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Physicochemical and sensory properties of cassava starch – based fish and beef crackers ('keropok')

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Abstract

Physicochemical properties and acceptability of fish and beef crackers ('keropok'), an important product in Malaysia, prepared using cassava starch, beef and fish were investigated. Fish and beef crackers of acceptable quality containing 40:60 fish or beef to starch ratio, 3.1% bullion cube; 1.7% egg yolk, 2.2% salt, 29.6% water and 10mg/kg colouring matter were produced. Among the colours considered, the orange and dragaco (tartrazine E 122) colour containing fish and beef crackers were more acceptable to the panelists than the non-coloured (control) as well as the green based ones. Crackers made from fish had higher percentage linear expansion (189%) than beef based crackers (117%). Fish crackers were rated better in terms of crispiness, taste and overall acceptability.

Introduction

Cassava roots play an important role in the African diet and they are processed using simple traditional methods into products such as 'gari' and 'fufu'. Protein-energy malnutrition is one of the most serious nutritional deficiency problems in many areas where cassava is the main staple diet [1]. Attempts have been made to map out strategies for combating this nutritional problem. Supplementation with animal or plant proteins has been suggested as one way of improving the nutritional quality of cassava based diets [1, 2, 3]. In recent times, prawn crackers made from starch and fish flavours have been introduced into Nigerian market.

These products have become very popular as snack and leisure foods.Fortunately, they can be used as vehicles for getting animal protein required by the teeming consumers in Nigeria who do not have access to adequate protein rich foods.

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Corn or sago starch flour based crackers ('keropok') are popular snack food in Malaysia and many other ASEAN countries, which have since been found common in Nigerian market. They are produced by gelatinisation of starch with water to form dough loaves, which are shaped, cooked and thinly sliced. The slices are then dried and expanded into a low-density porous product upon immersion in hot oil. Fish, prawn, salt, sugar and other ingredients are usually added [4, 5]. Crackers produced from minced fish with varying levels of cassava flours have been reported [5]. There appears to be a dearth of information on the use of beef to produce palatable ready to serve crackers. Acceptability of beef or fish crackers may create an additional variety in the diets of many people in Nigeria where cassava forms the staple food. Furthermore, the popularity of cassava starch in cracker manufacture could create further demand for cassava starch made in Nigeria.

The purpose of this study is to produce beef and fish crackers of acceptable quality using cassava starch and other ingredient and to evaluate and compare their physico-chemical properties.

Materials and Methods

Raw material source and preparation

Fresh mud cat fish *(Clarias niloticus),* fresh beef muscle, and food colours: Dragaco (Tartrazine: E102), orange (Quinoline yellow: E124) and Blue (Carmosine: E122), egg, salt and bullion cubes were purchased from local market in Maiduguri. The fish was descaled, filleted and then finely minced using Kenwood mincer (model A901, Thorn EMI Kenwood Small Appliance Ltd., Havant, Hants). The beef was washed and minced as described for the fish before use. One starch sample (SA) was home processed from fresh cassava roots using the method described by Ihekeronye and Ngoddy [6]. The other sample (SB) was purchased from a local market in Benin City. The starch samples were sun dried then packaged in polyethylene bags before transferring them to the Department of Food Science and Technology Laboratory, University of Maiduguri. The starch samples were pulverised using a hammer mill (Gibbons Electric Woodrolfe Road, Tolllesbury, Essex, UK) to particle size range of 250 – 425mm before use. The eggs were assessed for quality using visual defects such as cracked shell, blood spot or meat spot in the yolk.

Processing methods for fish and beef crackers

The formulations contained fish or beef, 26.56%; starch, 39.84%; bullion cube, 3.1%; egg yolk, 1.7%; salt, 2.2% and water, 26.6%, all by weight. The fish or beef to starch ratio of 40:60 as reported by Yu *et al* [5] was used throughout this study. Two types of fish (FSA and FSB) and beef (BSA and BSB) based cracker samples were prepared using the different starches, SA and SB. The food colours were applied at 10mg/kg, respectively.

The minced fish or beef, starch (SA or SB) and other ingredients were mixed at room temperature (28±2°C) employing Kenwood mixer equipped with a paddle beater until a homogeneous mixture was obtained. The resulting dough was stuffed into 4cm diameter polyethylene bags using a sausage stuffer. The rolls were steamed (100°C) for 80 – 90 mins for fish crackers and 120 mins for beef crackers under atmospheric pressure to gelatinise the starch. After steaming, the cooked rolls were placed overnight in a refrigerator (4 – 10°C) to cool. The cylindrical rolls were removed from the polyethylene bags and carefully sliced using a sharp knife to fairly uniform thickness. The sliced crackers were then dried for 6h using a tray drier (Armfield Technical Education Company Ltd, Hampshire, England) set at a temperature of 41°C, relative humidity of 41% and air flow rate of 1.7 m/s. After drying, some of the samples were fried in hot groundnut oil (160 – 180°C) for 3 – 5 mins and the remainder were packaged in polyethylene bags and reserved for analysis.

Chemical analysis

Starch, fried fish or beef crackers were analysed for moisture, crude protein, fat and ash by AOAC [7] methods. Carbohydrate was calculated by difference and energy by using the Atwater factors of 4, 9 and 4 for protein, fat and carbohydrate, respectively. Titratable acidity and pH of starches (SA and SB) were determined by the methods described by Pearson [8].

Water absorption and swelling properties

The water absorption and swelling properties of starch samples SA and SB were determined by methods of Fleming *et al* [9].

Linear expansion

The percentage linear expansion of dried fish or beef crackers was calculated as described by Yu *et* al [5].

$$\% \text{ Linear expansion} = \frac{\text{Length after puffing} - \text{Length before puffing}}{\text{Length before puffing}} \times 100$$

A trained panel of 12 members comprising of staff and students of the Department of Food Science and Technology was used to determine the preference of various fish and beef crackers along with control samples for colour, crispiness, taste and overall acceptability. A nine point hedonic scale (1 = dislike extremely and 9 = liked extremely) was used [10].

Statistical Analysis

Chemical and sensory analyses data were statistically analysed by one-way ANOVA [11] with Ducan's Multiple Range Test applied to determine differences between means. Statistical significance was accepted at 5% level.

Results and Discussion

Physicochemical Properties of Cassava starch

The physicochemical properties of cassava starches, SA and SB used in the preparation of fish and beef crackers are presented in Table 1. With the exception of slight differences in ash and fat, SA and SB had similar compositions with the values within the range reported for cassava starch [12]. The water swelling capacity of starch SB was slightly higher than that of SA after 60 mins. Also, SB had higher water absorption capacity at 28°C and 70°C compared to SA. It appeared fermentation had occurred in starch SB [13], which perhaps, slightly influenced its water absorption capacity.

Proximate composition of dried and fried fish and beef crackers

Table 2 shows the proximate composition of dried and fried fish and beef crackers. Dried beef crackers (BSA and BSB) had slightly higher protein content than dried fish crackers (FSA and FSB).

There were variations in the ash content of dried fish and beef crackers. Those with higher moisture content (FSB and BSB) had lower ash content and vice versa. The ash content of crackers prepared from starch SA were higher than those prepared from starch SB. This may be due to the initially higher ash content of the latter (Table 1). With the exception of fish crackers FSA, all the dried crackers had similar fat content (Table 2).

After frying, the moisture contents of both the fish and beef crackers from different starches decreased considerably (Table 2). The highest moisture content was obtained from FSB cracker and the lowest from FSA. The fish and beef crackers at 1.3 – 3% moisture content should therefore store well if appropriately packaged.

Table 1: Physicochemical properties of the starches used in the formulation of fish and beef crackers.

Properties	SA	SB
Moisture (%)	10.5	11.0
Protein (%)	0.13	0.14
Fat (%)	0.06	0.04
Ash (%)	1.30	0.53
Carbohydrate (%)	88.2	88.4
Energy (Kcal)	353.2	353.24
Swelling capacity (cm^3) at 28°C		
5 min	4.0	5.0
60 min	15.0	18.0
Water absorption (g/100g)		
28°C	80.1	89.8
70°C	77.1	82.7
pH	7.1	5.3
Titratable acidity (% lactic acid)	0.01	0.1

Each value is a mean of triplicate determination.
SA = Starch A and SB = Starch B.

Table 2: **Proximate composition of dried and puffed fish and beef crackers prepared from starch samples.**

	Dried fish and beef crackers				Puffed fish and beef crackers			
	FSA	**FSB**	**BSA**	**BSB**	**FSA**	**FSB**	**BSA**	**BSB**
Moisture (%)	8.0	10.9	8.0	10.9	1.3	3.0	1.8	1.8
Protein (%)	7.2	7.2	7.8	7.7	10.0	7.6	10.7	9.1
Fat (%)	1.7	0.8	0.8	0.8	33.7	30.8	18.5	18.3
Ash (%)	5.7	4.3	5.2	4.5	5.5	5.0	5.6	5.3
Carbohydrate (%)	77.8	77.1	78.3	76.1	49.6	53.6	63.4	65.5
Energy (kcal/100g	355.3	344.4	351.6	342.4	541.7	522.0	464.9	463.5

Each value is a mean of triplicate determinations.
FSA and BSA are fish and beef crackers from starch A while FSB and BSB are fish and beef crackers from starch B.

Table 3: **Length, thickness and linear expansion of fish and beef crackers prepared from starch samples.**

Samples	Length (cm)	Thickness (mm)	Linear expansion (%)
FSA	22.1 ± 1.5	1.6 ± 0.3	189 ± 64
FSB	21.4 ± 1.1	1.6 ± 0.2	164 ± 50
BA	12.3 ± 0.9	1.5 ± 0.1	117 ± 19
BSB	12.9 ± 1.0	1.5 ± 0.1	98 ± 14

Each value is a mean of triplicate determinations.
FSA and BSA are fish and beef crackers from starch A while FSB and BSB are fish and beef crackers from starch B.

Table 4: Effect of colour component on overall acceptability of fish and beef crackers

Colour component	FSA	FSB	BSA	BSB
Yellow	8.0[a]	7.5[a]	7.3[a]	7.4[a]
Dragaco	7.7[a]	7.5[a]	7.3[a]	7.4[a]
Green	4.9[c]	4.8[c]	5.2[b]	4.8[b]
Nature (control)	6.5[b]	6.1[b]	6.2[ab]	6.4[a]

Each value is a mean of triplicate determinations.
Means within the same column with different superscripts (a, b, c) are significantly different ($P < 0.05$).
FSA and BSA are fish and beef crackers from starch A while FSB and BSB are fish and beef crackers from starch B.

Table 5: Sensory characteristics of puffed fish and beef crackers prepared from yellow and Dragaco colour.

Samples	Colour	Crispiness	Taste	Overall acceptability
Yellow colour				
FSA	8.0[a]	7.9[a]	7.5[a]	7.2[a]
FSB	7.5[a]	7.4[ab]	7.4[ab]	7.1[a]
BSA	7.3[a]	6.9[b]	6.5[b]	5.9[b]
BSB	7.4[a]	6.2[b]	6.0[b]	5.7[b]
Dragaco colour				
FSA	7.7[a]	7.7[a]	7.7[a]	7.7[a]
FSB	7.5[a]	7.5[a]	7.4[a]	7.1[a]
BSA	7.5[a]	6.1[b]	5.6	5.6[b]
BSB	7.5[a]	5.8[b]	5.6[b]	5.6[b]

Each value is a mean of triplicate determinations.
Means within the same column with different superscripts (a, b, c) are significantly different ($P < 0.05$).
FSA and BSA are fish and beef crackers from starch A while FSB and BSB are fish and beef crackers from starch B

The highest value was recorded for BSA crackers and the lowest from FSB crackers. The fat content of all samples after frying increased many folds from 0.8% and 1.7% to 18.3% and 33.7%. The fish crackers had higher fat content than the beef crackers. The fish crackers perhaps absorbed more fat during frying. The differences in the nature of the fish and beef muscles, their tenderness and relative degree of comminution attained during mincing may have led to the differences in fat absorption during frying. Generally, fish muscles are more tendered than beef muscles. The use of fat in frying increased the energy density of all the fried products compared to the dried crackers (Table 2).

The most important effect of fish and beef supplementation on proximate composition of cassava-based crackers was the improvement in the protein content. This increase in protein content would result in a reduction of the quantity of cassava-needed to meet the daily protein requirement of Nigerian consumers. This is desirable especially in children as unsupplemented cassava foods are bulky.

Physical properties of crackers

The fish based crackers (FSA and FSB) had higher length due to linear expansion than the beef based ones (Table 3). Also crackers made from fish had higher percentage linear expansion than crackers made from beef. Differences in the nature of the protein molecules of fish and beef may have been the reason for the differences in linear expansion. Linear expansion to some extent depends on the physical properties of the fish – starch or beef – starch mixtures. A well-mixed structure will result in smooth texture and better expansion [4]. Mixing that is not homogenous causes decreased gelatinisation and therefore the expansion ratio is lowered. Linear expansion of fish and beef crackers made from starch SA were higher than those made from starch SB.

The reason for this is not yet understood. It is probable that the lower pH and higher titratable acidity of starch SB may have been the reason. More work is required in this direction.

Sensory evaluation.

The results of the effects of different colour components on the overall acceptance of fish or beef crackers are presented in Table 4. Fish crackers containing orange colour (Quinoline yellow: E124) had the highest rating of acceptance ($P < 0.05$), followed by fish and beef crackers containing the Dragaco colour (Tartrazine: E102) compared with the control. The dried fish and beef crackers containing orange colour and those containing Dragaco colour were fried and subjected to sensory evaluation (Table 5) to test for crispiness, taste and overall acceptability. There were no significant differences in the general acceptability of fish and beef crackers based on these two colours ($P > 0.05$). However, the fish crackers had higher rating in terms of crispiness, taste and overall acceptability ($P < 0.05$) compared to the beef crackers. The source of starch had no effect on the overall acceptability of the crackers. Yellow and Dragaco colours were acceptable to the panellists.

Conclusion

Acceptable fish or beef crackers can be prepared using locally available cassava starch, fish and beef. However, the use of fish appears more promising. It would be valuable to study the effects of different fish varieties especially the cheaper ones in the preparation of crackers of acceptable quality.

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