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EFFECT OF PACKAGING MATERIALS ON THE QUALITY OF PRECOOKED COWPEA (*Vigna unguiculata* L.) FLOUR

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Abstract
This study investigated the effect of packaging materials on the quality of precooked cowpea flour during storage. Precooked cowpea flour was packaged with high-density polyethylene (HDPE), aluminium foil (ALF), and polypropylene (PPE). Proximate composition, functional and microbiological properties of the flour samples were analyzed monthly. Sensory properties of soup prepared from precooked cowpea flour were compared with soup prepared from fresh cowpea beans. Throughout the storage, moisture, ash, protein, fat, fibre, and carbohydrate contents were <6.50%, 3.83-4.85%, 21.32-23.61%, 3.33-3.44%, 2.31-2.40% and 60.31-62.35%, respectively. Bulk density of samples packaged in HDPE and ALF increased significantly (p<0.05) within the first two months, and decreased in PPE, while water and oil absorption capacity and swelling capacity reduced significantly (p<0.05) as storage progressed. After 6 months of storage, there was no significant (p>0.05) difference in the degree of lightness (L), while significantly (p<0.05) higher values were recorded for redness (a*) (4.725) and yellowness (b*) (16.050) in sample packaged with PPE. Total aerobic bacteria count was highest (8.0×10^3 CFU/g) in PPE, followed by HDPE (6.4×10^3 CFU/g) and ALF (6.0×10^3 CFU/g). Mould count also followed a similar trend. Soup prepared from precooked cowpea flour compared significantly (p<0.05) with the one prepared from raw cowpea in terms of colour, flavour, consistency, and overall acceptability. This study showed that ALF and HDPE preserved the quality of precooked cowpea flour better compared to PPE during storage.*

Keywords: *Aluminium foil; Bean soup; Polyethylene; Polypropylene; Precooking*

Introduction

Legumes are a good source of protein and other essential macro and micro-nutrients (Sánchez-Arteaga *et al.,* 2015; Schoenlechner, 2016). Consumption of legumes has been attributed to positive physiological effects in man and animals, owing to their ability to suppress a good number of diseases (Ngoma *et al.,* 2018), and consequently, could be regarded as functional foods. The utilization of legumes as a source of protein in cereal, root, and vegetable-based foods constitutes one of the major ways of combating nutrition insecurity in sub-Saharan Africa (Patil *et al*, 2016; Ngoma *et al.,* 2018; Kurek *et al.,* 2019). Numerous leguminous crops including cowpea (*Vigna unguiculata*), soybean (*Glycine max*), pigeon pea (*Cajanus cajan*), mung bean (*Vigna radiata*), Bambara nut (*Vignas subterranea*) and faba bean (*Vicia faba*) are cultivated around the globe (Guzel and Sayar, 2012; Khalid *et al.,* 2012; Frota *et al.,* 2017). Among these, cowpea has the highest culinary applications (Frota *et al.,* 2017).

Cowpea is a leguminous plant, which is widely cultivated due to its adaptability to many agro-ecological conditions (Syanda, 2019). Over 5.4 million tons of cowpea is cultivated around the globe annually, and Nigeria alone produces about 60% of the total tonnage, hence the largest producer of cowpea globally (IITA, 2019). Cowpea, like other legumes, is a good source of important nutrients such as protein (22.3%), fat (2.10%), dietary fibre (4.10%), total ash (3.77%), and carbohydrate (60.07%) (Khalid *et al.*, 2012). Also, Frota *et al.* (2017) reported a high content of essential amino acids in cowpea. Cowpea is a major raw material in the preparation of bean cakes (*moin-moin* and *akara*), soup (*gbegiri*), pastries and complementary foods (Olapade *et al.,* 2012).

Traditional use of cowpea grains in food preparation is associated with drudgery, and thus, a lot of time is wasted in preliminary operations (Vazquez *et al.*, 2015). Therefore, the processing of cowpea into flour is highly imperative. Furthermore, the utilization of cowpea flour as a raw material in food preparation is constrained by its unpleasant beany flavour, poor digestibility, and long cooking time (Malomo *et al.,* 2017). Precooking of cowpea before its conversion into flour has been reported as a means of alleviating these problems (Mojica *et al.,* 2014; Ugen *et al.,* 2015).

Deterioration of food products commences immediately after processing and continues during storage (Giannou *et al.*, 2014; Uchechukwu-Agua *et al.,* 2015). Therefore, the packaging of these products is required to maintain their quality (Meena, 2015). According to Putranda (2017), factors such as cost, strength, durability, and permeability among others, are usually considered when selecting a packaging material for a given food product. Low/medium gauge polyethylene, aluminium foil, polypropylene, and polyvinyl chloride are common packaging materials for food products due to their availability, low cost, and strength (Adebowale *et al.,* 2017).

The utilization of precooked cowpea flour in soup, complementary foods, and pastries production is well documented (Olapade *et al.,* 2012; Malomo *et al.,* 2017).However, little or no attempt has been made to evaluate the effects of packaging materials on precooked cowpea flour, therefore, this paper evaluated the effect of packaging materials on the chemical, functional, microbial and sensory properties of precooked cowpea flour during ambient storage.

Materials and Methods

Materials

The white-seeded cultivar of cowpea (*Vigna unguiculata* L.) beans was procured from IITA, Ibadan, Nigeria. The beans were packaged in airtight containers (ZipLock, China), and stored at a temperature of -4 °C and 30% relative humidity until required. High-density polyethylene (700 gauge), polypropylene (100 µ), and aluminium foil (75 µ) were obtained from PJD Supermarket, Ilorin, Nigeria.

Methods

Preparation of Pre-cooked Cowpea Flour

Precooked cowpea flour was prepared according to the method described by Mojica *et al.* (2014). Cowpea was sorted to remove unwanted materials such as straws, stones, and damaged beans. The sorted beans were soaked in water for 20 min, dehulled manually, and boiled at 100 °C for 30 min. Subsequently, the cooked beans were cooled and dried at 50 °C for 18 h in a cabinet dryer (L'equip dehydrator, Eco vision). The dried beans were finely ground using a grinder (BLG-402, China) and sieved using a wire mesh size of 450 µm.

Packaging and Storage of Precooked Cowpea Flour

Precooked cowpea flour was packaged in three packaging materials namely high-density polyethylene (HDPE), aluminium foil (ALF) and polypropylene (PPE). The packaged samples were stored in a cool dry platform at ambient temperature (27±2 °C) and relative humidity (78±2%) for six months. The samples were analyzed monthly for proximate composition, functional and microbial properties, while mineral contents and colour attributes were analyzed in the first and last day of storage. Freshly prepared precooked cowpea flour (FPCP) served as the control.

Preparation of *Soup from Raw and Precooked Cowpea Flour*

Soup was prepared from raw cowpea and FPCP. In the case of the former, cowpeawas soaked, dehulled, and cooked for 30 min. Ingredients such as pepper, palm oil, and seasoning were added. This served as control. For the preparation of soup from precooked cowpea flour, FPCP was reconstituted with potable water (1:5, % w/v) and ingredients such as pepper, palm oil and seasonings were added. The mixture was cooked for 5 min. The soup samples were served immediately for sensory evaluation.

Analyses

Determination of Chemical Composition of Precooked Cowpea Flour

The proximate composition of cowpea flour was determined using standard methods (AOAC, 2005).Minerals (Ca, Mn, Cu, Fe, Na, and K) were determined according to the procedures outlined by AOAC (2005).

Determination of Functional, Colour Attributes and Microbial Properties of Pre-cooked Cowpea Flour

Methods described by Narayana and Narsinga (1992) were used for the determination of loose and packed bulk density, while water and oil absorption capacity were determined according to the methods described by . The procedure outlined by Akpata and Miachi (2001) was used for the determination of swelling capacity.

Colour attributes, L* (a measure of lightness), a* (a measure of redness and greenness) and b* (a measure of yellowness and blueness) were measured with the aid of colour meter (Chromameter CR-400/410, Japan)
Total aerobic bacterial and mould counts were determined using nutrient and potato dextrose agar, respectively (Roberts and Greenwood, 2003).

Sensory Evaluation of Soup Prepared from Cowpea

Sensory evaluation of soups prepared from raw cowpea and freshly prepared precooked cowpea flour was carried out by a 50 panellists that comprised male (42%) and female (58%) students and staff of Department of Home Economics and Food Science, University of Ilorin, Nigeria. The panellists analyzed the samples for appearance, colour, consistency, mouth-feel, flavour, and overall acceptability (Olapade *et al.*, 2012). The soups were served to the panellists at 70 °C in individual booths under fluorescent light. Potable water was provided in between samples for palate cleansing.

Statistical Analysis

Except otherwise stated, all analyses were conducted in triplicates. Two-way analysis of variance and t-test were used to generate means and standard deviations, while Duncan multiple range test was used to separate the means. This was done at $p<0.05$, with the aid of Statistical Package for the Social Scientists (SPSS) version 17.0.

Table 1 Effect of Packaging Materials on The Proximate Composition of Cooked Cowpea Flour During Storage

Storage Time (month)	Packaging materials	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
0	FPCP	6.46 ± 0.00^{a}	4.27 ± 0.00^{c}	21.42 ± 0.00^{fg}	3.34 ± 0.00^{cd}	2.31 ± 0.00^{g}	62.30 ± 0.00^{cd}
1	HDPE	6.46 ± 0.01^{a}	4.11 ± 0.01^{d}	21.41 ± 0.01^{fg}	3.38 ± 0.01^{e}	2.35 ± 0.01^{cde}	61.34 ± 0.02^{g}
	ALF	6.43 ± 0.01^{bcd}	4.26 ± 0.01^{c}	21.40 ± 0.01^{fg}	3.37 ± 0.01^{abcd}	2.33 ± 0.01^{efg}	62.20 ± 0.01^{cd}
	PPE	6.39 ± 0.01^{fg}	4.26 ± 0.07^{c}	21.36 ± 0.01^{fg}	3.36 ± 0.01^{abcd}	2.34 ± 0.01^{def}	62.23 ± 0.01^{ef}
2	HDPE	6.45 ± 0.00^{ab}	4.85 ± 0.07^{a}	21.42 ± 0.02^{fg}	3.36 ± 0.01^{abcd}	2.36 ± 0.01^{bc}	60.88 ± 0.02^{h}
	ALF	6.42 ± 0.01^{cd}	4.26 ± 0.01^{c}	21.41 ± 0.01^{fg}	3.36 ± 0.01^{abcd}	2.32 ± 0.01^{fg}	62.21 ± 0.04^{f}
	PPE	6.37 ± 0.00^{gh}	4.28 ± 0.01^{c}	21.40 ± 0.54^{fg}	3.36 ± 0.00^{abcd}	2.33 ± 0.00^{defg}	62.22 ± 0.01^{ef}
3	HDPE	6.44 ± 0.01^{bcd}	4.40 ± 0.14^{b}	21.55 ± 0.21^{fg}	3.40 ± 0.01^{abcd}	2.39 ± 0.01^{ab}	60.56 ± 0.04^{i}
	ALF	6.42 ± 0.01^{de}	4.26 ± 0.00^{c}	21.38 ± 0.01^{fg}	3.34 ± 0.01^{cd}	2.32 ± 0.00^{g}	62.29 ± 0.01^{c}
	PPE	6.35 ± 0.01^{hi}	4.30 ± 0.01^{c}	21.33 ± 0.0^{fg}	3.36 ± 0.00^{abcd}	2.33 ± 0.00^{defg}	62.26 ± 0.01^{de}
4	HDPE	6.42 ± 0.01^{de}	3.99 ± 0.16^{e}	23.38 ± 0.11^{b}	3.41 ± 0.02^{abcd}	2.39 ± 0.01^{a}	60.35 ± 0.01^{j}
	ALF	6.39 ± 0.01^{fg}	4.27 ± 0.01^{c}	21.36 ± 0.01^{fg}	3.34 ± 0.01^{cd}	2.31 ± 0.01^{fg}	62.31 ± 0.02^{bc}
	PPE	6.35 ± 0.01^{hi}	4.31 ± 0.01^{c}	21.32 ± 0.02^{fg}	3.36 ± 0.00^{abcd}	2.35 ± 0.01^{cde}	62.30 ± 0.02^{cd}
5	HDPE	6.44 ± 0.01^{abc}	3.83 ± 0.01^{f}	23.61 ± 0.01^{a}	3.43 ± 0.00^{ab}	2.39 ± 0.01^{a}	60.31 ± 0.01^{j}
	ALF	6.39 ± 0.01^{fg}	4.28 ± 0.02^{c}	21.35 ± 0.01^{fg}	3.33 ± 0.02^{d}	2.31 ± 0.01^{g}	62.35 ± 0.01^{a}
	PPE	6.37 ± 0.01^{gh}	4.31 ± 0.01^{c}	21.32 ± 0.00^{fg}	3.36 ± 0.01^{abcd}	2.35 ± 0.01^{cde}	62.31 ± 0.01^{bc}
6	HDPE	6.41 ± 0.01^{ef}	3.84 ± 0.02^{f}	23.59 ± 0.01^{a}	3.42 ± 0.01^{abc}	2.40 ± 0.01^{a}	60.35 ± 0.02^{j}
	ALF	6.38 ± 0.00^{g}	4.28 ± 0.01^{c}	21.34 ± 0.01^{fg}	3.44 ± 0.16^{a}	2.32 ± 0.02^{fg}	62.35 ± 0.03^{a}
	PPE	6.35 ± 0.01^{hi}	4.33 ± 0.01^{c}	21.29 ± 0.01^{g}	3.35 ± 0.01^{bcd}	2.35 ± 0.01^{cd}	62.35 ± 0.02^{ab}

Values are means±standard deviations of triplicate scores. Column values with different superscripts were significantly ($p<0.05$) different. FPCP freshly prepared precooked cowpea flour, HDPE high-density polyethylene, ALF aluminum foil, PPE polypropylene.

Results and Discussion

Effect of Packaging Materials on the Chemical Composition of Precooked Cowpea Flour during Storage

The proximate composition of packaged precooked cowpea flour during storage was presented in Table 1. Throughout the storage, moisture, total ash, protein, fat, fibre and carbohydrate contents were <6.50%, 3.83-4.85%, 21.32-23.61%, 3.33-3.44%, 2.31-2.40% and 60.31-62.35%, respectively. Khalid *et al.* (2012) also reported protein (22.3%), fat (2.10%), dietary fibre (4.10%), total ash (3.77%) and carbohydrate (60.07%) contents for whole cowpea beans. This implied that precooking had no effect on the proximate composition of cowpea flour. Throughout the storage, PPE showed most resistance to moisture absorption by precooked cowpea flour compared to HDPE and ALF. This implied that the proliferation of spoilage organisms will be minimum in precooked cowpea flour packaged with PPE (Sánchez-Arteaga *et al.,* 2015). This could be due to the high moisture barrier efficiency of PPE. This result contradicted the findings of Daramola *et al.* (2010), who reported that HDPE prevented cassava flour from moisture absorption better than polyvinyl chloride. There was no significant ($p>0.05$) difference in ash content between FPCP and sample packaged with ALF and PPE throughout the storage. In the sixth month of storage, there was a significant ($p<0.05$) reduction in ash content of the sample packaged with HDPE. This implied stability of essential minerals of precooked cowpea flour packaged with ALF and PPE during storage. There was no significant ($p>0.05$) difference in the protein content of all the samples during the first three months of storage. This suggested reduced proteolytic activity in the samples during the early period of storage. Significantly ($p<0.05$) higher protein content was recorded for sample packaged with HDPE compared to those packaged with ALF and PPE after the 4th month of storage. This could be due to the ability of HDPE to prevent the proteolysis of cowpea proteins because of its strength and good sealing property. Agrahar-Murugkar and Jha (2011) also reported higher protein content of full-fat soy flour packaged with polyethylene during storage. There was a significant ($p<0.05$) increase in the fat content of samples packaged with HDPE, ALF, and PPE at the end of four months of storage. Fat content remained stable during the latter period of storage. This implied that the packaging materials considered in this study were good in preventing lipolytic activity throughout the storage. Agrahar-Murugkar and Jha (2011) had reported good barrier properties of aluminium foil and polyethylene against lipolysis. There was a significant ($p<0.05$) increase in fibre content in all the samples after the first month of storage and became stable during the latter part of storage. This validated the reduction in carbohydrate after the first month of storage. An Increase in fibre content could be attributed to the bioavailability of cellulose and hemicellulose consequent to carbohydrate reduction (Agrahar-Murugkar and Jha, 2011). Throughout the storage, significantly ($p<0.05$) higher fibre and lower carbohydrate were recorded for sample packaged with HDPE compared to ALF and PPE. This contradicted the report of Yar *et al.* (2017) who reported the least protection of wheat flour packaged with polyethylene compared to polypropylene and polyvinyl chloride.

Table 2 Effect of Packaging Materials on the Mineral Composition of Precooked Cowpea Flour During Storage

Storage Time (month)	Packaging material	K (mg/g)	Na (mg/g)	Ca (mg/g)	Cu (mg/g)	Mg (mg/g)	Mn (mg/g)	Fe (mg/g)	Zn (mg/g)
0	FPCP	0.163 ± 0.00^{a}	0.153 ± 0.00^{a}	0.406 ± 0.00^{a}	0.058 ± 0.00^{a}	0.549 ± 0.00^{a}	0.090 ± 0.00^{a}	0.241 ± 0.00^{a}	0.034 ± 0.00^{a}
6	HDPE	0.010 ± 0.00^{b}	0.010 ± 0.00^{b}	0.379 ± 0.09^{b}	0.021 ± 0.00^{b}	0.353 ± 0.01^{b}	0.035 ± 0.00^{a}	0.180 ± 0.01^{b}	0.023 ± 0.00^{c}
	ALF	0.010 ± 0.00^{b}	0.010 ± 0.00^{b}	0.255 ± 0.00^{c}	0.020 ± 0.00^{b}	0.350 ± 0.01^{b}	0.060 ± 0.00^{b}	0.195 ± 0.01^{b}	0.028 ± 0.00^{b}
	PPE	0.009 ± 0.01^{c}	0.009 ± 0.00^{c}	0.169 ± 0.00^{d}	0.019 ± 0.00^{c}	0.318 ± 0.10^{c}	0.450 ± 0.01^{c}	0.165 ± 0.01^{c}	0.019 ± 0.00^{c}

Values are means±standard deviations of duplicate scores. Column values with different superscripts were significantly ($p<0.05$) different. FPCP freshly prepared precooked cowpea flour, HDPE high-density polyethylene, ALF aluminum foil, PPE polypropylene.

The mineral content of pre-cooked flour as influenced by packaging materials during storage was presented in Table 2. There was a significant ($p<0.05$) reduction in all the elements considered after six months of storage. This reduction may be linked with a reduction in ash content during storage. After the 6th month of storage, significantly ($p<0.05$) higher K, Na, Cu, Mg, and Fe were recorded for samples packaged with ALF and HDPE compared to PPE. Higher Ca and Mn were recorded for sample packaged with HDPE compared with ALF and PPE, however, significantly ($p<0.05$) higher Zn was recorded for the sample packaged with ALF. Variation in mineral contents of precooked cowpea flour could be due to differences in barrier protection properties of the packaging materials (Galic*et al.,* 2009).

Table 3 Effect of Packaging Materials on The Functional Properties of Cooked Cowpea Flour During Storage

Storage time (month)	Packaging material	Loose density (g/cm^3)	Packed density (g/cm^3)	Oil absorption capacity (mL/g)	Water absorption capacity (mL/g)	Swelling capacity (g/g)
0	FPCP	0.71 ± 0.06^{c}	0.76 ± 0.06^{c}	2.17 ± 0.03^{ab}	4.90 ± 0.04^{a}	5.71 ± 0.10^{a}
1	HDPE	0.72 ± 0.03^{c}	0.84 ± 0.28^{bc}	2.13 ± 0.00^{bc}	4.06 ± 0.01^{d}	5.23 ± 0.06^{defg}
	ALF	0.69 ± 0.03^{c}	0.76 ± 0.00^{c}	1.83 ± 0.06^{d}	4.17 ± 0.00^{c}	5.51 ± 0.00^{b}
	PPE	0.71 ± 0.00^{c}	0.89 ± 0.06^{ab}	2.22 ± 0.03^{a}	4.47 ± 0.03^{b}	5.38 ± 0.03^{bc}
2	HDPE	0.75 ± 0.03^{bc}	0.87 ± 0.06^{abc}	1.80 ± 0.00^{de}	3.46 ± 0.06^{h}	5.20 ± 0.00^{defg}
	ALF	0.69 ± 0.06^{c}	0.77 ± 0.85^{c}	1.85 ± 0.03^{d}	3.61 ± 0.00^{e}	5.34 ± 0.08^{cd}
	PPE	0.71 ± 0.00^{c}	0.76 ± 0.01^{c}	2.07 ± 0.06^{c}	3.58 ± 0.03^{ef}	5.49 ± 0.01^{b}
3	HDPE	0.83 ± 0.06^{ab}	0.87 ± 0.06^{abc}	1.80 ± 0.00^{de}	3.47 ± 0.00^{gh}	5.18 ± 0.00^{efg}
	ALF	0.71 ± 0.00^{c}	0.77 ± 0.85^{c}	1.83 ± 0.10^{d}	3.59 ± 0.01^{ef}	5.31 ± 0.06^{cdef}
	PPE	0.77 ± 0.06^{bc}	0.87 ± 0.03^{abc}	2.07 ± 0.03^{c}	3.53 ± 0.01^{ih}	5.32 ± 0.03^{cde}
4	HDPE	0.83 ± 0.57^{ab}	0.95 ± 0.06^{ab}	1.78 ± 0.03^{de}	3.36 ± 0.06^{j}	5.19 ± 0.01^{defg}
	ALF	0.71 ± 0.00^{c}	0.87 ± 0.85^{abc}	1.80 ± 0.00^{de}	3.44 ± 0.01^{gh}	5.19 ± 0.00^{defg}
	PPE	0.77 ± 0.00^{abc}	0.87 ± 0.85^{abc}	2.10 ± 0.01^{bc}	3.21 ± 0.00^{l}	5.21 ± 0.01^{defg}
5	HDPE	0.83 ± 0.03^{ab}	0.95 ± 0.01^{ab}	1.21 ± 0.00^{i}	3.29 ± 0.04^{k}	5.16 ± 0.11^{fg}
	ALF	0.83 ± 0.06^{ab}	0.87 ± 0.03^{abc}	1.66 ± 0.03^{f}	3.39 ± 0.00^{ij}	5.20 ± 0.14^{defg}
	PPE	0.83 ± 0.03^{c}	0.77 ± 0.03^{c}	1.72 ± 0.07^{ef}	3.12 ± 0.03^{m}	5.22 ± 0.00^{defg}
6	HDPE	0.87 ± 0.06^{a}	0.95 ± 0.00^{ab}	1.07 ± 0.01^{j}	3.06 ± 0.06^{m}	5.15 ± 0.00^{g}
	ALF	0.83 ± 0.03^{ab}	0.97 ± 0.00^{a}	1.36 ± 0.00^{h}	3.37 ± 0.00^{j}	5.21 ± 0.03^{defg}
	PPE	0.83 ± 0.03^{ab}	0.87 ± 0.03^{abc}	1.44 ± 0.03^{g}	2.82 ± 0.01^{n}	5.22 ± 0.06^{defg}

Values are means±standard deviations of duplicate scores. Column values with different superscripts were significantly ($p<0.05$) different. FPCP freshly prepared precooked cowpea flour, HDPE high-density polyethylene, ALF aluminum foil, PPE polypropylene

Effect of Packaging Materials on the Functional Properties of Precooked Cowpea Flour during Storage

The effect of packaging materials on the functional properties of precooked cowpea flour during storage was presented in Table 3. Results obtained showed that loose and packed bulk density of samples packaged in HDPE and ALF increased significantly ($p<0.05$) after two months of storage, and decreased in sample packaged in PPE. Loose and packed bulk density of the samples reduced during the latter part of the storage period. Abiodun *et al.* (2014) also reported a reduction in the bulk density of trifoliate yam during storage. Water and oil absorption capacity, and swelling capacity of precooked cowpea flour reduced significantly ($p<0.05$) as storage progressed. This reduction could be attributed to a loose association of amylose and amylopectin fractions of starch, which probably resulted as its granular structure weakened due to storage (Adebowale *et al.,* 2017). Rate of reduction of water absorption and swelling capacity was most pronounced in sample packaged with HDPE, and oil absorption capacity in ALF. This corroborated the findings of Adebowale *et al.* (2017) who reported a pronounced reduction in water absorption capacity of water yam (*Discorea alata*) flour packaged with polyethylene compared to the one packaged with plastic materials. Variation in functional properties of pre-cooked cowpea flour packaged in HDPE, ALF and PPE during storage could be attributed to differences in their strength and water vapour transmission rate. Ojokoh and Gabriel (2010) had reported that properties of flour change based on its immediate micro environment.

Table 4 Effect of packaging materials on the colour properties of cooked cowpea flour during storage

Storage time (month)	Packaging material	L*	a*	b*
0	FPCP	90.290±0.00[a]	0.150±0.00[c]	15.300±0.00[b]
6	HDPE	79.680±0.00[b]	4.190±0.18[b]	15.110±0.24[b]
	ALF	78.085±2.03[b]	4.310±0.03[b]	15.115±0.46[b]
	PPE	80.705±3.71[b]	4.725±0.29[a]	16.050±0.11[a]

Values are means±standard deviations of triplicate scores. Column values with different superscripts were significantly ($p<0.05$) different. FPCP freshly prepared precooked cowpea flour, HDPE high-density polyethylene, ALF aluminum foil, PPE polypropylene.

Effect of Packaging Materials on the Colour Attributes of Precooked Cowpea during Storage

Table 4 showed the colour attributes of precooked cowpea flour during six months of storage. There was a significant ($p<0.05$) reduction in L* while a* increased during the storage. After 6 months of storage, there was no significant ($p>0.05$) difference in L* of all the samples, and significantly ($p<0.05$) higher a* (4.725) and b* (16.050) were recorded in samples packaged with PPE. These results contradicted the findings of Sloan *et al.* (2016) who reported that the colour attributes of dehydrated *taro* (*Colocasia esculenta*) were not significantly affected by different packaging materials. Significantly ($p<0.05$) higher a* and b* in sample packaged with PPE could be due to higher rate of ascorbic acid oxidation, pigment degradation, and browning reactions, probably due to its low water vapour barrier efficiency (Guzel and Sayar, 2012; Sloan *et al.,* 2016).

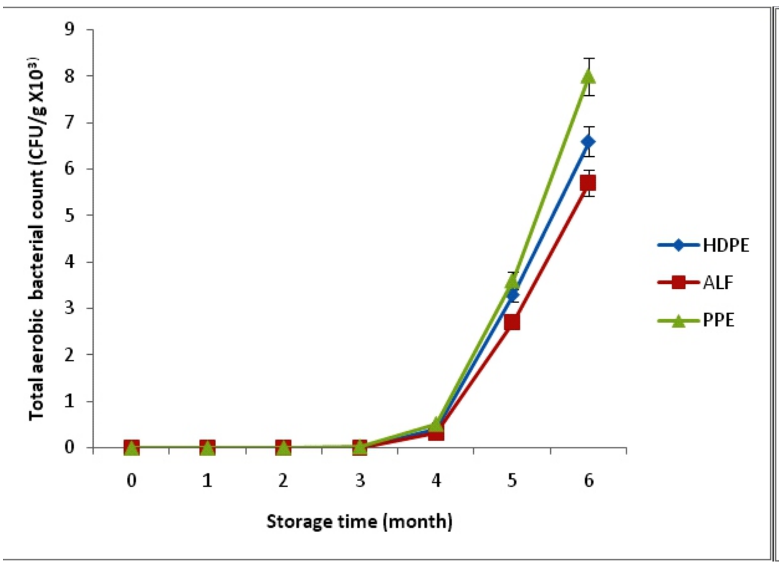

Figure 1. Total aerobic bacterial count of pre-cooked cowpea flour during

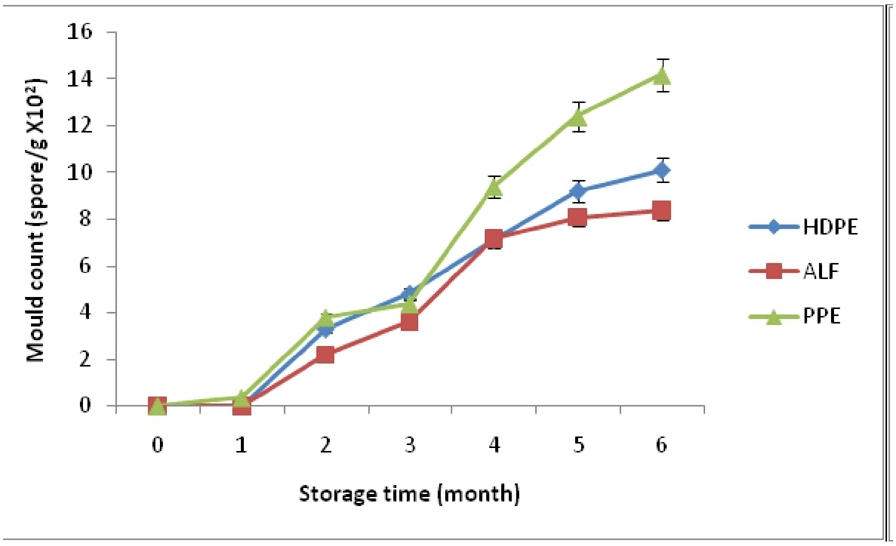

Figure 2. Total mould count of pre-cooked cowpea flour during storage. HDPE high-density polyethylene, ALF aluminum foil, PPE polypropylene.

Effect of Packaging Material on the Microbial Load of Precooked Cowpea Flour during Storage

Figures 1 and 2 showed the effect of packaging materials on total aerobic bacterial and mould population respectively during storage. There was no visible growth of bacteria and mould during the first three and one months of storage, respectively. This could be due to the efficiency of the packaging materials and hygienic preparation of precooked cowpea flour. During the latter part of storage, total aerobic bacteria and fungal counts of precooked cowpea flour increased. Visible bacteria growth was observed during the fourth month of storage and the second month of storage for mould. Fasoyiro *et al.* (2016) also reported an increase in the microbial load of maize-pigeon flour during storage. Increased microbial proliferation during the latter part of storage could be due to the absorption of atmospheric moisture by precooked cowpea flour as the packaging materials weakened. At the end of 6 months of storage, total aerobic bacteria count was highest (8.0×10^3 CFU/g) in sample packaged in PPE, followed by HDPE (6.4×10^3 CFU/g) and lowest in sample packaged with ALF (6.0×10^3 CFU/g). There was also variation in mould count of samples, and was of the order PPE>HDPE>ALF. Babajide *et al.* (2010) also reported higher microbial counts in yam and cassava flours packaged with polypropylene compared to those packaged with HDPE. Variation in microbial counts of precooked cowpea flour packaged in HDPE, ALF, and PPE could be due to differences in their rate of moisture permeability (Putranda, 2017).

Table 5 Sensory properties of fresh cowpea andprecooked cowpea flours

Cowpea	Colour	Flavour	Consistency	Appearance	Mouthfeel	Overall Acceptability
Raw	7.55±0.89	7.60±0.75	7.60±0.99	7.20±0.83	7.80±0.70	7.90±0.64
Precooked	7.45±0.95	7.75±0.72	7.10±1.02	7.50±0.72	6.85±1.04	7.50±1.10
$t_{observed}$	0.345	0.645	1.569	-2.238	3.395	1.405
Significance	Not significant	Not significant	Not significant	Significant	Significant	Not significant

Values are means±standard deviations of twenty scores. $t_{observed} < t_{critical}$(2.024)= No significant difference ($p < 0.05$)

Sensory Properties of Soup Prepared from Cowpea

Sensory properties of soup prepared from raw cowpea beans and precooked cowpea flour were presented in Table 5. Results showed that soup prepared from precooked cowpea flour compared significantly ($p<0.05$) with the one prepared from raw cowpea beans in terms of colour, flavour, consistency, and overall acceptability. Soup prepared from precooked flour was rated significantly ($p<0.05$) higher in appearance while soup prepared from raw beans was more preferred in terms of mouth feel. This result implied that bean soup prepared from precooked cowpea flour will be acceptable by the populace. This is advantageous because preparation of soup from precooked cowpea flour will save time and energy. Malomo *et al.* (2017) also reported high acceptability of *moinmoin* (steamed cowpea paste) prepared from precooked cowpea flour.

Conclusions

This study showed variation in chemical composition, functional, and colour attributes of pre-cooked cowpea flour packaged in different packaging materials. Samples packaged with HDPE and ALF retained the chemical, functional, and microbiological properties of precooked cowpea flour better than sample packaged with PPE. Soup prepared using precooked cowpea flour compared significantly ($p<0.05$) with the one prepared using raw cowpea beans in terms of colour, flavour, consistency, and overall acceptability.

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