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Full Length Research Paper

The nutritional composition, sensory evaluation and microbiological studies of fish cake made from shrimp bycatch

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This study reports on the nutritional composition, sensory evaluation and microbiological studies of fish cake made from shrimp bycatch. The yield of mince from the bycatch was 80.26% mince; 10.21% residue and 9.53% loss. The mince proximate composition was 66.32% moisture; 20.08% protein; 3.45% lipid and 3.93% ash. The proximate composition of the raw fish cakes was 64.40% moisture; 19.13% protein; 4.14% lipid; 6.11% ash and 6.22% carbohydrate. The deep fried fish cake had 60.12% moisture; 21.01% protein; 8.50% lipid; 6.30% ash and 4.07% carbohydrate. No significant difference (P > 0.05) was observed between the proximate composition of raw and deep fried fish cake. The peroxide values (PV) of raw and deep fried fish cake ranged from 7.20 - 22.00 mEqO_2/Kg of lipid during six week storage period. There was significant correlation between storage time and peroxide values in both treatments. Microbiological analysis showed that the Total Viable Count (TVC) decreased with increase in frozen period. The results obtained were within the acceptable limit of International Commission on Microbiological Specification for Food. The organoleptic properties of the deep fried cake indicated that the product was acceptable until about the fourth week. The study showed that fish cake from shrimp bycatch is microbiologically safe and nutritionally high in protein, fat as well as calcium.

Key words: Bycatch, fishcake, shrimp, sensory, proximate, mince, peroxide values, staphylococcus.

INTRODUCTION

Conventional shrimp trawls are poor selective fishing gears and so retain large quantities of non- target species, collectively termed bycatch (Saila, 1983). Bycatch from shrimp trawls was estimated to be around 11.2 million tonnes worldwide (Alverson et al., 1994). The mortality of bycatches from shrimp trawls has attracted worldwide at-tention (Saila, 1983; Andrew and Pepperell, 1992; Alver-son et al., 1994).

The Sea Fisheries Decree NO 71 of 1992 requires that all shrimp trawl cod end should not exceed 44 mm mesh size. The law also recommends that the ratio of fish: prawns should be maintained at 75:25. In practice, this is never maintained and more fish (as high as 90% fish), re-lative to prawns are caught.

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The huge bycatch rate has resulted in the evolution of a thriving trade in by-products. About 100,000 tons of by-catch fish are produced annually from the industrial sec-tor. This is about 25% of the total annual fish produced in Nigeria which is estimated at 400,000 MT. Bycatch thus, supports an estimated 12 billion Naira industry in the coa-stal states in Nigeria. At sea, shrimp trawlers freeze the valuable catch referred to as the cruise targets. Excess of cruise target and fish bycatch is traded at sea through a system where motorized artisanal canoes buy the fish and transport it to shore where it is processed and mar-keted (CEHRD, 2007).

Available report has shown that the trade in bycatch was borne out of food shortage (CEHRD, 2007). Bycatch sales intensified when target shrimp (*Penaeus notialis*) catch rates dropped and cruise targets were rarely attain-ed within specified shrimping duration. For instance, in the early years fleets spend a maximum of two weeks on sea and return to base. Now the fishery has dwindled so

Table1. Formula for spiced minced fish cakes.

Ingredients	Percentage
Minced Fish	80.00
Wheat Flour	7.80
Chuffed, Fresh Onions	4.00
Concentrated Tomato purees	4.00
Deodorized vegetable oil	2.00
Ground melon	1.00
Salt	0.70
Chili pepper	0.40
Monosodium glutamate	0.06
Thyme	0.02
Curry powder	0.02
Total	100.00

much that vessels spend up to 45 days fishing. The above scenario results in a situation whereby management of companies subscribe to on-the-sea sales of by-products to augment costs. Currently, the leadership of bycatch traders' unions has succeeded in penetrating the management of the shrimp companies and secured official approval of the business.

The dominant families representing bycatch fish are Clupeidae (mostly *Ilisha africana*, the West African Iiisha). Polynemidae (thread-fins especially *Polydactylus quadrifilis*). Others include members of the Ophichthidae, Soleidae, Rajidae and Mobulidae. Bycatch composition in coastal shrimp fisheries are croakers *Pseudotolithus elongatus, P. senegalensis and P. typus*. (Dominant), puffer fish *Ephiphion guttifer* (very abundant), hairtail *Trichurus lepturus* (dominant), swimming crab *Callinectis* sp (abundant) (CEHRD, 2007).

Zynudheen et al. (2004) examined the utilization of trawl bycatch in Gujarat (India) while Eyo et al. (2005) reported on the assessment of fish bycatch species from coastal artisanal shrimp beam trawl fisheries in Nigeria. Recently, the global trend has been towards a better utilization of bycatch to promote the beneficial aspects of the under-utilized fish (Anonymous, 1982) . In Nigeria, there have been no studies on the utilization of bycatch as fish-based cake. This study examines the possibility of incurporating the mince of the bycatch in a fish- based cake as a snack. The product can be used to solve the problem of protein energy malnutrition especially among pre-school children. Consumption of snack food is a worldwide practice. Snack foods are important vehicles for delivery of essential nutrients because of the growing change in eating habits (Henshaw and Agunbiade, 2004). To gain consumer acceptance of a fish based product rather than the carbohydrate snacks, the consumer would have to be convinced of the quality and possible nutritional advantages with respect to the standard product it is replacing.

This production of fish-based cake was carried out to determine the nutritional composition, sensory quality and some aspects of chemical and microbiological changes of the products during storage. This study therefore, reports on the nutritional composition, sensory evaluation and microbiological studies of fish cake made from shrimp bycatch.

MATERIALS AND METHODS

Source of raw materials

A bag of bycatch (20 kg from different sizes ranging from 5 - 14 cm) commonly referred to as 'miscellaneous' fish was purchased from the Ijora cold room fishing company depot in Lagos, Nigeria. The samples contained moonfish (*Vomer setapinnis*), bigeye grunt (*Brachydeuterus auritus*), Bonga (*Ethmalosa fimbriata*), Croaker (*Pseudotolithus* sp), Flat herrings (*Sardinella maderensis*).

Production of mince

The fish samples were thawed, gutted and washed to get rid of blood, pieces of gut, kidney, tissue and swim bladder. The mince was obtained using the Baader 694 (Lubeck, FRG) meat/bone separator using 3 mm drum orifices. It was steamed for a period of 40 min to soften the bones (Akande, 2000) and then grinded with the mixer blender (Minohun, Model: MS-223) to obtain boneless slurry, the mince was then weighed on a DE Series, Platform Scale (Model: DE60K5N). The production yield and proximate composition of the mince were determined.

Preparation of fish cake

The composition results in percentage, which were produced from flour, vegetable oil, salt, onion, pepper and seasonings, are summarized in Table 1. The mince flesh was then mixed thoroughly with the above ingredients in a double action Leland food mixer (Leland Southwest 100DA70 Double Action ^{TM} Mixer) for 10 min. Cakes with an average weight of 60 g were molded using an accupat food for-mer (Accupat Model DA). Some of the fish cakes were deep fried in hot pure vegetable oil and the remaining stored in a chest freezer at a temperature of -20°C. Samples were taken on weekly basis for six weeks for further analysis.

Chemical analysis

Several chemical analyses of the mince and fish cake were investigated including moisture, protein, lipid and ash. Two gram samples were used for moisture determination by drying to constant weight in an air oven at 103 ± 2° C for 24 h based on AOAC (1994). Percent protein (Kjeldahl N x 6.25) was determined by total nitrogen method from a 2 g portion of sample for each treatment by AOAC (1994) method. Lipid was extracted from 2 g portion of sample for each treatment using a modified Bligh and Dyer method (1959). Ash for each treatment was determined according to AOAC (1994) by placing the residue from moisture determination in a muffle furnace at 525°C to incinerate until the sample was completely free from carbon particles. The dish was then placed in a dessicator to cool before weighing. The carbohydrate content was calculated by difference.

Two grams of the fresh and fried cake balls were oxidized by wet ashing procedure (Perkin Elmer Inc., 1971) and the calcium was determined by Atomic Absorption Spectrophotometry (AAS) using a Perkin-Elmer 209 at a wavelength of 432 nm.

Peroxide value (PV)

Lipid extract obtained from the crude fat was used for the determi-

Table 2. Organoleptic assessment score sheet used by taste panel.

Factor	Scores				
	1	2	3	4	5
Appearance	Unacceptable	Fair	Medium	Good	Very good
Saltiness	Too salty	Slightly too salty	Acceptable	Slightly salty	No salt
Rancidity	Extremely rancid	Highly rancid	Medium rancid	Slightly detectable rancidity	No detectable rancidity
Flavour	Undesirable fishy	Slightly undesirable fishy	Medium fishy	Good	Excellent
General Acceptability	Very bad	Bad	Fair	Good	Excellent
Texture	Very bready	Fairly bready	Medium bready	Good	Excellent

Table 3. Production yield of the mince from the bycatch produced using pepper blender.

Parameters	Percentage Yield (%)
Mince	80.26 ± 0.008
Residue	10.21± 0.003
Loss (by difference)	9.44 ± 0.008

Table 4. Composition of the mince from bycatch.

Parameters	Percentage (%)
Moisture	66.32 ±1.15
Protein	20.08 ± 0.86
Lipid	3.45 ± 0.35
Ash	3.93 ± 0.63
Carbohydrate	3.94 ± 0.22
Calcium	2.29.± 0.68

nation of peroxide value using a modified method of Lee (1971). About 0.5 - 1.0 g (w) of the lipid was accurately weighted into a 250 cm^3 of chloroform (containing 0.01% Buthylated hydroxytoluene (BHT) and shaken for 30 s to dissolve the lipid. 50 cm^3 of solvent mixture (glacial/acetic acid: Chloroform 3:2 v/v) was added and the flask gently rotated to facilitate mixing. 1cm^3 of saturated potassium iodide was then added, mixed and kept in a dark cupboard for 3 min. 100 cm^3 of distilled water was added to the mixture and the liberated iodine titrated with 0.05 M sodium thiosulphate solution using 2% freshly prepared starch as an indicator.

Sensory evaluation

Frozen fish cake balls were thawed and deep fried in hot pure vegetable oil. Hot samples were served immediately to each member of the panel. The subjective evaluations of product quality were carried out by an experienced sensory judges composed of ten students and staff from the Fish Technology Section and student body from the Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos because of their knowledge of sen-sory evaluation methods and the food product being tested. Quality attributes studied include appearance, saltiness, rancidity, flavour, general acceptability and texture. Panel members scored all factors on a 5-point Hedonic scale which is summarised in Table 2 and a mean score of 3 was used as the acceptable limit. Panellists were given an opportunity to make additional comments. The number of samples tasted at one sitting was limited to two to minimize taste fatigue. Unsalted crackers and water were provided to each member of the panel after each test. (Akande et al., 1988)

Microbiological analysis

Fish mince and cake were analyzed for microbial population. Serial dilutions of the samples in quarter strength Ringers solution (Oxoid, Hampshire, UK) were used for microbial enumeration with the following media: Standard plate count agar (Oxoid) for Total Viable Count (TVC) and Baird Parker agar medium for *Staphylococcus aureus*. Portions (0.1 ml) of appropriate dilution were spread plated in triplicate. Counts on Standard plate count agar, were obtained after incubation for 48 h at 25°C, while Baird Parker agar plates were inoculated aerobically at 37°C for 24 h. Results were calculated as a mean of three determinations.

Statistical analysis

The minimum, maximum and mean values were calculated and the standard deviation determined. Data were compared by paired t-tests and analysis of variance. Significance was established at $p < 0.05$ (Sokal and Rohlf, 1987).

RESULTS

The yield and compositional data of mince using the blender are presented in Table 3. The percentage compositional yield of mince from the bycatch was found to be 80.26 ± 0.008% mince, 10.21 ± 0.003% residue (Skin and Offal) and 9.53 ± 0.008% loss calculated from difference. The proximate composition of mince (Table 4) produced from the bycatch showed 66.32 ± 1.15 % moisture, 20.08 ± 0.86% protein, 3.45 ± 0.35% lipid, 3.93 ± 0.63% ash, 3.94 ± 0.22% carbohydrate and 2.29 ± 0.68% calcium.

The summary of proximate composition analysis performed on raw and deep fried fish cake is shown in Table 5.

The deep fried fish cake had very high protein value. The protein content of 21.01 ± 0.24% in the deep fried fish cake is higher than that of raw (19.13 ± 0.69) fish cake. The deep fried fish cake also has high lipid content compared to the raw fish cake. The peroxide value (PV) ranged between 7.2 - 22.0 m$Eq0_2$/kg of lipid during stor-

Table 5. Proximate composition of raw and deep-fried spiced mince fish cakes.

Parameters (%)	TREATMENT	
	Raw cake	Deep fried
Moisture	64.40 ± 2.07	60.12 ± 2.42
Crude Protein	19.13 ± 0.69	21.01± 0.24
Lipid	4.14 ± 0.42	8.50 ± 0.36
Ash	6.11 ± 0.41	6.30 ± 0.16
*Carbohydrate	6.22 ± 0.35	4.07 ± 0.43

*Carbohydrate was calculated by difference.

Table 6. Rancidity development in raw and deep-fried spiced frozen mince fish cakes.

Types of Cakes	Storage time week	Peroxide on mEq0_2/kg of lipid
Raw cakes	0	17.20
	1	20.11
	2	21.02
	3	22.00
	4	19.32
	5	16.0
	6	15.0
Deep-fried Cakes	0	17.19
	1	16.00
	2	14.00
	3	12.45
	4	11.12
	5	9.00
	6	7.20

Table 7. Sensory evaluation of the fried fish cake by taste panel.

Sensory Evaluation	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Parameters	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
Appearance	4.6 ± 0.52	4.4 ± 0.52	4.0 ± 0.82	3.6 ± 0.42	3.4 ± 0.52	2.9 ± 0.57	2.5 ± 0.53
Saltness	4.0 ± 1.05	4.0 ± 1.05	4.4 ± 0.97	4.8 ± 0.42	4.3 ± 0.48	4.6 ± 0.52	4.6 ± 0.52
Rancidity	5.0 ± 0.00	5.0 ± 0.00	5.0 ± 0.00	4.7 ± 0.48	3.5 ± 0.53	3.5 ± 0.53	2.5 ± 0.53
Flavour	4.5 ± 0.53	4.3 ± 0.48	4.4 ± 0.52	3.8 ± 0.42	3.3 ± 0.48	2.8 ± 0.42	2.4 ± 0.52
General appearance	4.4 ± 0.52	4.3 ± 0.48	3.8 ± 0.42	3.7 ± 0.48	3.3 ± 0.48	3.1 ± 0.32	2.7 ± 0.48
Texture	4.8 ± 0.42	4.3 ± 0.48	4.9 ± 0.74	3.6 ± 0.56	3.4 ± 0.52	2.9 ± 0.57	2.5 ± 0.53

age from zero to 6 weeks (Table 6).The mean taste panel scores of the deep fried fish cake are as shown in Table 7. The evaluation showed that the product is organoleptically acceptable in terms of appearance, saltiness, rancidity, flavor, general appearance and texture from week 0 to week 4 based on the mean values of 3.0 and above obtained. After four weeks of storage, the panel evaluation mean results were less than 3.0 for all the parameters except for saltiness where a score of 4.6 ± 0.52 was recorded for both weeks 5 and 6. Statistically, however there was a significant difference ($P< 0.05$) in the sensory evaluation scores of the panel on the deep fried fish cake between the fourth and six weeks storage period.

The microbiological counts of the mince showed Total Viable Count (TVC) as 10.4×10^5 cfu/g and *S. aureus* as 3.1×10^2 cfu/g (Table 8) . Total Viable Counts of microbes ranged from 2.1×10^2 to 11.1×10^3 cfu/g in the raw frozen fish cake stored for 6 weeks at -20°C. *S. aureus* count ranged from less than100 to 3.1×10^2 cfu/g for the same storage period. The deep-fried cake showed Total Viable Counts of less than 100 cfu/g and no trace of *S. aureus* throughout the period of study (Table 9). Total Viable

Table 8. Microbiological counts of mince fish.

Parameter	Mince Fish
Total Viable Count	10.4×10^{-3} cfu/g
Staphylococcus aureus	3.1×10^{2} cfu/g

Table 9. Effect of frozen storage on the microbiological quality of raw and deep-fried fish cake.

Type of cake	Storage time (week)	Total viable count (TVC) (Cfu/g)	*Staphylococcus aureus* (Cfu/g)
Raw cakes	0	11.1×10^{5}	3.1×10^{2}
	1	7.8×10^{3}	1.3×10^{2}
	2	6.9×10^{3}	<100
	3	3.1×10^{3}	<100
	4	4.2×10^{2}	<100
	5	1.2×10^{2}	<100
	6	2.1×10^{2}	<100
Deep-Fried	0	<100	-
	1	<100	-
	2	<100	-
	3	<100	-
	4	<100	-
	5	<100	-
	6	<100	-

Count (TVC) decreased with frozen storage and figures were within the acceptable Limits of International Commission on Microbiological Specification for Foods (ICMS F) for a product of this nature.

DISCUSSION

The 80.26 ± 0.008% yield of mince from the bycatch used in this study is higher than the result obtained by Akande and Oladosu (1988) on other individual species of Nigerian fish mince recovered using the Baader - Johnson Food Processing Machine. The authors reported 65.27% for bonga (*E. fimbriata*), 65.27% for West African sardines (*Sardinella maderensis*) and 63.00% for West African shad (*I. africana*) . Miyauchi and Steinberg (1970) reported that the total yield of mince from various species of marine and fresh water fish ranged from 37 - 60%. The yield of mince obtained from tuna was about 84% Talabi et al., 1982), and about 63.54% from whole bycatch fish.

Yield of mince varies with species and is a function of anatomical features, state of maturity and quality of the species involved (Ali, 1987). Finne et al. (1980) observed that, fish that have just completed spawning are likely to produce more yield. Grantham (1981) reported that the yields of 60 - 80% could generally be obtained from whole fish. The yield from bycatch in this study conforms to the report of Grantham (1981). Information on composition and yield are essential, if fish and fish products are to be utilized efficiently, intrinsic and extrinsic qualities are bound to play their roles in this respect (Eyabi Eyabi, 1988).

There was a decrease in moisture content of deep-fried cakes thereby allowing for a concentration of the protein in these cakes. The lipid content also increased. During the process of deep-frying there was release of bound water into the pure vegetable oil, thereby leading to the low moisture content. However, there was no significant difference ($P > 0.05$) between the proximate composition particularly the protein content of the frozen raw and deep-fried cakes.

The organoleptic properties of the deep-fried cakes indicated that the products were acceptable according to the panel's evaluation, though statistically there was significant difference ($P < 0.05$) in the sensory evaluation between the fourth and six weeks storage based on the panel's score, comparisons being made using paired t-test. Rancidity did not set in until about the sixth week. Rancidity is caused by a higher rate of lipid oxidation, which consequently affects the flavor and general acceptability. Lipid oxidation did not pose a problem to frozen and deep fried samples (Ikeme, 1988).

There was a general trend of a decrease in peroxide value with an increase in storage time. Peroxide value is a measure of the hydroperoxides contained in the oil, being the first product of oxidation. With further decomposition, short chain compounds are produced which are responsible for the off-flavour usually associated with PV measurement during the first week of storage. Peroxide

values of 20 - 22 mEq0_2/kg of lipid are said to correspond with noticeable rancid taste. In this study, only in raw cakes were peroxide values of 20 - 22 mEq0_2/kg recorded which might just be incipient of noticeable rancid taster. The deep fried cakes had values below this range implying that the processes of frying might have removed some of the products of lipid oxidation. The raw cakes showed some of the characteristic peaks associated with the formation of hydroperoxides in a model system. There was no significant correlation between storage time and peroxide values in raw cakes with an observed correlation coefficient r = -0.48. Deep-fried fish cake showed significant negative correlation with storage time with an observed correlation coefficient r = -0.99. There was a significant difference ($P < 0.05$) between the PV of the raw and the deep-fried fish cake.

Microbiological count of the mince fish was lower than that of the fish cake. This could be as a result of the fact that the mince fish was still fresh and was just undergoing processing. Microbiological analysis of the cakes showed that Total Viable Count (TVC) decreased with increase in frozen period of six weeks. All the values obtained for the mince and fish cakes were within the acceptable International Commission on Microbiological Specification for Food (ICMSF) limits for a product of this nature. Although *S. aureus* was only found in the raw cakes, the values were still within the limit of 10^3 cfu/g recommended by ICMSF in Good Manufacturing Practice (GMP). The presence of S*. aureus*, though at an acceptable level, still emphasizes the need for better hygienic handling of raw materials although the microbial quality was not a problem within the six weeks frozen storage.

The presence of spices in the formulation of the cakes, which can be bactericidal in nature, may also have accounted for the low figures of micro-organisms. In fried fish cakes drastic reduction in bacteria, generally less than 100 cfu/g were observed, due to the heating processes which leads to the destruction of viable organisms and absence of *S. aureus.*

The present study aimed at production of a potential new fishery product in the form of fish cakes from shrimp bycatch with reasonably good nutritive value for human consumptions. Fish cakes were found to be microbiologically safe for a minimum of six weeks at frozen storage temperature of -20°C in a chest freezer.

The processing of bycatch fish species into fish cakes on cottage industry level can be encouraged to reduce poverty. In this study, the blender was able to grind the steamed fish into boneless slurry, to which flour was added to obtain a dough-like mixture before molding. The blender is an equipment that can be affordable and readily available. Fish cakes could provide a viable livelihood, especially to women entrepreneurs. The product could either be frozen for sale in the super markets for frying later at home or can be sold as fast food in a restaurant. The advantage of the low-cost technology is that it attuned to the needs of a developing country. It is also gender-fri endly, since women easily operate the blender, thus ensuring that they are not displaced from their traditional role of fish processing and marketing. Fish cake processing apart from its appeal in increasing protein intake can also be a viable commercial venture.

The findings in this study indicated that fish cake from bycatch is feasible, and nutritionally high in protein, fats and calcium. However, further study is required to assess the commercial potential of the fish cake product.

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