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Edible Coating Materials: Effect on the Quality of Smoked-dried African Catfish (*Clarias gariepinus* Burchell, 1822)

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ABSTRACTS---***The effect of edible coating materials on the quality of smoked catfish was conducted. Dried mixed beads coating was made from difference carbohydrate materials (corn, cassava and wheat flour) respectively with the addition of carboxy-methyl cellulose at 5:1 ratio. Twenty five table-sizes catfish was into cut of 4-5cm length and then divided into four parts according to the type of coating beads and smoked using traditional method. The adhesion degree, smoking loss and yield was determined. Also, the proximate composition, mineral elements and sensory evaluation of the smoked fish cuts was analyzed. The adhesion degree, smoking loss and yield was different significantly (p< 0.05) among the smoked fish samples. The proximate composition values and sensory attributes of samples were deferred. The fish sample coated with wheat beads had the highest 13.22 and 94.84% values for adhesion degree and yield respectively, but showed the least smoking loss 17.25%. The range value of proximate composition such as 66.11-67.97% protein and 15.10-16.10% fat of the coated smoked fish was higher than 63.09% and 13.45% (control). The control sample had the least moisture content 8.80% and highest nitrogen free extracts. There was no well-defined pattern for mineral content (mg/100g), calcium (6.92) was the highest among the mineral elements of the smoked fish, followed by 3.78 potassium, 1.98 iron, 1.27 zinc and the least value of 0.321mg/100g was discovered on manganese. This result showed the potential of using edible coating material most especially when using traditional method of fish smoking.***

Keywords--- edible coating, corn flour, cassava flour, wheat flour, smoking, catfish

1. INTRODUCTION

Fish muscle contains majorly protein, fat, high moisture, other nutrients such as mineral and vitamins occurred in traces which are necessary in a diet (Larsen *et al*. 2007). Fish is highly perishable due to its high moisture content and this lead to spoilage under the influence of high temperature after harvesting. Fish spoilage during postharvest is a general problem affecting fishing industry all over the world. In high ambient temperature of the tropics, fresh fish have the tendency to spoil within 12 to 20 h (Al-Jedah *et al*. 1999). Attempt has been made to reduce fish spoilage to minimum through improved preservation techniques.

Heating is one of the common methods in fish processing. Heat is applied for food in different ways (smoking, boiling, baking, roasting, frying and grilling) to enhance their flavor and taste, and increase shelf life (Garsia-Arias *et al.* 2003). In Nigeria smoked fish products are the most readily form of fish product for consumption. Despite the advantages of fish smoking, the high temperature involved in the process has some defects such as quality and quantity changes in protein, loss of soluble temperature-sensitive matter (Sikorski, 2001); loss and de-conformation of soluble nutrients (Mirnezami Ziabari *et al*. 2002). Smoking is one of the oldest methods of food preservation, it has become a means of offering diversified, high value added products as an additional marketing option for certain fish species where fresh consumption becomes limited (Gómez *et al.* 2009). The process releases different volatile chemical compounds (such as formaldehyde, phenols, and cresols) which are known to have different bacteriostatic and bactericidal effects, thus preserving and adding desired flavour. Estaca *et al.*, (2011) stated that direct contact of smoke with fish lead to its contamination (Potential health hazards) with polycyclic aromatic hydrocarbon (PAHs) if the process is not adequately controlled or if very intense smoking procedures are employed. Deterioration of nutritional quality, owing to high temperature, is a challenging problem in most traditional cooking methods (Shivendra *et al*. 2007).

In the past technique in upgrading traditional fish smoking was centered on prevention of direct contact between the fish and the source of heating (smoke generation) using fabricated smoking kiln and the use of coating material or hydrocolloid is common with fish frying, grilling etc. The growing demand for high quality food products with a long shelf-life contributes to the development of new processing techniques which ensure that the product's natural properties and appearance are not adversely affected (Guilbert *et al*., 1996). Food coating attracted widespread interest in the past decades. The main role of edible coatings is to preserve the high quality of a food product (Longares *et al*. 2004; Wan *et* *al.* 2005). Edible coatings may be applied directly on the surface as additional protection to preserve product quality and stability; also, protect food against the loss of nutrients (Wan *et al*., 2005). Edible coatings are known to protect perishable food products from mass transfer solid matters for a long time and as well reducing the quality changes. The different types of agricultural materials used to prepare edible coatings include polysaccharides, lipids and proteins (Krochta and Mulder-Johnston, 1997; Cutter, 2006; Ilter *et al.* 2008). Asmita and Uday (2013) used hydrocolloids coating on chickpea and green gram splits during deep fat frying. Information on the use of coating material during fish smoking is rare and scarce, therefore this current work investigated the effect of different edible coating materials on the quality of smoked Catfish.

2. MATERIALS AND METHODS

Twenty five averaged table-sized Catfish were purchased life from Odey-Fish farm located at New Owerri layout, World Bank, Owerri. The coating carbohydrate materials such as corn flour, wheat flour, high quality cassava flour, and Carboxy methyl cellulose (CMC) were obtained from Owerri main market.

Preparation of Coating Beads and Fish Smoking Process

Twenty five averaged table-sized catfish were used. The head and internal tract of the fish was de-gutted and cut into length of 4-5cm and washed to remove unwanted materials from the body. Beads coating was produced by mixing each coating material (corn flour, cassava flour and Wheat flour) with carboxy-methyl-cellulose (CMC) at ratio of 5:1 respectively. The control sample was made without any coating beads. The fish cut surface area was coated with required beads at thickness range of 3-5mm. The coated fish cuts were smoked using traditional process. The prepared fish samples were placed over a burning wood at height of 4.5 Feet for about 6-8 h covered with a cardboard. During the process a thermometer was used to monitor the temperature of the smoking process, the temperature range was between 100-120^{o}C. The Figure 1 showed the steps used for the preparation of coating beads and smoking process.

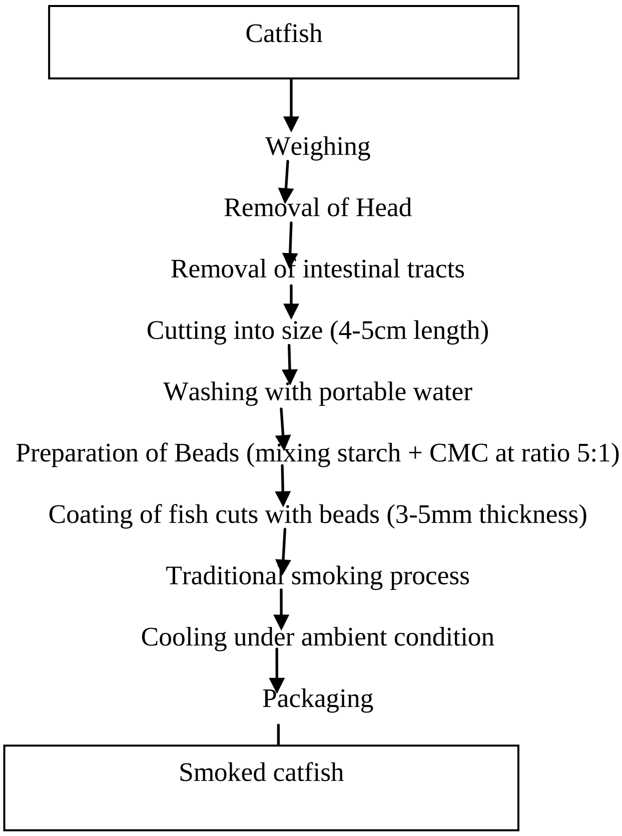

Figure 1: Steps involve in smoked catfish cuts preparation.

Adhesion Degree, Yield and Smoking Loss of Coated Catfish Determination

Adhesion degree, yield, and smoking loss values were carried out (Osman, 2013). The mass of the raw catfish cut (X), the mass of the coated catfish cut before smoking (Y), and the mass of the coated catfish cut after smoking (Z); were determined using sensitive weighing balance as stated in equation 1-3.

$$\text{Adhesion degree: } \frac{Y-X}{Y} \times \frac{100}{1} \quad (1)$$

$$\text{Yield: } \frac{Z}{X} \times \frac{100}{1} \quad (2)$$

$$\text{Smoking Loss: } \frac{Y-Z}{Y} \times \frac{100}{1} \quad (3)$$

Sensory evaluation

Consumer-oriented test was conducted to determine product acceptability using scoring test with the aid of 9-points hedonic scale. The sensory characteristics of the product such as color, taste, aroma, mouth-feel and general acceptability were examined by a team of twenty five (25) semi-trained panelists which was drawn from staff of the college who are familiar with the smoked products. Sample presentation was randomized and presented to each panelist at the same time using identical containers sensory. Each panelist was asked to score each coded sample based on a nine point hedonic scale with 9 = extremely like and 1 extremely dislike. Data collected from judges were subjected to statistical analysis.

Proximate Composition analysis of smoked fish samples

The standard methods described by A.O.A.C (2000) was used to determine moisture, fat, protein, crude fiber, ash content and nitrogen free extract (%NFE) of the smoked fish was determined by total difference.

Mineral element determination of smoked fish samples

The method described by Onwuka (2005) was used in the determination of mineral content. Half gram (0.5g) of the dry milled sample was weighed into a pre – acid rinsed digest tube. $10cm^3$ of 6M HCl was added and heated to dryness in a water bath. The residue was dissolved in a mixture of $10cm^3$ of 6M HNO_3 acid, warmed on a water bath and filtered using a Whatman filter paper into $100cm^3$ calibrated flasks. The filter paper was washed with distilled water and the filtrate diluted with the distilled water and made up to the $100cm^3$ mark. The digest was used for the determination of calcium, sodium and potassium by the flame photometry method. The heavy metals such as Fe, Zn, and Mn were determined using the atomic absorption spectrophotometer method.

Statistical analysis

The data obtained from different analyses were subjected to various statistical analyses which include simple descriptive mean, standard deviation and analyses of variance (ANOVA), while Turkey's test was used to separate the means and correlation among the sample's attributes examined using Statistical package for social science 20.0 Software Inc. USA.

3. RESULTS AND DISCUSSION

Adhesion degree, Smoking loss and % Yield of Coating Material of Smoked Catfish

The Table 1 showed the effect of different coating beads on adhesion degree, smoking loss and yield of smoked catfish. Significantly ($p< 0.05$), the mean value of coated samples for each parameter studied varied. The fish sample coated with beads from wheat flour had the highest adhesion degree 13.22%, the least smoking loss 17.25% and 94.84% highest yield among the coated samples. The uncoated (control) sample showed highest value 32.56% smoking loss when compared with other experimental samples. The indication from these result suggest the relationship between the degree of adhesion of coating material and yield of fish during smoking process. This observation was in agreement with the findings of Osman *et al.* (2013); Asmita *et al.* (2013); Osman and Şűkrű (2010) where in separate reports discovered varied mean values for adhesion degree, frying loss and yield of chicken meat ball, deep-fat fried fish and deep-fat chicken nuggets respectively coated with batter and beads from different coating or hydrocolloid materials. In this work, the smoked fish coated with beads from wheat flour having the highest yield and the least smoking loss could be due to the physical and chemical properties of the flour (such as particle size, protein level etc.) which may differ when compared with other materials (corn and cassava flour). The degree of adhesion and degradation of coating during smoking process could provide a better barrier of thin film that can affect the rate of mass transfer from the food matrix such as fish tissue. Again, the least fish yield of 82.05% discovered on the control sample reveals the effect of direct exposure to high heat energy from the burning wood. However, this situation can be prevented with the use of edible coating material (Kilinccęker *et al.* 2009; Duxbury, 1989) in addition to protective shield provided against the toxic polyalcyclic Hydrocarbon (PAH) substance generated from smoke.

Table 1: Adhesion degree, Smoking loss and % Yield of Coating Material of Smoked Catfish

Smoked Fish sample	Number of sample	Adhesion degree %	Smoking Loss %	Yield %
Corn beads coated	5	$9.86^{c}\pm0.05$	$20.11^{b}\pm0.04$	$89.66^{c}\pm0.16$
Cassava flour beads coated	5	$11.14^{b}\pm0.11$	$19.05^{c}\pm0.01$	$92.76^{b}\pm0.11$
Wheat flour beads coated	5	$13.22^{a}\pm0.06$	$17.25^{d}\pm0.02$	$94.84^{a}\pm0.03$
Control (Uncoated)	3	-	$32.56^{a}\pm0.12$	$82.05^{d}\pm0.06$

Mean score not followed by the same superscript letter are significantly (p< 0.05) across the rows

Effect of Edible Coating Materials on Proximate Composition of Smoked Catfish

The result in Table 2 & Figure 2 showed the proximate composition of smoked catfish coated with beads from different source of edible carbohydrate coating materials. The mean proximate composition of samples varied significantly (p< 0.05). The moisture content of the coated smoked fish samples ranged from 10.86 to 11.28%, these values was higher when compared with 8.80% control sample. The moisture content of the control was similar to 6.7- 7.33% (Yola and Timothy, 2012), but lower when to the values of the experiential samples. During smoking process the moisture content observed among samples may be attributed to a number of factors which include the chemical components, nature (such as presence of coating, thickness of the coating film and adhesion capacity of the coating material) and size of food item, degree and time of exposure to heat energy during smoking. Similar trend of moisture content variation was observed on deep-fat fried fish coated with chickpea flour bead and batter (Asmita *et al.* 2013) and fried chicken meat coated with Oat flour beads (Osman, 2013). Loss of moisture content cause changes on the chemical composition of foodstuff (Ogbonnaya and Ibrahim, 2009). The crude protein of the coated samples was discovered between 66.11 and 67.97%; the least value of 63.09% was discovered on the control. This observation indicate the ability of the adhesion capacity of the coating material as a protective shield against rate of migration and denaturation of the solid mass such as protein in foodstuff during heat treatment. However, the crude protein discovered was higher than 59.28% reported for traditionally smoked catfish (Ogbonnaya and Ibrahim, 2009). Again, the fat content of the coated samples varied, the mean score ranged between 15.10 and 16.10% (coated smoked fish) and these values was higher than 13.45% control. Also, the values was higher when compared with10.0% (Holma and Maalekuu, 2013) but lower to 21.20% reported by Ogbonnaya and Ibrahim (2009). However different nutritional components of fish undergo different changes at elevated temperature irrespective of pre-treatment employed used during processing. The ash content showed no significant difference among the coated smoked fish samples, the values range between 3.56 and 3.60% and the control sample had the least value 3.45%. Amount of ash content in foodstuff is a measure of mineral elements that are important in human nutrition (Onyeka, 2008). The fiber was discovered from 1.61 to 1.67% and the nitrogen free extract (NFE) was between 0.25 and 13.58%. The highest value of NFE discovered could be attributed to changes on the chemical composition of foodstuff during processing The use of edible coating material either inform of batter or beads during fish smoking process provides not only shield against loss of solid mass but also a barrier against toxic substance polycyclic aromatic hydrocarbon (PAHs) generated from the smoking process.

Table 2: Proximate composition of coated smoked catfish

Parameter	Corn starch beads coated	Cassava starch beads coated	Wheat starch beads coated	Smoked catfish (control)	Least significant different (p<0.05)
*Moisture (%)	$10.86^{c}\pm0.01$	$11.09^{b}\pm0.01$	$11.28^{a}\pm0.01$	$8.80^{d}\pm0.05$	0.00707
*Protein (%)	$66.11^{c}\pm0.05$	$67.01^{b}\pm0.05$	$67.97^{a}\pm0.06$	$63.09^{d}\pm0.01$	0.00745
*Fat (%)	$16.10^{a}\pm0.06$	$15.10^{a}\pm0.06$	$15.23^{c}\pm0.01$	$13.45^{d}\pm0.01$	0.00850
*Ash (%)	$3.58^{a}\pm0.01$	$3.56^{a}\pm0.01$	$3.60^{a}\pm0.05$	$3.45^{c}\pm0.01$	0.00745
*Fiber (%)	$1.61^{c}\pm0.01$	$1.61^{c}\pm0.01$	$1.67^{b}\pm0.01$	$1.63^{c}\pm0.01$	0.01179
*NFE (%)	$1.74^{b}\pm0.02$	$0.82^{c}\pm0.01$	$0.25^{d}\pm0.01$	$10.58^{a}\pm0.05$	0.00122

*Mean of triplicate sample; ± standard deviation; mean score with different superscript letter across the row are significantly different (p<0.05). NFE = Nitrogen Free Extract.

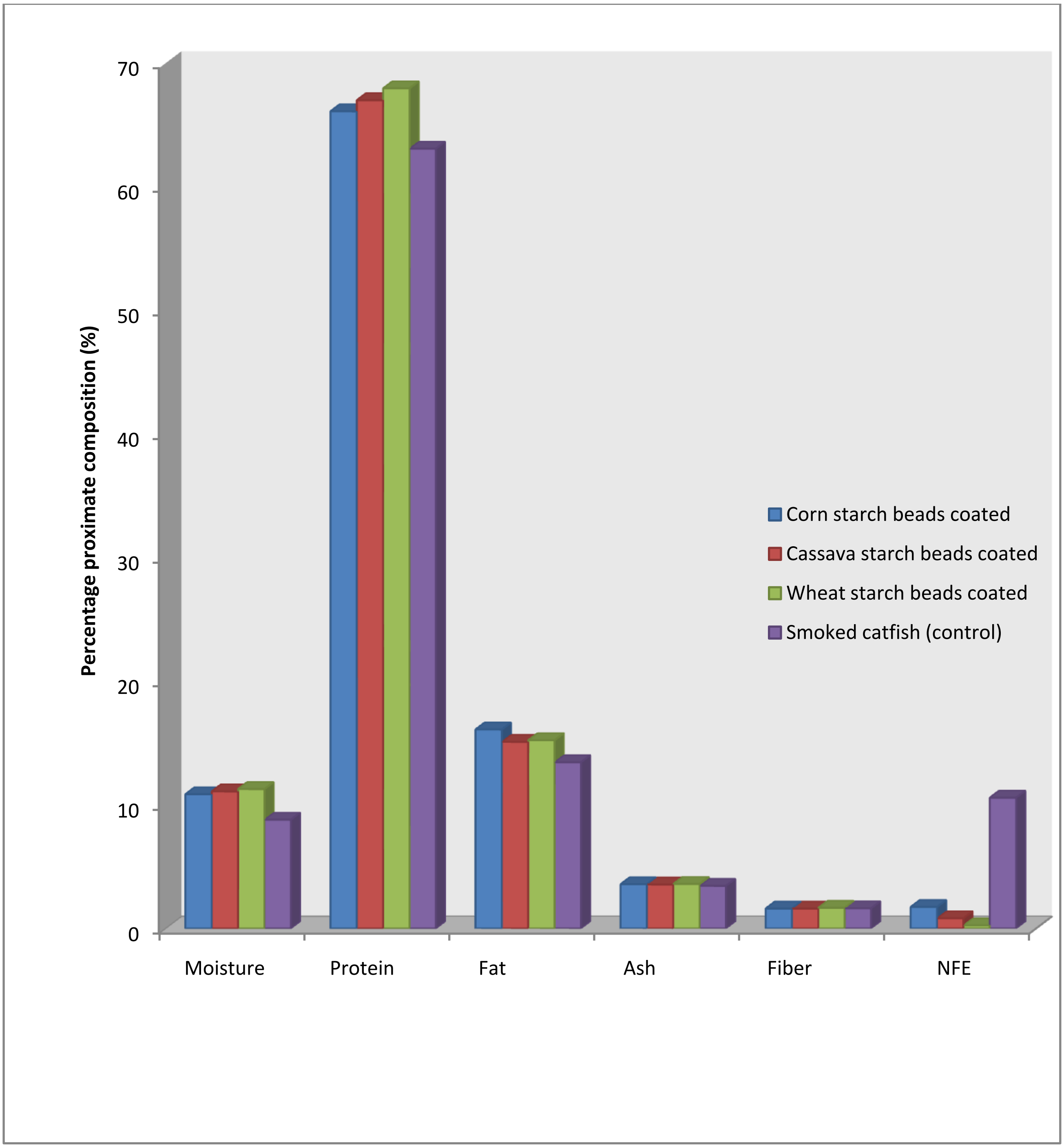

Figure 2: Proximate composition of coated smoked catfish

Mineral Content of Smoked Catfish Coated with Edible Carbohydrate Materials:

The mineral element content of smoked catfish was presented in Table 3. The descending order of mineral content discovered are calcium highest value, followed by potassium, iron, sodium, zinc and manganese was the least irrespective of the coating material used. The mineral elements (mg/100g) discovered on smoked fish ranged from 6.43-6.92 calcium, 2.96-3.78 potassium, 1.88-1.98 iron, 0.78-0.98 sodium, 1.20-1.27 zinc and 0.321-0.386 manganese. Akon and Salihu (2004) discovered lack of well-defined magnitude order for major mineral element in dried fish. The result discovered in this work was not tallies with the report of Akinneye *et al.* (2010) who discovered highest concentration of zinc among the mineral elements of dried fish samples. But the finding was in agreed with Kirchgessner and Schwall (1986) who detected highest value of calcium from oven-dried fish samples. However, the variation on the nutritional composition of fish tissue may be attributed to a number of factors which include species of fish, seasonality, feeding, size and maturity and as well as method of processing.

Table 3: Mineral Content of Smoked Catfish with Edible Coating Materials

Smoked Fish sample	Calcium mg/100g	Sodium mg/100g	Potassium mg/100g	Manganese mg/100g	zinc mg/100g	Iron mg/100g
Corn beads coated	6.82	0.88	3.71	0.321	1.22	1.96
Cassava flour beads coated	6.78	0.82	3.68	0.386	1.20	1.98
Wheat flour beads coated	6.92	0.78	3.78	0.382	1.21	1.92
Control (Uncoated)	6.43	0.98	2.96	0.379	1.27	1.88

Sensory Evaluation of Smoked Catfish

The mean scores for sensory attributes of smoked catfish as influenced by edible coating materials are presented in Table 4. The result from the Table 4 did not shown any significant difference ($p< 0.05$) on the sensory attributes of the experimental coated samples of fish but differs significantly from the control. This observation was similar to the finding of Osman and Şűkrű (2010) who reported no significant difference ($p< 0.01$) on sensorial parameters of deep-fat fried chicken nuggets coated with mixture of batter and beads. The indication from this work implies that the source of carbohydrate coating material may not significantly affect the sensory attributes of the coated smoked fish. The nature and chemical properties of carbohydrate coating material from different source (cereal and tuber) are similar. General acceptability of the control sample was the highest 8.05, followed by 6.35 (cassava flour beads coated) and the least value of 5.35 was discovered from sample coated with corn flour beads respectively. The result of Pearson's correlation (Table 5) showed 0.998 and 0.987 correlation values ($p = 0.05$) for taste and aroma respectively to general acceptability of coated smoked fish. This result obtained showed the influence of taste and aroma attributes on the general acceptability and consumer preference for the smoked fish.

Table 4: Mean scores for sensory attributes of coated smoked catfish

Sensory Attribute	Smoked catfish (corn flour coated)	Smoked catfish (cassava flour coated)	Smoked catfish (wheat flour coated)	Smoked catfish (control)
Appearance	5.0^b	5.50^b	5.80^b	8.05^a
Aroma	5.20^b	5.70^b	5.65^b	7.15^a
Taste	5.0^b	5.95^b	5.80^b	7.60^a
Texture	4.90^b	5.80^b	5.35^b	7.90^a
Overall acceptability	5.35^b	6.35^b	6.25^b	7.85^a

Mean score with different superscript letter are significantly different across the row ($p>0.05$).

Table 5: Pearson correlation of sensory attributes of coated smoked catfish

		Correlations Appearance	Aroma	Taste	Texture	Overall acceptability
Appearance	Pearson Correlation	1				
Aroma	Pearson Correlation	.989*	1			
Taste	Pearson Correlation	.977*	.995**	1		
Texture	Pearson Correlation	.974*	.995**	.986*	1	
Overall acceptability	Pearson Correlation	.968*	.987*	.998**	.975*	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

4. CONCLUSION

In this study there was significant effect of edible coating material either informs of beading (dry mixture) or batter on the nutritional of value of smoked fish. The effect of heat during smoking process on proximate composition of fish was minimized in coated samples when compared with the control in terms values discovered. The protective shield or barrier of the coating against the rate of mass transfer or loss of solid matter from the tissue of the fish is of great importance during smoking process. From the findings, the rate of loss of protein, fat and ash content was minimized in coated smoked fish during smoking. The mineral content of the smoked did not show well-define pattern. The fish subjected to coating beads or batter during smoking showed different nutritional component. Again, the consumer acceptability of smoke fish depends largely on the aroma and taste of the fish. The present study provides a possible application of edible carbohydrate coating as technique that can be adopted by artisanal in fish processing in Nigeria and elsewhere.

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