respectively were selected as the packaging materials for production of composite materials for this study. Paper, cardboard and polythene materials were laminated into six composites using Linea DH -650 laminating machine. These are Cardboard lined with Polythene materials.(CN), Polythene lined with Cardboard materials (NC), Polythene-Cardboard-Polythene materials (NCN), Paper lined with Polythene (PN), Polythene lined with Paper materials (NP) and Polythene - Paper -Polythene materials (NPN).

Polythene bag of thickness 0.27mm commonly used for fish packaging was used as control C. Each of the samples was formed into an A4 envelope size of 21 X 30 cm manually done with proper sealed edges. The cost for the unit production of each packaging material was determined.

Some physical properties (thickness, impact test, water absorption rate, oil absorption rate and opacity) were determined as follows.

2.2 Determination of the thickness of packaging material

The thickness of the seven packaging materials was determined by taking ten random measurements with a micrometer screw gauge.

2.3 Impact Analysis

The impact tests were conducted on each of the packaging materials according to ASTM D 882-95 A using method B. A dart with 51.0 mm diameter hemispherical head was dropped from a height of 1.50 m. A uniform missile weight increment was employed during the test until failure was achieved. A test sample were replicated twenty times for each of the packaging material and the total missile weight that achieved 50% deformation of the test sample was recorded. Those treatments were replicated on twenty samples of each of the packaging material.

2.4 Water and Oil absorption test

The water and oil absorption rates were determined by using ten pieces of the packaging materials measuring 20 x 20 cm were immersed in water and oil respectively .The increased in weight after one hour was determined in accordance with BS 6504. The absorption rates for water and oil were calculated from the measurement.

2.5 Opacity test

The opacity test on the packaging materials were determined by physical observation and classified to transparent and none transparent.

2.6 Processing and smoking of fish

Life catfish were purchased and harvested from one of the Kano State Department of Fisheries farm located at Mariri in the Wudil LGA in Kano State. The catfish were killed by clubbing the head. The fish were gutted and the lower parts of the belly were opened to bring out the guts and gills. The fish were then thoroughly washed to remove the blood and other impurities and allowed to drain. A saturated salt solution of 360g per liter of water as recommended by Beatty and Fouger (1957) and Berhimpon et al (1991) *was* used for brining. The fish were placed inside iced fish box and transported from the harvesting site to the Nigerian Stored Products Research Institute, Kano, for smoking and drying.

The charcoal container was loaded with 1 kg charcoal, properly fired and placed inside the fish smoking kiln to attain a temperature of $120^{o}C$. A fan was used to achieve uniform distribution of hot air. The fish were then arranged on the shelves on which red oil has initially been rubbed and 0.5kg of saw dust was introduced into the burning chamber to give the smoking condition. One kg charcoal were added continuously two hourly during the smoking process and the temperature of the drying chamber was continuously monitored using mercury in glass thermometer installed in the top, middle and bottom parts of the chamber. The smoking/drying was stopped when the fish were properly dried to safe moisture content. When the heating elements were removed the fans were still in on position to cool the dried fish to ambient and were later packed in the seven different packaging materials and labeled accordingly. The packaged samples were kept on a shelf inside a laboratory and stored at ambient temperature and relative humidity of 25-$41^{o}C$ and 75-87% respectively. Initial analysis for sensory evaluation, microbial and chemical was conducted.

2.7 Chemical analysis

The moisture content was determined by a mechanical moisture analyzer IND ML50. The fat content of was determined by AOAC, 2000 while the microbial content

2.8. Microbial analysis

Total Plate Count (TBC)

This was done using the pour plate method of AOAC, 2000. One milliliter of the serially diluted samples was taken in duplicates and plate count agar was poured at $40^{0}C$ on the plates. The samples and the medium were properly mixed, allowed to set and incubated at $35^{0}C$ for 24h. The number of colonies on the plates was counted.

Yeast and mould Counts. This was done by plating out serially diluted samples on Potato Dextrose Agar (PDA) at room temperature (30- $35^{0}C$) for 48-72h.

2.9 Statistical analysis

The method of statistical analysis for the ANOVA was the ANOVA procedure for a one way completely randomized design using the Statistical Analysis Software (SAS) 1999 package.

3. Results and discussion

3.1 Cost of packaging materials

The unit cost of the seven types of packaging materials used in this study was shown in Table 1. The cost of each of these packaging materials are still minima and affordable. These costs are less than ₦ 50.00 per unit and each pack which can take up to three (3) to four (4) smoked medium dried fish with market value of between ₦600.00 to ₦800.00. These costs of production of these packaging materials are economical and the materials are also available; thereby meeting one of the requirements of functional packaging materials with a low production costs. (Tice, 2003). Furthermore, the cost can be further reduced if the production processes were fully mechanized and with high volume of production. The reduction of energy usage by eliminating the need for refrigerator and freezing in the use of these packaging materials and the job opportunities are other advantages in it use .

Table 1. Unit cost of A4 size packaging materials

No	Type of packaging material	Unit cost (₦)
1	Nylon-cardboard-nylon	25.80
2	Nylon-paper-nylon	32.00
3	Nylon –cardboard	16.80
4	Cardboard-nylon	16.80
5	Nylon-paper	20.00
6	Paper-nylon	20.00
7	Nylon alone (control)	10.00

3.2 Physical properties of the packaging materials

The results of the physical properties (thickness, water absorption rate, oil absorption rate, opacity and impact resistance weight were shown for the six composite packaging materials and the control in Table 2.

Table 2. Some physical properties of the packaging materials before storage

Packaging material	Thickness (mm)	Water absorption ($g/cm^2/min$)	Oil absorption ($g/cm^2/min$)	Opacity (Physical observation)	Impact Resistance (g)
CN	0.40	5.628	8.799	Not Transparent	30
NC	0.40	6.574	10.230	Not Transparent	25
NCN	0.46	0.769	4.123	Not Transparent	40
PN	0.23	5.168	7.418	Not Transparent	40
NP	0.23	10.00	10.857	Not Transparent	30
NPN	0.31	1.73	2.50	Not Transparent	50
C	0.27	0.36	0.280	Transparent	35

3.3 Thickness of the packaging on catfish quality

The thickness of the packaging materials used in this study are as shown in Table 3. These values met the standard for partial barrier of at least 0.15mm (Emblem and Emblem, 1996). Size, geometry and thickness are some of the factors that affect the performance of packaging material. For a given packaging material of the same shape and geometry, the thicker the material the lower the permeation; as permeation is inversely proportional to thickness (Paine and Paine, 1993). For NCN, CN, NC with the same geometry and size, the NCN with highest thickness is expected to have lower permeation than CN and NC; and likewise NPN is expected to have lower permeation than NP and PN. Moisture content increase or decrease in the stored catfish in different packaging materials is a measure of permeation. The lower the moisture content, the lower the permeation. From this study it was observed that the thicker packaging materials have lower moisture content, after six months of storage. Hence it can be established that the higher the thickness of the packaging of the same size and geometry the lower the moisture content. Therefore, thickness of packaging material improves the barrier property.

3.4 Water absorption rate

The water absorption rates measurement for all the packaging materials are reported in Table 4. Packaging materials C, NCN and NPN show lower water absorption rate than the other packaging materials. The lower water absorption rate of the C, NCN and NPN, might be due to their microstructure composition. The NCN and NPN packaging materials were laminated with nylon material in the inner and outer covers, while C is entirely nylon. It is well known fact that nylon (Polyethene) has better barrier properties than paper and cardboard which were used as either inner or outer layer of the packaging materials with higher water absorption rate. The water absorption rate is directly proportional to the moisture content of the stored products and inversely proportional to the barrier properties (Huey-Min and Garaciela, 1998). This relationship was established in this study as packaging materials with low water absorption rate have lower moisture level of the stored catfish; as seen in Table 4.

3.5 Oil absorption rate

The oil absorption rate measurement for all the packaging materials are reported in Table 5. The oil absorption rate is a function of the composition of the packaging material. Packaging materials with internal surface of cardboard and paper like NC and NP have higher oil absorption rate than other. It was also observed during the study that from the fifth month of storage packaging material NC and NP have oil stains all over the pack. This might be responsible for the increase in their microbial load and fat content from the fifth month of storage as observed in Table 5.

3.6 Opacity of the packaging material

The opacity assessment were carried out by visual observation and classified into transparent and none transparent. All the six composite packaging materials were non-transparent while the control C was transparent. It has been discovered that storing food in colored or opaque containers will prevent light from passing through to the food and thereby extend the shelf life. Brown and Forel (2009) observed that UV light catalyzes the oxidation of food causing photo-oxidative rancidity, vitamin loss and fading of natural color. The high fat content of the C packaging material in spite of its low oil absorption rate might be due to it transparency nature which made the stored catfish exposed to oxidation reaction. This also affects the microbial loads as seen in Table 5 which shows higher values for the control used as packaging materials.

Table 3. Thickness of Packaging Material and Moisture Content of Stored Catfish after six months

Packaging Material	Thickness (mm)	Moisture Content (%)
CN	0.40	10.5
NC	0.40	9.7
NCN	0.46	8.8
PN	0.23	9.9
NP	0.23	9.9
NPN	0.31	9.2
C	0.27	9.6

Table 4. Effect of Water Absorption Rate of Packaging Materials on the Moisture Content Stored Catfish

Packaging Materials	Water absorption rate ($g/cm^2/min$)	Moisture Content of catfish (%)
CN	5.628	10.5
NC	6.574	9.7
NCN	0.790	8.8
PN	5.168	9.9
NP	10.00	9.9
NPN	1.623	9.2
C	0.230	9.6

Table 5. Effect of Oil Absorption Rate (OAR) on Fat Content and Microbial Loads of Stored Catfish.

Packaging materials	OAR $g/cm^2/min$	Mean Fat content %	TPC Cfu $x10^{-4}$	Yeast /mould
N	8.799	11.5	16	11
NC	10.230	12.2	16	19
NCN	4-123	10.8	13	6
PN	7.418	11.6	16	7
NP	10.857	12.2	15	6
NPN	2.50	11.0	10	5
C	0.280	12.4	18	17

3.7 Impact resistance weight of packaging materials.

The impact resistance weight for the packaging materials range from 25 to 50 g. From the result obtained in this study the impact resistances of the packaging materials used are affected by the material composition, thickness, layer numbers and position the load were applied. For packaging materials made from nylon and cardboard, the NCN of three layers and 0.46 mm thickness has 40g impact resistance weight compared with CN and NC having 30 and 25g respectively. This trend was also observed in the NPN, NP and PN with 50, 40 and 30g respectively.

These composite packaging materials were designed to be used as primary packaging materials with carton as the secondary. The export specifications for cartons are 51 x 47 x 47 cm for standard size, 61 x 47 x 47 cm for medium size and 76 x 52 x 53 cm large size. With the size of 30 x 22 cm used for each of the packaging design in this study, it is obvious that the medium size for export will be the ideal secondary packaging materials; with the number of pack per carton to be 40 (4 x10).

With this information it can be deduced that for a dried three dried fish per pack with average mass of 87.52g the maximum force per unit area applied on the stored fish in the secondary carton will be 201 N per cm^2 while the force for the least impact resistance for the packaging material was 438.87 N per cm ^{2}. Hence since the packaging materials with the least impact resistance has a higher force than the maximum force applied on the packaging materials used to store the catfish, one can reasonably assume the all the packaging materials have enough strength to withstand the subjected load during

4. Conclusions

Six composite packaging materials were studied with the common one of polythene bag for storage of smoked dried catfish for six months. Composite packaging materials protected smoked dried catfish from physical, chemical and biological damage over a period range of 3 to 6 months with Nylon-Cardboard-Nylon being the best, followed by Nylon-Paper. These two packaging materials are not only safe, inexpensive and versatile but are also flexible with in- built barrier properties to preserved smoked dried catfish for 6 months with minimal losses. They are able to protect the stored, catfish against extraneous agents and unhygienic handling. The Nylon cover outside will be able to convey an attractive printed information of the stored product to the consumers which will serves as effective marketing tools for promoting products identification.

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