



EFFECT OF DIFFERENT PACKAGING MATERIALS ON MINERAL COMPOSITION OF LOCALLY PRODUCED OKPA FROM BAMBARA GROUNDNUT

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Abstract

The effect of packaging materials on the sensory properties and mineral composition of locally produced *okpa* from bambara groundnut flour were investigated. *Okpa* mix was prepared using traditional method and wrapped in different packaging materials including: aluminum foil, banana leaves, nylon and tin before cooking. The sensory acceptability of the samples was evaluated using a 9 point Hedonic scale. The results showed that the colour, taste, mouth-feel and aroma of all the samples were significantly different ($p > 0.05$). The overall acceptability scores were 5.60, 5.58, 7.00 and 5.10 for *okpa* packaged with aluminum foil, banana leaves, nylon and tin respectively. The mineral compositions of samples were evaluated using standard analytical methods. The results revealed that these packaging materials significantly ($p < 0.05$) affected the mineral composition of the samples. The sample packaged with aluminum foil had the highest calcium content (0.504 pp), while the sample packaged with tin and nylon had the highest potassium content (1.034 ppm) and iron (1.233 ppm) respectively. The present study showed that the mineral content and sensory properties of the *okpa* were affected by different packaging materials.

Keywords: Packaging materials, mineral composition, sensory evaluation, Okpa, bambara groundnut.

Introduction

Okpa is a well cherished food in the eastern part of Nigeria (Orhevba *et al.*, 2016). The product is prepared after the seeds have been dehulled, milled into flour and then mixed with palm oil or crude palm fruit extract, water, salt, pepper and other spices. The paste is wrapped with banana leaves, transparent polyethylene pack, tin or plastic containers, before steaming to form the product Okpa (Enwere, 2008). These packaging materials mentioned, have all been notable for their ability to reduce or improve the *okpa* product physical and chemical qualities.

Bambara groundnut (*Vigna subterranea*) is a seed crop of African origin and it grown solely by farmers as a famine culture crop because of its agronomic values and its tendency to grow in soils that are regarded as insufficiently fertile for cultivation of other more favored species such as common beans and peanuts (Anchirinah *et al.*, 2001). It is known for its increased nutritional benefits, its ability to grow and produce in a harsh condition where peanuts completely fail. However, it remains less grown and not known in tropical Africa. The seeds consist of essential nutrients and are considered enough to make this legume a complete food. It is one of the five important protein sources for many Africans. It is said that the seed is regarded as a completely balanced food because it is rich in iron 4.9-48 mg/100 g, compared to a range of 2.0-10.0 mg/100 g for most food legumes, protein 18.0-24.0% with high lysine and methionine contents, ash 3.0-5.0%, fat 5.0- 7.0%, fibre 5.0-12.0%, potassium 1144-1935 mg/100 g, sodium 2.9-12.0 mg/100 g, calcium 95.8-99 mg/100 g, carbohydrate 51-70%, oil 6-12% and energy 367-414 kcal/100 mg (Vurayai *et al.*, 2011).

The South Eastern Nigerians are one of the highest consumers of Bambara nut in Nigeria. It is most consumed by people when prepared in the form of cake commonly known as Okpa (Nangii and Rao,

2017). It is a source of protein in the diets of a large percentage of the population, particularly people who cannot afford costly animal food protein (Bamishaiye *et al.*, 2011). It is known by different names in Nigeria as it known as “Okpa, by the Igbos, the Hausa’s call it “Fuijiya while the Yoruba’s call it Erivour (Temegne *et al.*, 2018). As a legume crop, the Bambara nut is classified into group namely, the pulse and oil seed. Its seed is very nutritious but not commonly used, which is rich in proteins and minerals (Nangii and Rao, 2017). Okpa is prepared traditionally by soaking in cold water, dehulled and mashed Bambara groundnut or from dry, milled powder which is mixed with water and other ingredients to form a paste (Ibinabo *et al.*, 2005). The paste is wrapped with either banana leaves, transparent polyethylene bags, tins or plastic containers before steaming (Alozie *et al.*, 2009).

Food contact surfaces are made up of materials which can be transferred from the food contact surface into the food and are consequently taken up by humans. Scientific findings have shown that food contact materials are relevant exposure pathways for hazardous substances.

There have been some health concerns regarding residual monomer and components in plastics, including stabilizers, plasticizers, and condensation components. Aluminum cans naturally coated with aluminum oxide are the most widely used material for cooking okpa with higher effective barrier to temperature, moisture, high resistance to most forms of corrosion and chemical attack (Marsh and Bugus, 2007). The use of Aluminum cookware, utensils and wrappings can increase the amount of Aluminum in food; however the magnitude of this increase is not of practical significance (WHO, 2010). Stainless steels are also a group of iron based alloys containing at least 10.5% chromium and a maximum of 1.2% carbon. Stainless steel is perfectly good for packaging food as the taste and appearance remain unchanged. The release of appreciable quantities of metals such as Cr, Ni and Fe and consequent excessive intake of these metals can cause health hazards (WHO, 2001).

Packaging materials must be such that any potential transfer to foods does not raise safety concerns, change the composition of the food in an unacceptable way or have adverse effects on the taste and or odour of the foods (Marsh and Bugus, 2007). Accominotti *et al.* (2008) measured the chromium and nickel levels in meals cooked in stainless steel pans; two tested pans contained 17 and 18% of chromium.

Natural packaging materials like banana and etere or uma (*Thaumatococcus danielli*) leaves are used in packaging quick consumed food products (Onwuka, 2014), these natural packaging materials has retained their place as the safest materials for food packaging considering their low record toxicity. They boost the colour, flavour and enhance the nutritional potentials by leaching some important biochemical compounds associated with green leaves into okpa during cooking. Due to scarcity in urban areas where they are highly demanded, okpa is presently packed in tin containers, and flexible plastics like polyethylene film bags, aluminum foils and plates (Onwuka, 2014) to meet higher demands and decency involved due to change in life style. These packaging leaves imparts either desirable or undesirable flavour component into food products. Desirable flavour enhances product acceptability unlike undesirable ones (Kabuo, 2013). Acceptability of okpa also depends on appearance or colour, taste, aroma and texture which are major parameters that determine product quality (Nwosu, 2014).

Considering the above factors it is expected that different packaging materials could have different effects on the chemical qualities of Bambara nut pudding, hence this study tries to use different packaging material to package ‘okpa’ and then determine the impact of these packaging materials on their mineral content.

Aim and Objectives of the Study

The aim of this study is to determine the effects of packaging materials on the mineral composition of locally produced Okpa from bambara groundnut.

The specific objectives of the study include:

1. To prepare and package okpa using different packaging materials
2. To determine and compare the mineral composition of the okpa packaged with different materials.

MATERIALS AND METHODS

Source of Raw Material

Bambara groundnuts, pepper, salt, seasoning, red palm oil, uziza, aluminum foil, nylon and tin cans were purchased from Eke Ekwuluobia market both in Aguata Local Government Area of Anambra State while banana leaves were plucked from a local farm in Oko community. These materials were taken to the Food Processing Laboratory of Department of Food Technology, Federal Polytechnic Oko for further processing.

Sample Preparation

Processing of Bambara Groundnut Flour

Bambara groundnut flour was prepared according to the method of Asomugha and Peter (2021) with slight modification. The Bambara groundnut was sorted to remove extraneous materials and damaged seeds. The seeds were then soaked in tap water at a ratio of 1:2 (w/v) for 24 hours at room temperature. It was manually dehulled and dried in the hot air oven at a temperature of 50°C for 19 hours. The dried samples were then milled using the attrition mill in the food processing laboratory to obtain the flour and was sieved into flour using sieves and then the flour was packaged in an air tight container prior to further use.

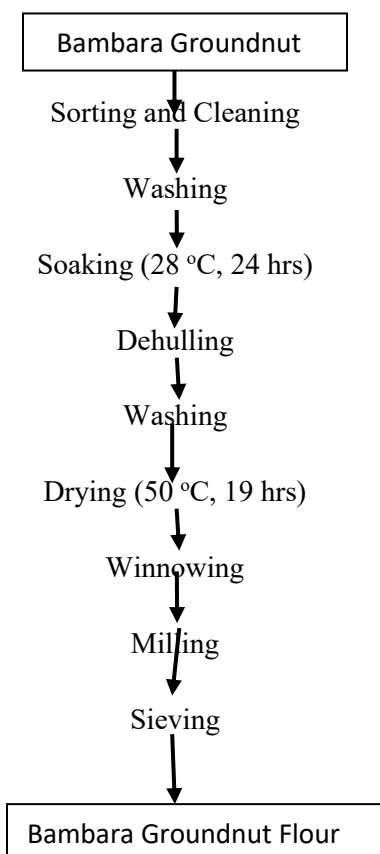


Fig. 1: Flow chart for the processing of bambara groundnut flour.

Source: Asomugha and Peter (2021).

Preparation of Okpa

The method described by Asomugha and Peter (2021) was followed in the preparation of the Okpa with slight modification. The Okpa flour was sieved into a big bowl, salt, ground pepper and uziza (*Piper guineense*) were added and thoroughly mixed. Palm oil was added and thoroughly mixed into the flour until an even yellow colour was obtained. Then, 750ml of lukewarm water was added till there were no lumps. The remaining 250ml of lukewarm water was added to the mixture. The entire mixture was divided into four equal portions. The banana leaves were softened over fire, removed from their stalks and washed. Thereafter, the banana leaves, nylon, aluminum foil and tin can were used to package each of the four portions which were carefully labelled, placed into a pot containing boiling water. The pot was covered and allowed to cook in medium heat for 30-40 minutes. The samples were allowed to cool and packaged into different containers till they were needed for analysis.

Mineral Analysis

The analysis for essential mineral content was investigated using the method of AOAC (2012). Nitric and hydrochloric acid (10 ml each) were individually added to the sample of 0.5 g in a digestion flask. The mixture was digested for 10 min. The digested mixture was filtered. The filtrate was made up to 50 ml with distilled water. Calcium, iron, potassium, tin and magnesium were measured by Flame Atomic Absorption Spectrophotometer.

Statistical Analysis

Data generated from the respective analyses were subjected to Analysis of Variance and their means were separated using the Duncan Multiple Range Test (Statistical Package for Social Science, version 25.0) at 5% probability.

Results

Table 1: Sensory qualities of okpa as influenced by different packaging materials

Samples	Colour	Taste	Mouth-Feel	Aroma	Overall Acceptability
AAA	7.10 ^{ab} ±1.10	5.70 ^{ab} ±2.11	5.00 ^b ±1.89	4.90 ^{ab} ±2.38	5.60 ^{ab} ±1.59
BBB	6.90 ^{ab} ±1.10	6.80 ^a ±1.93	5.90 ^{ab} ±2.23	5.50 ^{ab} ±2.42	5.58 ^{ab} ±2.33
CCC	8.00 ^a ±1.15	4.70 ^b ±1.77	6.80 ^a ±1.03	6.90 ^a ±1.52	7.00 ^a ±1.03
DDD	6.20 ^b ±2.04	5.00 ^{ab} ±2.00	6.30 ^{ab} ±1.70	4.50 ^b ±2.64	5.10 ^b ±1.46

*Values are means ± standard deviations of sensory evaluation. Means with the same superscript in the same column are not significantly different at $p > 0.05$.

Keys:

AAA: Okpa packaged with aluminum foil.

BBB: Okpa packaged with banana leaves.

CCC: Okpa packaged with nylon.

DDD: Okpa packaged with tin

The effect of packaging materials on the sensory qualities of locally produced bambara groundnut pudding (okpa) is presented in Table 1. The mean score for the colour of the samples ranged from 6.20 to 8.00. The highest score for colour was adjudged for sample CCC (Okpa packaged with nylon) while the lowest score was adjudged for sample DDD (Okpa packaged with tin). There was significant difference ($p > 0.05$) in the colour of samples. This indicates that the different packaging materials used did affect the colour of the samples. This is in line with the observation of Ezeocha *et al.* (2021) who reported similar range of scores (6.85 – 7.75) for colour. Colour is one of the first indicators of quality; it contributes and influences the market value of a product (Okwunodulu *et al.*, 2019).

Taste is one of the major determining factors of consumer's acceptance of a particular product. The scores adjudged for the taste of the samples ranged from 4.70 to 6.80. Sample BBB (Okpa packaged with banana leaves) recorded the highest score while sample CCC (Okpa packaged with nylon) and DDD (Okpa packaged with tin) recorded the lowest score. There was significant difference ($p > 0.05$) in the taste of all the samples; implying that the packaging materials did affect this quality attribute. This is in agreement with the observation of Ezeocha *et al.* (2021) who noted that the panelists preferred the moi-moi packaged with leaves than the one packaged with nylon. The varied results could be due to differences in product formulation.

There was significant difference ($p > 0.05$) in the mouth-feel of the samples which ranged from 5.00 to 6.80. The lowest mouth-feel score was adjudged for sample AAA (Okpa packaged with aluminum foil) while the highest score was adjudged for sample CCC (Okpa packaged with nylon). There was significant difference ($p > 0.05$) in the taste of all the samples.

Similarly, the results showed that the aroma of the samples were significantly different ($p > 0.05$). This indicates that the aroma of the okpa samples was affected by different packaging materials. The scores recorded for aroma ranged from 4.50 in sample DDD (Okpa packaged with tin) to 6.90 in sample CCC (Okpa packaged with nylon). The high score adjudged for the aroma of the sample packaged with nylon could be due to the fact that the panelists are more familiar with the sample. Okwunodulu *et al.* (2019) and Ezeocha *et al.* (2021) reported similar scores for the aroma of moi-moi packaged with different materials.

The highest overall acceptability score (7.25) was recorded for sample CCC (Okpa packaged with nylon) while the lowest score was recorded for sample DDD (Okpa packaged with tin). However, there was significant difference ($p > 0.05$) in overall acceptability score of all the samples. This indicates that different packaging materials affected the sensory acceptability of bambara groundnut pudding (okpa). The three samples with highest overall acceptability scores which include samples CCC (Okpa packaged with nylon), AAA (Okpa packaged with aluminum foil) and BBB (Okpa packaged with banana leaves) were subjected to further analysis in order to ascertain the effect of these packaging materials on their mineral composition.

Table 2: Mineral Composition (ppm) of okpa as influenced by different packaging materials

Samples	Iron	Magnesium	Calcium	Potassium	Tin
AAA	1.173 ^b ±0.00	0.024 ^b ±1.01	0.504 ^a ±0.01	0.833 ^b ±0.00	0.011 ^b ±0.00
CCC	1.233 ^a ±0.00	0.035 ^a ±0.00	0.443 ^b ±0.00	0.449 ^c ±0.00	0.024 ^a ±1.77
DDD	0.354 ^c ±0.00	0.011 ^c ±0.00	0.249 ^c ±0.00	1.034 ^a ±0.01	0.004 ^c ±0.00

*Values are means ± standard deviations of sensory evaluation. Means with the same superscript in the same column are not significantly different at $p > 0.05$.

Keys:

AAA: Okpa packaged with aluminum foil.

CCC: Okpa packaged with nylon.

DDD: Okpa packaged with tin

The results of the mineral composition of okpa as influenced by different packaging materials are presented in Table 2. There was significant difference ($p < 0.05$) in the iron content of the samples which ranged from 0.354 ppm to 1.233 ppm. Sample DDD (Okpa packaged with tin) recorded the lowest iron content while sample CCC (Okpa packaged with nylon) recorded the highest iron content. Aremu *et al.* (2022) reported similar iron content (1.41 and 1.24 mg/100g) for bambara groundnut puddings sold in Lafia Nasarawa state. The values obtained in this study are lower than 1.355 to 1.667 ppm reported by Obiegbuna *et al.* (2019) for vended bambara groundnut puddings sold within Ifite in Awka. Iron is

important for haemoglobin formation which carries oxygen to the body tissues. Iron deficiency (anemia) is characterized by poor oxygen-carrying capacity, a condition that causes fatigue in athletes (Okwunodulu *et al.*, 2021).

The magnesium content of the samples was 0.011 ppm, 0.024 ppm and 0.035 ppm for samples DDD (Okpa packaged with tin), AAA (Okpa packaged with aluminum foil) and CCC (Okpa packaged with nylon). There was significant difference in the magnesium content of the samples. The value obtained for magnesium in this study are very low compared to 15.89 to 20.03 ppm reported by Obiegbuna *et al.* (2019) for okpa collected from different vendors in Awka. Okwunodulu *et al.* (2021) reported higher magnesium content ranging from 108.30 to 126.46 mg/100g for okpa fortified with different plant ash. The variations could be due to differences in the formulation. Magnesium helps to activate the enzymatic systems responsible for calcium metabolism in bones and forms an essential constituent for reproduction and normal functioning of the nervous system (Innocent-Ukachi and Onukwugha, 2019).

There was significant difference ($p < 0.05$) in the calcium content of the samples. The calcium content ranged from 0.294 ppm to 0.504 ppm. The highest value was recorded in sample AAA (Okpa packaged with aluminum foil) and the lowest value was recorded in sample CCC (Okpa packaged with nylon). The results showed that packaging of okpa with aluminum foil retained more calcium than those of nylon and tin. This agrees with the findings of Okwunodulu *et al.* (2019) who noted that moi-moi packaged in aluminum plate retained more calcium although their values (187.50 – 215.50 mg/100g) were much higher than those obtained in this study. Calcium has been reported to help reduce the risk of osteoporosis, cardiovascular diseases and cancer among the elder people. Calcium also helps to build strong bones and teeth, vital for nerve transmission and muscle function, necessary for blood clotting, aids in conversion of food into energy among others (Sajib *et al.*, 2014).

The potassium content of the sample ranged from 0.449 ppm in sample CCC (Okpa packaged with nylon) to 1.034 ppm in sample DDD (Okpa packaged with tin). The results showed that the samples varied significantly ($p < 0.05$) in their potassium content; indicating that packaging materials affected the potassium content of the sample. The values obtained in this study are lower than 5.888 to 6.725 ppm reported by Obiegbuna *et al.* (2019) for okpa from different vendors in Awka. Aremu *et al.* (2022) also reported high potassium content of 219.63 mg/100g and 232.86 mg/100g for okpa collected from different vendors in Lafia Nasarawa state. The variation in these results could be due to differences in the formulation and raw materials used in preparation of the okpa.

Conclusion

The results from this study indicate that different packaging materials had significant effects on the sensory attributes of bambara groundnut puddings (okpa). However, the mineral composition of the bambara groundnut puddings (okpa) was also affected significantly by different packaging materials. The sample packaged with nylon had the highest iron and magnesium, while the samples packaged with tin and aluminum foil had the highest potassium content and calcium content respectively.

Recommendation

Further studies on the effect of these packaging materials especially nylon, tin and aluminum foil on the heavy metal composition of okpa should be investigated.

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