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Effect of Different Packaging Materials on Some Properties of Enhanced *Aadun* (Maize Meal Snack)

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Abstract

The optimum condition of the enhanced *aadun* was achieved at 5.18% moisture content, 16.04% protein, 5.77% fibre, 4.78% ash, 20.24% and 47.99% carbohydrate which was stored in the different packing materials namely, leaf (control) which is commonly used by the locals for storage *aadun* snack, low density polyethylene (LDPE), high density polyethylene (HDPE) and food grade plastic container (PC). The initial properties of the enhanced *aadun* (prior to storage) were determined, while the stored samples were kept for eighteen weeks. Samples in each packaging material were analysed for proximate and microbial loads at the end of every two weeks. The data obtained were analysed statistically to determine the effect of the packaging material on the aforementioned properties. Results for the proximate properties showed that the ash, fibre, fat, protein decreased significantly ($P < 0.05$) in all the samples while the carbohydrate and moisture contents increased significantly ($P < 0.05$). The samples in the PC, HDPE and LDPE were within the acceptable moisture limit (<10%) of snacks. The energy content also decreased significantly ($P > 0.05$). The choice of packaging material also influenced the level of microbial infestation within eighteen weeks of storage, with leaf permitting the highest, followed by LDPE, HPDE and then PC.

Keywords

Enhanced *aadun*, microbial, proximate and storage

1. Introduction

Aadun is an indigenous staple food commonly consumed by the Yoruba ethnic group of south-western Nigeria, it is usually reddish in colour and often moulded into balls. *Aadun* is a snack food prepared from dried maize grain which constitutes nearly 80% of the entire snack [1]. It is characterized by its fine texture, ease of digestion and sweetness.

Aadun is traditionally served during ceremonial events such as marriage and naming ceremonies and had found acceptability in the past by warriors, women, kids and people of all ages [2]. According to [2], *Aadun* is an excellent source of energy with phosphorus and magnesium been its chief mineral but low in crude protein and it is normally sold with less significant packaging in environmental conditions that can lead to its immediate deterioration.

Consumers are not only becoming more conscious of the nature of nutritional properties of the diet they consume but also on the effect of food borne disease which is capable of causing not just health hazards but environmental hazards through the use of unsafe packaging materials. The type of packaging material can go a long way in determining the shelf life of a product and also the level of microorganism contamination as most hawkers or producers package "*aadun*" in plant leaves (traditional way) which is prone to shrinkage and may end up exposing the food to dangerous pathogens thereby leading to spoilage and low shelf life. Also, improved packaging methods will go a long way in reducing contamination thereby extending the shelf life of the snack and its acceptability.

2. Methods

2.1 Materials

Samples of freshly harvested white maize-TZL Comp 4C2 (commonly used by indigenous manufacturers) and unshelled groundnut seeds were obtained from a farm in Minna, Niger state, Nigeria. The *aadun* (control) used for the comparative assessment and the groundnut enhanced *aadun* snacks were prepared using the method of [2]. Other ingredients such as palm oil, seasonings and salt were obtained from *Kasuwa Gwari* market in Minna.

2.2 Formulation of *aadun* enhanced with groundnut paste

Formulations of *aadun* from different combination levels of maize flour (60-78%), groundnut paste (5-20%) and palm oil (10-20%) were generated using a constrained D-optimal mixture-process experimental design of Design Expert (version 11, Stat-Ease Inc., USA) while salt and pepper remained constant at 0.5% and 1.5% respectively. There were seventeen runs (treatments) in all with the control (78% maize, 20% oil, 1.57% pepper and 0.34% salt). Figure 1 shows the flow chart for the production of enhanced *aadun*.

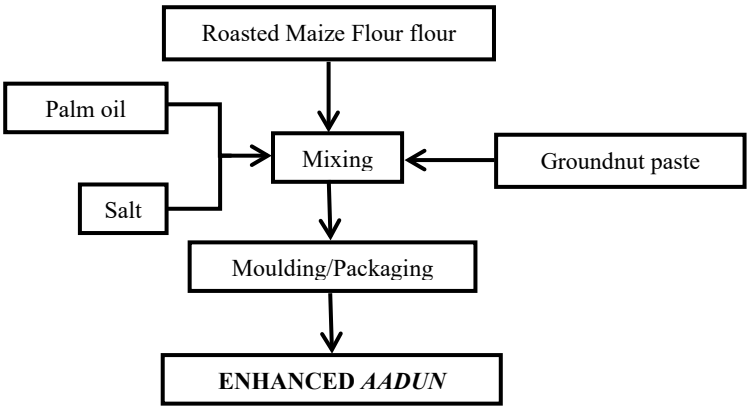

Figure 1. Flow chart for the production of enhanced *aadun*.

2.3 Properties of the stored enhanced *aadun* samples

The stored *aadun* samples were prepared at optimal conditions (roasted maize flour-64.798%, groundnut paste-20% and palm oil-13.202%). The samples (about 100g) were then placed in the different storage materials namely, leaf (control) which is commonly used by the locals for storing *aadun* snack, low density polyethylene (LDPE), high density polyethylene (HDPE) and food grade plastic container (PC) as shown in Plates I and II respectively. Proximate composition and microbial loads were carried out prior to storage and during storage at an interval of two weeks. All procedures were carried out in triplicates and data collected from the study were subjected to analysis of variance (ANOVA). Differences among the means were separated using Duncan's Multiple Range Test and significance was accepted at 5% level of confidence ($p < 0.05$).

Plate I. Enhanced *aadun* packaged in leaf and LDPE.

Plate II. Enhanced *aadun* packaged in HDPE and PC.

3. Results

The results of the proximate composition and microbial loads of *aadun* prepared from different ratios (optimal production condition) of roasted maize flour, groundnut paste and palm oil and stored for a period of eighteen weeks are as presented in following tables.

3.1 Proximate composition of *aadun* during storage

The results of the proximate composition of *aadun* stored in different storage materials are as presented in Tables 1 to 6.

Table 1. Proximate composition of enhanced *aadun* stored in leaves (control)

Duration (week)	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
0	5.18±0.01^{a}	16.04±0.03^{j}	5.77±0.02^{j}	4.78±0.04^{j}	20.24±0.04^{j}	47.99±0.03^{a}
2	5.57±0.03^{b}	15.28±0.03^{i}	5.41±0.01^{i}	4.33±0.02^{i}	19.72±0.04^{i}	49.69±0.03^{b}
4	6.05±0.02^{c}	14.57h±0.03^{h}	5.14±0.01^{h}	3.93±0.02^{h}	18.23±0.03^{h}	52.08±0.04^{c}
6	6.80±0.02^{d}	14.13±0.03^{g}	3.96±0.02^{g}	3.64±0.03^{g}	16.89±0.01^{g}	54.58±0.03^{d}
8	7.35±0.01e	13.68±0.01^{e}	3.7±0.02^{f}	3.58±0.01^{f}	15.06±0.01^{f}	56.63±0.02^{f}
10	8.26±0.03^{f}	13.94±0.02^{f}	3.34±0.01^{e}	3.53±0.03^{e}	14.74±0.02^{e}	56.19±0.02^{e}
12	8.66±0.02^{g}	12.87±0.02^{d}	3.08±0.03^{d}	3.34±0.02^{d}	14.35±0.01^{d}	57.7±0.03^{g}
14	9.13±0.04^{h}	12.28±0.04^{c}	2.95±0.01^{c}	3.17±0.03^{c}	13.89±0.02^{c}	58.59±0.04^{h}
16	9.71±0.04^{i}	11.65±0.02^{b}	2.69±0.01^{b}	3.21±0.01^{b}	13.26±0.02^{b}	59.48±0.04^{i}
18	10.08±0.01^{j}	10.47±0.02^{a}	2.48±0.03^{a}	2.87±0.02^{a}	12.53±0.02^{a}	61.57±0.04^{j}

Values with the same subscripts along the same column are not significantly different (p≥0.05). Values are Mean ± SEM of triplicate determination.

Table 2. Proximate composition of *aadun* stored in LDPE

Duration (week)	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
0	5.18±0.01^{a}	16.04±0.03^{j}	5.77±0.02^{j}	4.78±0.04^{i}	20.24±0.04^{j}	47.99±0.03^{a}
2	5.48±0.02^{b}	15.46±0.03^{i}	5.56±0.01^{i}	4.44±0.02^{g}	19.53±0.02^{i}	49.52±0.03^{b}
4	5.83±0.03^{c}	14.92±0.03^{h}	5.34±0.01^{h}	4.64±0.01^{h}	18.84±0.03^{h}	50.42±0.04^{c}
6	6.10±0.01^{d}	14.47±0.04^{g}	4.93±0.01^{g}	4.48±0.02^{g}	18.18±0.02^{g}	51.83±0.01^{d}
8	6.23±0.02^{e}	14.14±0.02^{f}	4.35±0.01^{f}	4.14±0.01^{f}	17.44±0.03^{f}	53.69±0.03^{e}
10	6.51±0.02^{f}	13.24±0.04^{e}	3.86±0.03^{e}	3.77±0.03^{e}	16.70±0.04^{e}	55.91±0.04^{f}
12	6.85±0.03^{g}	12.72±0.03^{d}	3.56±0.02^{d}	3.50±0.01^{d}	15.73±0.01^{d}	58.25±0.02^{g}
14	7.08±0.04^{h}	12.43±0.01^{c}	3.13±0.03^{c}	3.68±0.01^{c}	15.05±0.02^{c}	59.21±0.03^{h}
16	7.27±0.02^{i}	12.04±0.03^{b}	3.39±0.04^{b}	3.38±0.02^{b}	14.86±0.02^{b}	59.48±0.04^{i}
18	7.36±0.02^{j}	11.61±0.02^{a}	3.03±0.01^{a}	3.06±0.04^{a}	14.36±0.01^{a}	60.59±0.04^{j}

Values with the same subscripts along the same column are not significantly different (p≥0.05). Values are Mean ± SEM of triplicate determination.

Table 3. Proximate composition of *aadun* stored in HDPE

Duration (week)	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
0	5.18±0.01^{a}	16.04±0.03j	5.77±0.02^{j}	4.78±0.04^{i}	20.24±0.04^{j}	47.99±0.03^{a}
2	5.45±0.03^{b}	15.69±0.01^{i}	5.58±0.01^{i}	4.56±0.04^{h}	19.78±0.02^{i}	48.94±0.01^{b}
4	5.66±0.02^{c}	15.32±0.04^{h}	5.40±0.02^{h}	4.36±0.02^{g}	19.16±0.02^{h}	50.10±0.04^{c}
6	5.73±0.02^{d}	14.93±0.02^{g}	5.09±0.01^{d}	4.19±0.02^{f}	18.65±0.02^{g}	51.42±0.03^{d}
8	5.78±0.02^{e}	14.61±0.01^{e}	5.25±0.02^{e}	4.02±0.01^{d}	18.32±0.01^{f}	52.02±0.04^{f}
10	6.08±0.01^{f}	14.66±0.03^{f}	5.32±0.02^{g}	4.13±0.01^{e}	18.28±0.03^{e}	51.52±0.02^{e}
12	6.13±0.01^{g}	13.86±0.01^{d}	5.29±0.01^{f}	3.86±0.02^{c}	17.66±0.02^{d}	53.20±0.04^{g}
14	6.22±0.02^{h}	13.36±0.02^{c}	4.86±0.01^{c}	3.83±0.02^{c}	17.33±0.03^{c}	54.40±0.04^{h}
16	6.43±0.02^{i}	13.49±0.02^{b}	4.81±0.02^{b}	3.76±0.02^{b}	17.08±0.03^{b}	54.43±0.02^{h}
18	6.53±0.01^{j}	13.29±0.02^{a}	4.57±0.01^{a}	3.67±0.02^{a}	16.90±0.01^{a}	55.04±0.03^{i}

Values with the same subscripts along the same column are not significantly different (p≥0.05). Values are Mean ± SEM of triplicate determination.

Table 4: Proximate composition of *aadun* stored in Plastic container

Duration (week)	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
0	5.18±0.01^{a}	16.04±0.03^{i}	5.77±0.02^{i}	4.78±0.04^{i}	20.24±0.04^{j}	47.99±0.03^{a}
2	5.37±0.02^{b}	15.85±0.02^{h}	5.69±0.03^{h}	4.66±0.01^{h}	20.06±0.01^{i}	48.38±0.02^{b}
4	5.54±0.02^{c}	15.77±0.02^{g}	5.58±0.02^{g}	4.58±0.01^{g}	19.91±0.01^{h}	48.63±0.03^{c}
6	5.71±0.01^{d}	15.32±0.01^{f}	5.34±0.03^{f}	4.47±0.02^{f}	19.58±0.02^{g}	49.57±0.04^{d}
8	5.82±0.01^{e}	15.09±0.02^{d}	5.28±0.03^{e}	4.42±0.02^{e}	19.39±0.01^{f}	49.99±0.02^{e}
10	5.87±0.02^{f}	14.89±0.01^{b}	5.15±0.01^{d}	4.27±0.01^{d}	19.11±0.01^{e}	50.71±0.04^{f}
12	5.93±0.00^{g}	15.26±0.03^{e}	5.12±0.01^{d}	4.08±0.02^{b}	18.67±0.03^{c}	50.93±0.02^{g}
14	5.96±0.03^{g}	15.03±0.02^{c}	5.08±0.02^{c}	4.14±0.03^{c}	18.78±0.02^{d}	51.01±0.02^{h}
16	6.05±0.04^{h}	14.89±0.01^{b}	5.01±0.02^{b}	4.06±0.01^{b}	18.37±0.03^{b}	51.63±0.05^{i}
18	6.11±0.02^{i}	14.75±0.01^{a}	4.94±0.03^{a}	3.95±0.02^{a}	18.21±0.01^{a}	52.04±0.03^{j}

Values with the same subscripts along the same column are not significantly different (p≥0.05). Values are Mean ± SEM of triplicate determination.

3.2 Microbial load of *aadun* samples during storage

The mean microbial load (cfu/g) of samples stored in different storage materials are presented in Tables 5 to 6.

Table 5. Microbial load of enhanced *aadun* samples stored in control and LDPE

Control			LDPE		
(Weeks)	Bacteria(cfu/g)	Fungi(cfu/g)	(Weeks)	Bacteria(cfu/g)	Fungi(cfu/g)
0	0	0	0	0	0
2	1.10×10^{4}	8.0×10^{3}	2	2.23×10^{2}	1.57×10^{2}
4	2.53×10^{4}	1.61×10^{4}	4	9.10×10^{2}	6.30×10^{2}
6	6.03×10^{4}	3.10×10^{4}	6	2.40×10^{3}	1.81×10^{3}
8	1.41×10^{5}	6.45×10^{4}	8	7.03×10^{3}	2.50×10^{3}
10	2.61×10^{5}	1.10×10^{5}	10	1.83×10^{4}	5.83×10^{3}
12	6.71×10^{5}	2.35×10^{5}	12	4.1×10^{4}	1.21×10^{4}
14	1.41×10^{6}	4.71×10^{5}	14	1.10×10^{5}	3.43×10^{4}
16	2.91×10^{6}	9.07×10^{5}	16	3.27×10^{5}	6.07×10^{4}
18	6.18×10^{6}	2.30×10^{6}	18	8.73×10^{5}	1.81×10^{5}

+Values are means of triplicate determinations

Table 6. Microbial load of enhanced *aadun* samples stored in HDPE and Plastic container

HDPE Week	Bacteria(cfu/g)	Fungi(cfu/g)	PC Week	Bacteria(cfu/g)	Fungi(cfu/g)
0	0	0	0	0	0
2	3.27×10^{1}	2.10×10^{1}	2	2.60×10^{1}	1.20×10^{1}
4	8.20×10^{1}	5.10×10^{1}	4	5.57×10^{1}	2.87×10^{1}
6	1.33×10^{2}	9.70×10^{1}	6	9.70×10^{1}	4.53×10^{1}
8	3.27×10^{2}	1.74×10^{2}	8	1.77×10^{2}	8.20×10^{1}
10	7.70×10^{2}	3.11×10^{2}	10	3.74×10^{2}	1.95×10^{2}
12	1.60×10^{3}	6.45×10^{2}	12	7.30×10^{2}	4.12×10^{2}
14	3.21×10^{3}	1.75×10^{3}	14	1.22×10^{3}	9.10×10^{2}
16	6.77×10^{3}	3.83×10^{3}	16	2.57×10^{3}	1.71×10^{3}
18	1.21×10^{4}	7.03×10^{3}	18	5.60×10^{3}	3.13×10^{3}

+Values are means of triplicate determinations

4. Discussion

4.1 Effect of packaging materials on the proximate composition of stored aadun samples.

The proximate composition of the enhanced *aadun* snack stored for 18 weeks varied with the type of packaging material.

4.2 Moisture content of the packaged *aadun* samples

The moisture content of the enhanced *aadun* stored in all the packaging materials increased significantly ($P \leq 0.05$) throughout the storage period as shown in Figure 2. This may be due to the moisture absorbed from the atmosphere during storage. The steady but gradual increase in the moisture content of the samples in the LDPE (5.18 to 7.36%, HDPE (5.18 to 6.52) and PC (5.18 to 6.12%) could be as a result of the relative moisture permeability of the packaging materials. The highest increase (5.18 to 10.08%) found in the samples stored in the control may be as a result of the shrinkage nature of leaves. Moisture content is an indicator of shelf stability; increase in moisture content can enhance microbial growth which leads to deterioration of foods [3]. [4] reported an increase in moisture content from 3.5 to 5% in Thai rice extruded snack supplemented with mulberry during storage of 4 months. Irrespective of storage temperature and relative humidity, the moisture content of the samples in the LDPE were higher than those stored in HDPE and plastic containers; which is in agreement with earlier findings of [5, 6] who reported higher moisture content for LDPE during storage for *pupuru* and African breadfruit seed flour, respectively.

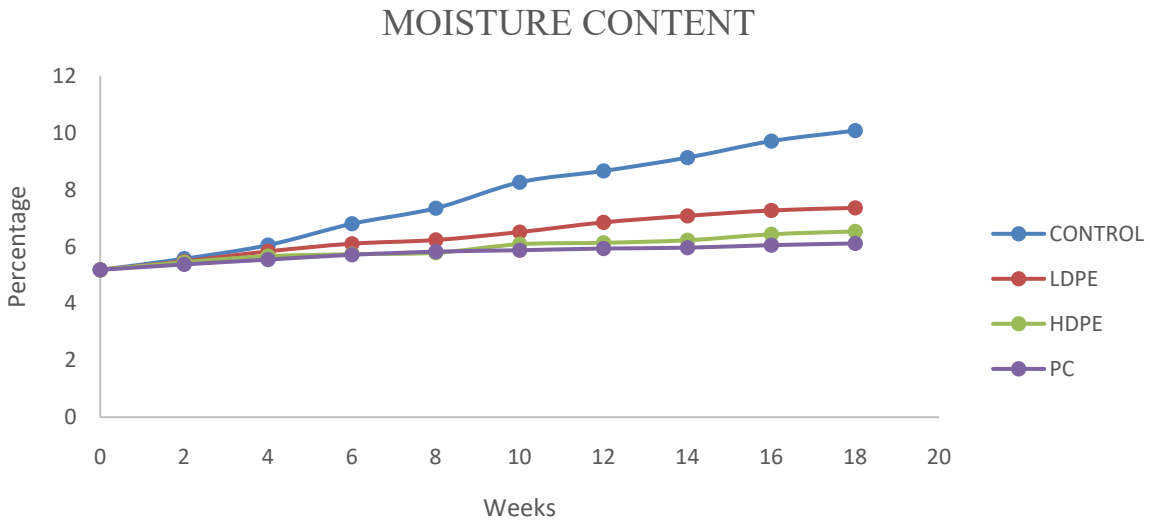

Figure 2. Effect of packaging materials on the moisture content of the samples.

4.3 Protein content of the packaged *aadun* samples

The protein content of the samples stored in the plastic container and HDPE (Figures 3 and 4) decreased slightly from 16.04 to 14.75% and 16.04 to 13.29% respectively, compared to the other storage materials. The protein content of the enhanced *aadun* samples decreased significantly ($P \leq 0.05$) in the four storage materials as the period of st orage increased as shown in Figure 4.9. The decrease in protein content in all samples stored in the different materials could be as a result of the effects of moisture content and microbial activities in the stored sample. The result for protein content of this study are in agreement with the previous work of [7] who reported similar trend of decrease in protein of sweet potato flour from 9.69 to 6.36%. Proteins are vital component of diet required for the survival of human and animals and the basic function of protein in nutrition is to provide adequate amount of amino acids [8].

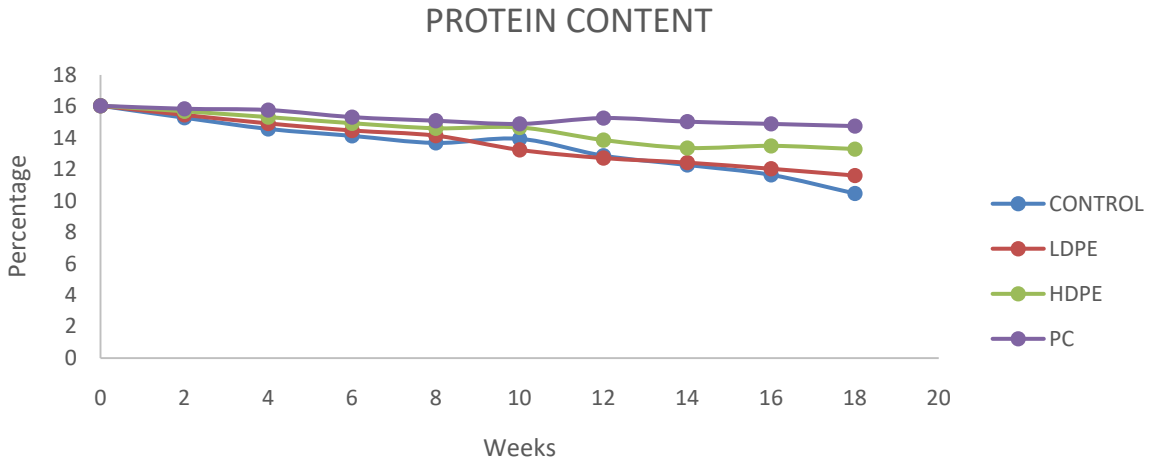

Figure 3. Effect of packaging materials on the protein content of *aadun* samples.

4.4 Fibre content of the packaged *aadun* samples

During the storage period of 18 weeks, the fibre value decreased significantly ($P \leq 0.05$) from an initial value of 5.77 % to a minimum value of 2.48, 3.03, 4.57 and 4.94% for samples stored in leaf, LDPE, HDPE and PC as shown in Figure 3. [9] reported values of 2.27% to 2.01 (transparent cellophane), 1.45 (aluminium foil), 2.15 (plastic bottle) and 1.74% (glass bottle). [10] reported that the fibre value of *abacha* increased from 0.51 to 0.48% after storing in sterile polythene bag for 4 months. Crude fibre helps in lowering of blood sugar level and brings down the absorption of glucose [11]. It is pertinent to note that crude fibre increases satiety and hence helps to impact some degree of weight management [12] due to low energy and low fat flour formulated. Dietary fibre is the edible part of plant or analogous. carbohydrates that are resistant to digestion and absorption in the small intestine.

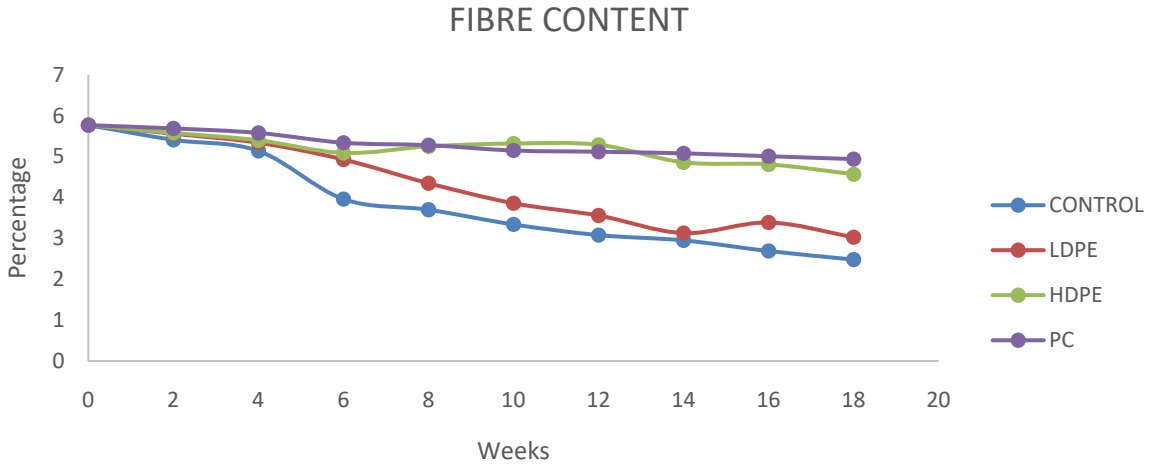

Figure 4. Effect of packaging materials on the fibre content of *aadun* samples.

4.5 Ash content of the packaged *aadun* samples

Ash content of a food is reported to give an idea of the mineral elements present [13], and it indicates the composition of inorganic constituents after organic materials such as fats, proteins, and carbohydrates, as well as moisture, have been removed by incineration [14].

The ash content of the snack decreased significantly in all the storage materials. The samples stored in the leaf recorded a final ash value of 2.86%, LDPE (3.06%), HDPE (3.83%) and PC (4.01%) after 18 weeks of storage from initial 4.78% (Figures 1-4). Statistically, the ash content decreased significantly ($P \leq 0.05$) during the storage period in all the storage materials with the least rate of decrease recorded in PC followed by HDPE, LDPE and then leaf (Figure 5). The low decrease in HDPE and PC might be as a result of low moisture content which inhibits the rapid growth of microorganisms. Some of these minerals that make up the ash content of a food aid in the metabolism of other organic compounds such as fat and carbohydrate [15]. The result is in line with the report of [16] who reported a decrease in the ash content of *lafun* stored in vacuum sealed opaque bag from 2.80 to 1.38% for 90 days. [17] reported that the ash content of *garri* ranged from 0.2 to 1.8% after 24 weeks of storage in different package types.

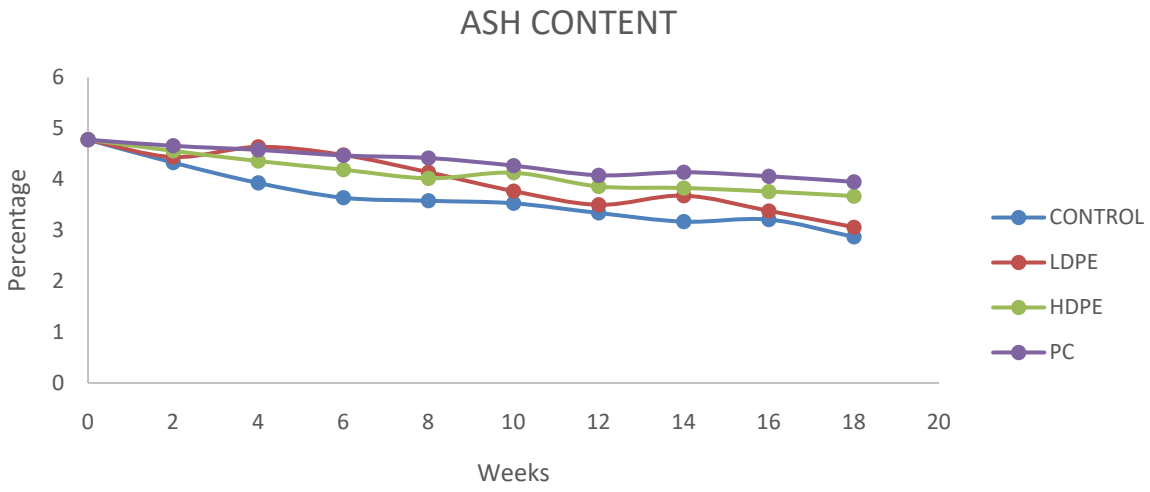

Figure 5. Effect of packaging materials on the ash content of the samples.

4.6 Fat content of the packaged *aadun* samples

Fats act as flavour retainers and help to improve sensory properties of baked products. However, diets high in fat predispose consumers to different illnesses such as obesity and coronary heart diseases [16]. The fat content of the samples stored in leaf and LDPE decreased more rapidly with respect to storage period than the samples in the HDPE and PC as shown in Figure 6. The decrease in fat content in the leaf and LDPE samples could be due to the activities of the enzymes lipase and lipoxidase during storage, which are enhanced by the moisture content of the samples [18]. The fat content of the sample in the PC recorded the lowest decrease in fat while the samples stored in the leaf had the highest decrease. The samples decreased significantly ($P \leq 0.05$) from 20.24 to 12.53% (control), 14.36% (LDPE), 16.90% (HDPE) and 18.21% (PC) as shown in Tables 1 to 4. The quantity of fat in these samples decreased with an increase in the storage period, the observed trend of reduction is in agreement with the report of [19], who reported a decrease in fat content of 17.65 to 16.98% for defatted soybean cake after 90 days. The reduction could be as a result of the decrease in protein content. Also, the result observed is relatively high, which implies a high susceptibility to rancidity resulting in an off-flavour and a shorter shelf life.

4.7 Carbohydrate content of the packaged *aadun* samples

The samples in all the packaging materials showed a high value of carbohydrate during the 18 weeks of storage. The carbohydrate samples in all the materials increased significantly ($P \leq 0.05$) with increase in storage duration as shown in Figure 7. The samples increased from an initial value of 47.99% to 52.04% in PC, followed by 55.04% in HDPE, 60.59% in LDPE and the highest (61.57%) in control (Tables 1 to 4). This finding suggests that the percentage increment in carbohydrate depends on the percentage of all other components (moisture content, protein, fat, fibre and ash). The highest carbohydrate at the end of the storage period was observed in samples packed in leaf and this might be as a result of the high moisture content recorded for the sample at the end of the storage period. The sample stored in PC had

the least carbohydrate value which might be as a result of the low moisture content. Total carbohydrate is an indication of organic matter present in the samples and is directly proportional to the dry matter content. [20] reported that the difference in total carbohydrate content (51.06-56.71%) among *kokoro* samples can be attributed to the composition of other nutrients and the effect of processing on the maize samples.

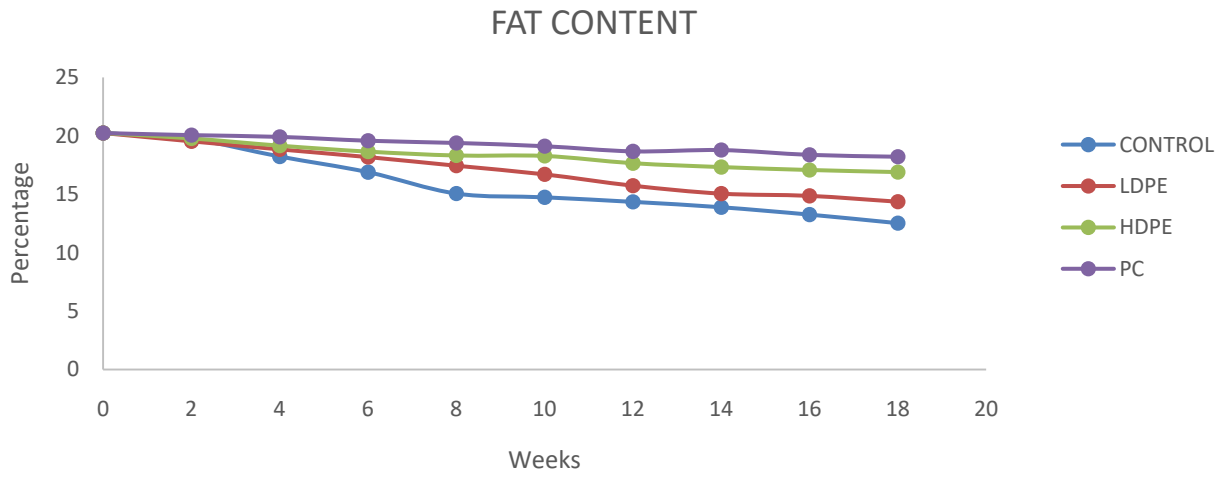

Figure 6. Effect of packaging materials on the fat content of the samples.

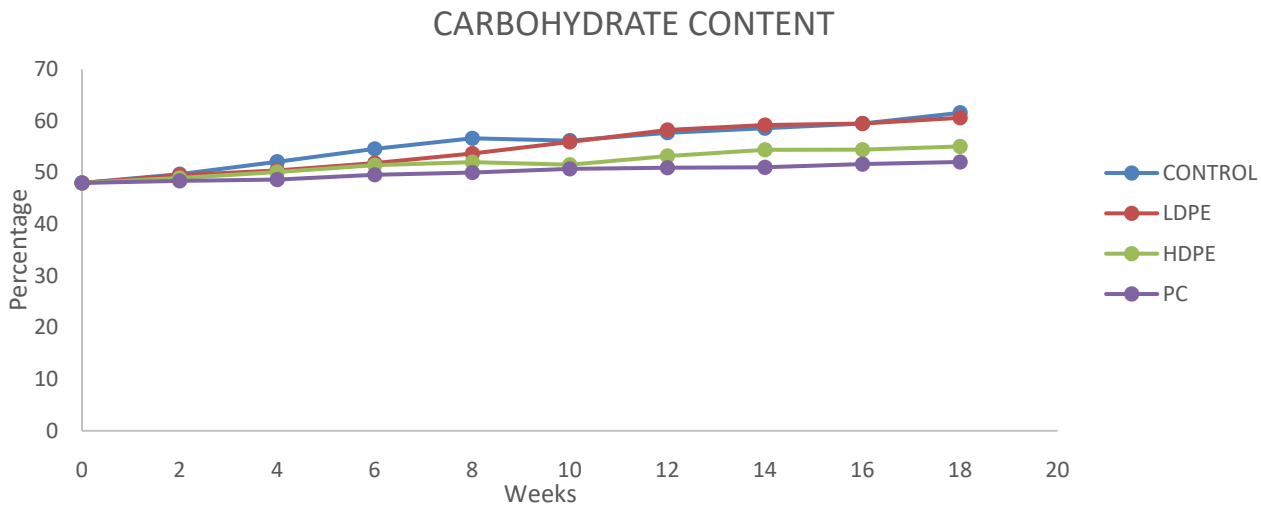

Figure 7. Effect of packaging materials on the carbohydrate content of the samples.

4.8 Effect of packaging materials on microbial load of stored *aadun* samples

The microbial load of the *aadun* samples stored in the different materials are presented in Tables 5 and 6.

4.9 Bacterial load of the packaged *aadun* samples

The result of the bacterial counts of the enhanced *aadun* samples stored in different packaging systems is presented in Figure 8. The initial bacterial count of the sample was 0cfu/g before storage; after two weeks of storage in the different packaging media, samples in the leaf recorded 1.1×10^4 cfu/g, LDPE (2.23×10^2 cfu/g), HDPE (3.27×10^1 cfu/g) and PC (2.6×10^1 cfu/g) respectively. The samples stored in the leaf and LDPE recorded high bacterial counts of 6.18×10^6 and 8.73×10^5 cfu/g respectively after 18 weeks of storage. While those in the HDPE and PC were 1.21×10^4 and 5.60×10^3 cfu/g respectively. These indicate that the storage media and period of storage have influence on the growth of total viable counts (Figure 8). [21] gave similar report on *dodo ikire* - a popular, age long over-ripe plantain-based snack;

they reported an increase in the bacterial count of *dodo ikire* snack stored in open storage, LDPE and HDPE from 2.0cfu/g to (10.0 $\times 10^5$cfu/g), (8.5$\times 10^5$) and (6.0 $\times 10^5$cfu/g) after four weeks.

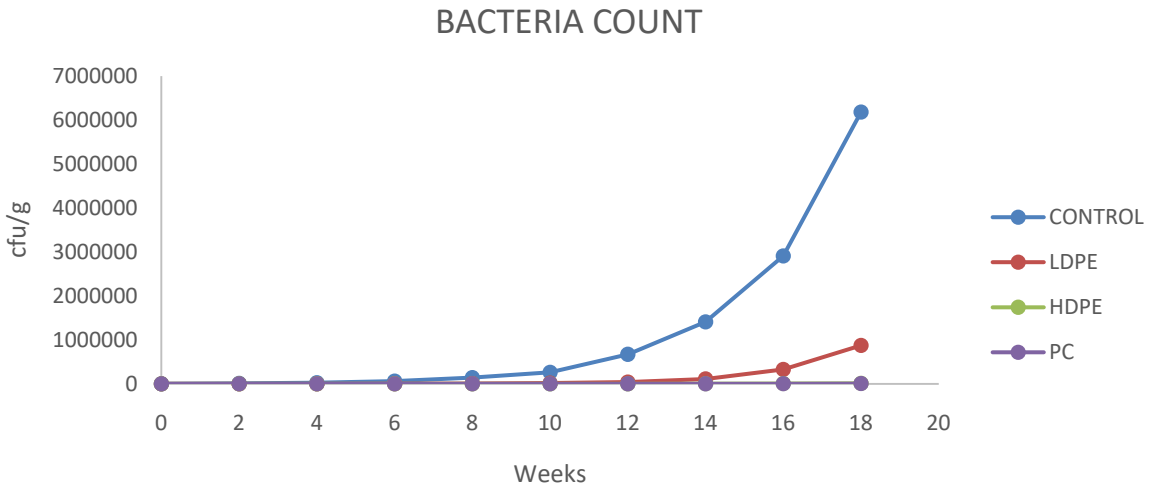

Figure 8. Effect of packaging material on the bacterial count of the samples.

4.10 Fungi counts of the packaged *aadun* samples

Fungal counts of the stored *aadun* snacks are represented in Figure 9. The four samples had no growth on the plate at 0 week and this was maintained until the second week. However, after 18 weeks of storage, the samples stored in the different media showed that the fungal counts have grown to 2.30$\times 10^6$cfu/g in the control, 1.81$\times 10^5$cfu/g (LDPE), 7.03$\times 10^3$cfu/g (HDPE) and 3.13$\times 10^3$cfu/g for PC. This trend is similar to the bacterial counts in the samples. This is in line with a microbiological claim which stated that most microbiological spoilage of common snacks may be attributed to fungal growth [22].

The maximum permissible level of total aerobic colony of ready-to-eat foods as given by Fylde Borough Council extracted from manual of [23] was 10^4 to less than 10^6cfu/g of ready-to-eat food products. Similarly, international commission on microbiological specification for foods [24], asserted that, ready-to-eat foods with standard total count below 10^4 cfu/g are still considered safe for human consumption. Since the level of infestation was minimal in HDPE and PC, use of traditional packaging systems (leaf and LDPE) should be discouraged. [25, 26] reported fungi to be the major contaminating microbe of peanut and maize during storage, therefore their occurrence might also be due to exposure of these street vended snacks to fungal spore resident in the air.

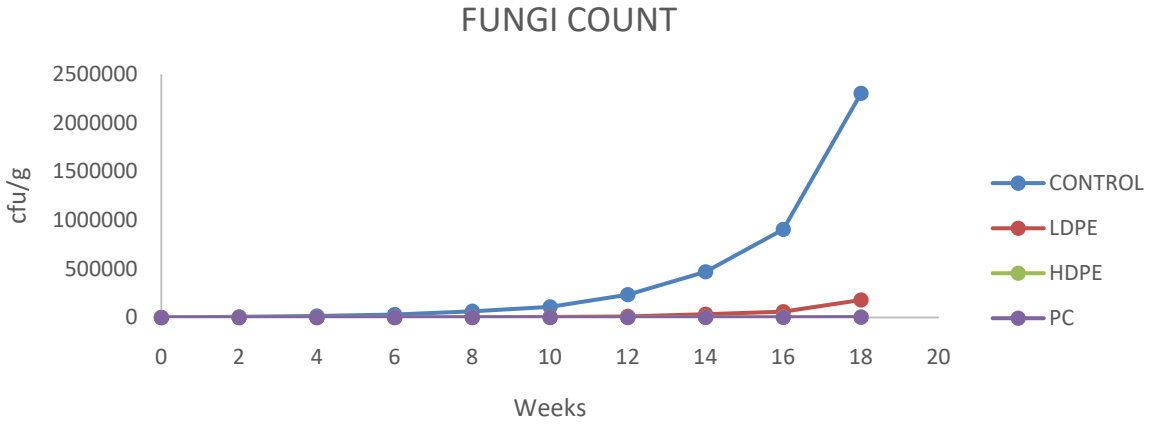

Figure 9. Effect of packaging material on the bacterial count of the samples.

5. Conclusion

The moisture and carbohydrate contents increased in all the samples during storage, however, the samples in the PC,

HDPE and LDPE were within the acceptable moisture limit (<10%) of snacks. The ash, fibre, fat, protein and energy values decreased in all the samples but the rate of decrease was less in PC followed by the HDPE and the LDPE, while those of the sample in the control decreased faster compared to the other materials. Based on the International Commission on Microbiological Specification for Foods, the shelf life of the control sample was less than two weeks, that of the LDPE was eight weeks, HDPE sixteen weeks while the sample stored in the PC was still safe for consumption at the end of the storage duration (eighteen weeks).

References

[1] Jonathan, S.G., Adeniyi M.A., & Asemoloye, M.D. (2015). Nutritional value, Fungi bio-deterioration and Aflatoxin contaminations of Maize Snack (*aadun*). *Researcher*, 7 (12), 26-31. (ISSN: 1553-9865).

[2] Adedokun, S.O. (2006). Effect of packaging material and storage condition on quality attributes of "*Aadun*" (A maize-based Nigerian snacks). M.Sc. Dissertation, Department of Food Science and Technology, University of Agriculture, Abeokuta.

[3] Adejumo, B. A. (2013). Some Quality Attributes of Locally Produced Wheat Flour in Storage. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 5(2), 47-49.

[4] Charunuch, C, Rungchang, S., Teangpook, C., & Sonted, V. (2008). Iron Fortification in Developing of Extruded Thai Rice Snack. *Kasetsart Journal of Natural Science*, 42(3), 60-66.

[5] Daramola, O.A., Idowu, M.A., Atanda, O.O., & Oguntona, C.B. (2010). Effects of packaging material on the quality of "pupuru" flour during storage. *African Journal of Food Science*, 4(5), 258-263.

[6] Fasasi, O.S. (2003). Effect of Different Packaging Materials on the Chemical Composition of African Breadfruit Seed (Treculia africana) Flour during Storage at Room Temperature. *In: Proceedings of 27th Annual Conference of Nigerian Institute of Food Science and Technology*, 153-154.

[7] Ogbonnaya, C., & Lawal, A. (2015). Comparative Study of Storage Stability of Sweet Potato and Yam Flours. *International Journal of Emerging Technologies in Engineering Research* 3(3), 44-49.

[8] Pugalenthi, M., Vadival, V., Gurumoothi, P., & Janardhanan, I. (2004). Comparative Nutritional evaluation of little known legumes Tamarindus indica, Erythrine indica and Sesbania bispinosa. *Tropic and Subtropic Agroecosyte*, 4, 107-123.

[9] Adedeji, T.O., & Oluwalana, I.B. (2018). The Effect of Packaging Material on the Quality Attributes of stored Fried Maize Chips. *Research Journal of Food and Nutrition*, 2(4), 13-19.

[10] Jonathan, S.G., Okoro, C.E, Adejoye, D.O, Asemoloye, M.D., & Kayode, F. (2017). Effects of Storage Methods and Fungal Biodeterioration on Nutrient and Aflatoxin Compositions of 'Abacha' a Staple Food from Nigeria. *Archives of Clinical Microbiology*, 8(5), 66-72.

[11] Hamza A.M, Collins A, Ado S.G, Ikuenobe C.E., & Ataga C.D. (2014). Proximate compositions evaluation and variability among cultivars of date palm (Phoenix dactylifera L.) in Nigeria. *International Journal of Plant Soil Science*, 3(3), 248-259.

[12] Mickelson, O., Makadani, D.D., Cotton, R.H., Titcomb, S.T., & Colmey, J.C. (2009). Effects of a high fibre bread diet on weight loss in collage age males. *American Journal of Clinical Nutrition*, 32(8), 1703-1717. https://doi.org/10.1093/ajcn/32.8.1703.

[13] Ndife, J., Obiegbunna, J., & Ajayi, S. (2013). Comparative evaluation of the nutritional and sensory quality of major commercial whole-wheat breads in Nigerian market. *Advance Journal of Food Science and Technology*, 5(12), 1-11.

[14] Iwe, M.O., Onyeukuw, U., Agiriga, A.N., & Fatih, Y. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and Brown cowpea seeds composite flour. *Cogent Food and Agriculture*, 2:1142409. doi: 10.1080/23311932.2016.1142409.

[15] Ojinnaka, M.C., & Nnorom, C.C. (2015). Quality evaluation of wheat cocoyam-soybean cookies. *Nigerian Journal of Agriculture, Food and Environment (NJAFE)*, 11(3), 123-129.

[16] Abosede, O.F., Kunle O., Emmanuel O.O., Adelodun, L.K., & Oladotun, A.F. (2022). Quality assurance, safety, and acceptability of stored yellow lactic lafun: an index of increasing it shelf life. *Innovare Journal of Agricultural Science*, 10(6), 20-27.

[17] Ogiehor, I., & Ikenebomeh, M. (2006). The effects of different packaging materials on the shelf stability of garri. *African Journal of Biotechnology*, 5, 741-745.

[18] Nasir, M., Masood, B, Faqir, A., & Sharif, M. (2003). Effect of Moisture on the Shelf Life of Wheat Flour. *International Journal of Agricultural and Biology*, 4, 458-459.

[19] Kolapo, A.L, Oladimeji, G.R, Ifejika, A.I, Osakwe, O.E., & Eyitayo, I.R. (2012). Aflatoxin, Nutritive Values and Microbiological Status of Stored Cakes of Some Selected Nigerian Oil Seeds. *Global Journal of Science Frontier Research Agriculture and Biology*, 12(5), 13-22.

[20] Akinsola, O.T., Alamu, E.O, Otegbayo, B.O, Menkir, A., & Maziya-Dixon, B. (2020). Evaluation of Quality and Acceptability of Snack (Kokoro) Produced from Synthetic Provitamin A Maize (Zea mays) Genotypes. *Frontiers Sustainable Food Systems*, 4:576217. doi: 10.3389/fsufs.2020.576217.

[21] Olatoye, K.K. & Lawal, A.I. (2016). Storability of "Dodo Ikire" (over -ripe plantain-basedsnack) at ambient temperature (28±2Cº). *Agricultural Engineering International: CIGR Journal*, 18(1), 263-268.

[22] James, M. (2000). Modern food microbiology Sixth edition. *Aspen publishers*, Gaithersburg, Maryland USA.

[23] Public Health Laboratory Service Guidelines (PHLSG). (2008). The Microbiological Quality of Ready-to-Eat Foods Sampled at the Point of Sale. Brough Council.

[24] International Commission on Microbiological Specification for Foods (ICMSF). (2010). UDA information office. Available at: http//fsrio.nal.usda.gov/sanitation-and-qualitystandard/micro biological-standards-and guidelines.

[25] Gachomo, E.W., Mutitu, E.W & Kotchoni, O.S. (2004). Diversity of fungal species associated with peanuts in storage and the levels of aflatoxins in infected samples. *International Journal of Agricultural Biology*, 6(6), 955-959.

[26] Jimoh, K.O., & Kolapo, A.L. (2008). Mycoflora and Aflatoxin production in market samples of some selected Nigerian food-stuffs. *Research Journal of Microbiology*, 3, 169-174.