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Impact of Packaging Materials on the Shelf Life of Enriched *Aadun* (Maize Meal Snack commonly consumed by the Southwestern region of Nigeria)

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ABSTRACT

Optimum condition at 64.80% maize flour, 20% groundnut paste and 13.20 % palm oil was formulated to produced nutritionally enhanced aadun snack. The snack was stored in the different storage materials namely, sweet prayer plant leaves (control) which is usually used by most locals, low density polyethylene (LDPE), high density polyethylene (HDPE) and food grade plastic container (PC). The initial properties (energy, oxidative and sensory properties) of the enhanced aadun (before storage) were investigated and stored in each of the storage materials. The enhanced aadun samples in each storage material were analysed at two weeks interval for eighteen weeks. The results obtained were analysed statistically to examine the effect of the storage material on the aforementioned properties. The results for energy content decreased significantly ($P>0.05$) in across all the samples stored. The free fatty acid, acid valve and peroxide value increased significantly ($P<0.05$) in all the storage materials during the storage period but only the samples stored in PC and HDPE were within the recommended limit of FAO (Food and Agricultural Organization) at the end of the storage period. The sensory quality of the control sample was acceptable up to 12 weeks while samples in other storage materials were still acceptable at the end of the storage period under ambient storage condition.

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Introduction

A snack is a minor meal often lesser than a regular meal, which is usually taken between meals and normally appreciated and consumed by all age groups and can be taken at any period of the day (Aroyeun *et al*., 2017). Snacking is a means for individuals to gain strength for their day-to-day activities. According to Henshaw and Imedioha, (1992) snacks baked from wheat, like biscuits and cakes has been vastly elevated despites their health consequences therefore making snacks consumers to abandon indigenous snacks such as "*aadun*" in spite of its high energy, fibre and minerals levels remains at inferior ebbs and has been confined as poor people snacks (Idowu and Adedokun, 2011).

Aadun is a traditional snack normally consumed by the Yoruba ethnic group of Nigeria, *aadun* is generally reddish in appearance and shaped into balls. *Aadun* is a snack food made from toasted maize flour which is more than three-quarter of the whole snack (Jonathan *et al.,* 2015). It is characterized by its fine texture, ease of digestion and sweetness.

FAO (1998) described street vended snacks as ready to eat foods and beverages made and/or sold by vendors and hawkers particularly in market streets and other open places; with this description, "*aadun*" can be categorized as a street vended snack. Street vended food, even when prepared under poor hygiene condition, is often consumed irrespective of the production source or quality of ingredients used. The choice of a specific street snack is determined by the taste, financial power and accessibility at the point of consumption (Sobukola *et al*., 2008).

Adedokun (2006) noted that *aadun* is a good energy snack with phosphorus and magnesium been its main mineral and it is normally sold with less significant packaging in environmental conditions that can lead to its immediate deterioration. Consumers are more concerned about 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 snack and also the level of 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 spoilage and low shelf life. The purpose of this work is to examine the effect of different packaging material on the energy content, oxidative properties and sensory analysis of *aadun* supplemented with groundnut paste.

Materials and Methods

Materials

Samples of freshly harvested white maize (commonly used by locals) and unshelled groundnut seeds were obtained from a farm in Minna, Niger state, Nigeria. The groundnut enhanced *aadun* snacks were prepared using the method of Adedokun (2006). Other ingredients such as palm oil, seasonings and salt were gotten from *Kasuwa Gwari* market in Minna.

Storage Studies

Aadun samples for storage studies were produced at the optimal ratio condition attained from the experimental design. These samples were packaged using sweet prayer plant leaves, LDPE bags, HDPE bags and plastic container as shown in Plate 1 to 4. During the period of storage, the energy content, oxidative properties and sensory parameters of the sample in each packaging medium were evaluated every two weeks, while the daily temperature and relative humidity were recorded at an interval of six hours.

Methods

Energy content

The energy content of the enhanced snack was calculated from using the Atwater factor.

Oxidative stability properties

Measurement of rancidity in the enhanced snack was carried out by examining free fatty acid (FFA), acid value (AV) and peroxide value (PV) according to the methods of Association of Analytical Chemists, AOAC (2005).

Sensory Analysis

Sensory properties of the enhanced snack were evaluated by panellists based on colour, aroma, taste, texture, mouth feel and overall acceptability. The quality indices were assessed on a 9-point Hedonic scale as described by Mishra *et al*. (2012).

Statistical Analysis

All procedures were done in triplicates and data collected from the experiment 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 ($p< 0.05$).

Result and Discussion

The stored enhanced *aadun* was formulated an optimum condition of 64.798% maize flour, 20% groundnut paste and 13.202 % palm oil. The results of the energy content, oxidative properties and sensory properties of the stored snack are presented in Figure 1 to 5.

Effect of Packaging Materials on the Energy Content of Enhanced aadun Samples

The energy content of the enhanced *aadun* snack stored for 18 weeks varied with the type of packaging material. The results of the energy content in the different storage materials are presented in Figure 1. The energy content decreased significantly during the storage period. The energy decreased from an initial pre-storage value of 438.26 to 400.90 kcal/100g for samples stored in the control, 417.97 kcal/100g in LDPE, 425.47 kcal/100g in HDPE and 431.09 in PC after 18 weeks of storage duration as shown in Figure 4.14. The result (Table 1) indicated that there was no significant difference ($p > 0.05$) in the energy content of the control and the three storage materials during the storage period except for the control sample at twelfth week. The level of decrease was highest in the sample stored in the control while the lowest was recorded for sample in the PC. The decrease might be due to decrease in the carbohydrate, protein and fat levels of the samples during storage.

Plate I. Enriched *aadun* packaged in leaves

Plate II. Enriched *aadun* packaged in LDPE

Plate III. Enriched *aadun* packaged in HDPE

Plate IV. Enriched *aadun* packaged in PC

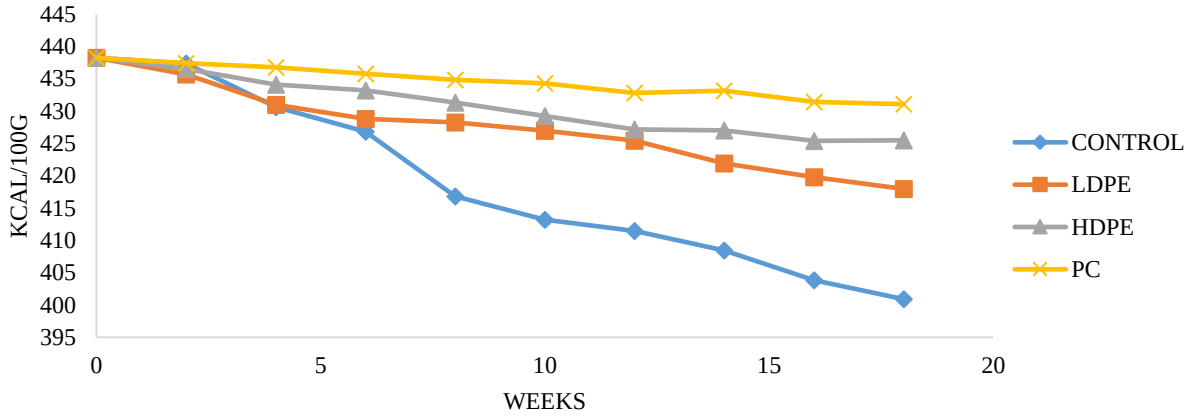

Figure 1. Effect of packaging materials on the energy content of the samples

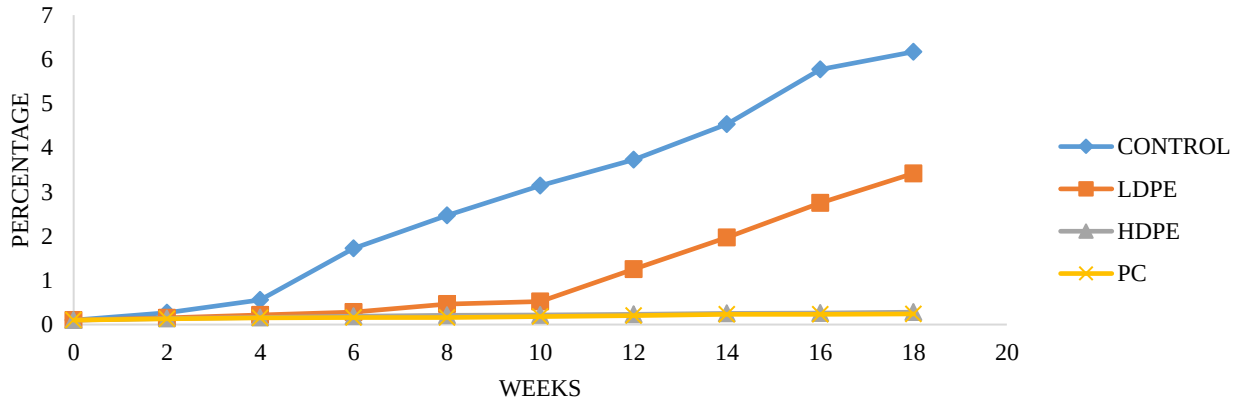

Figure 2. Effect of packaging materials on the FFA value of the samples

Effect of Packaging Materials on the Oxidative Properties of Enhanced aadun Samples

The results for the oxidative evaluation: FFA, AV and PV of the enhanced *aadun* samples stored in different materials are shown in Figure 2 to 5

Free Fatty Acid (FFA) of the Packaged aadun Samples

Free fatty acid content increased significantly ($p<0.05$) during storage period in all the storage materials as shown in Figure 2. The initial value of free fatty acid of the enhanced *aadun* was 0.10%, which at the end of the storage period rose to 6.17% in sample stored in the control, 3.42% for sample in LDPE, 0.28% sample in the HDPE and 0.24% for sample in the PC. The free fatty acid content of *aadun* samples stored in HDPE and PC has no strong indication of rancidity as to samples stored in LDPE and the control (leaf). Idowu and Rahman (2016) reported a FFA value of 1.1% for *kokoro* snack stored in polyethylene bags (100µm) after 12 weeks of storage. Idowu *et al* (2012) also reported a range of 0.29 to 0.47% for FFA value of twenty-eight street vended "*aadun*" samples.

Acid Value (AV) of the Packaged aadun Samples

The acid value increased significantly ($p<0.05$) across all the samples in the storage materials after 18 weeks (Figure 3). Sample stored in the control increased from an initial value of 0.21 to 12.35 mg KOH/g which is the highest acid value among the storage material after 18 weeks. While the least value (0.49 mg KOH/g) was the sample stored in the PC. The sample in the LDPE and HDPE was 6.83 and 0.55 mg KOH/g after 18 weeks of storage. The increase in acid value with storage indicates the degradation of the oils by hydrolytic scission (Ghosh *et al.*, 2014). Therefore, samples in the control deteriorate fast and quickly, followed by the samples in LDPE then HDPE and finally PC. The trend in acid value of this work is similar to the result of Afolabi *et al.* (2018) that noted an increase in the acid value of pure peanut butter from 1.90 to 2.77 mg KOH/g after 12 weeks of storage in hermetically sealed containers.

Peroxide Value (PV) of the Packaged aadun Samples

The peroxide value is used to evaluated the level of rancidity of oils during storage, hence, it can be used as an index in determining stability of fats and oils (Ekwu and Nwagu, 2014). The PV result (Figure 3) follows a similar pattern with AV and FFA. The PV of the *aadun* samples significantly ($P>0.05$) increased with increase in storage duration in all the storage material. The peroxide value increased from an initial value of 0.86 meq/kg to a final value of 22.45 meq/kg for sample stored in the control, 12.34 meq/kg for sample in LDPE, HDPE (8.44 meq/kg) and PC (3.09 meq/kg). However, the peroxide values in the HDPE and PC were significantly ($P< 0.05$) lower than 10 meq/kg, a value at which oil food is considered to be rancid while the value of samples stored in control and LDPE were higher than the acceptable limit after 18 weeks of storage duration. The rancidity of the sample stored in the control began after 6 weeks while that of sample stored in the LDPE was noticed at sixteenth week of storage.

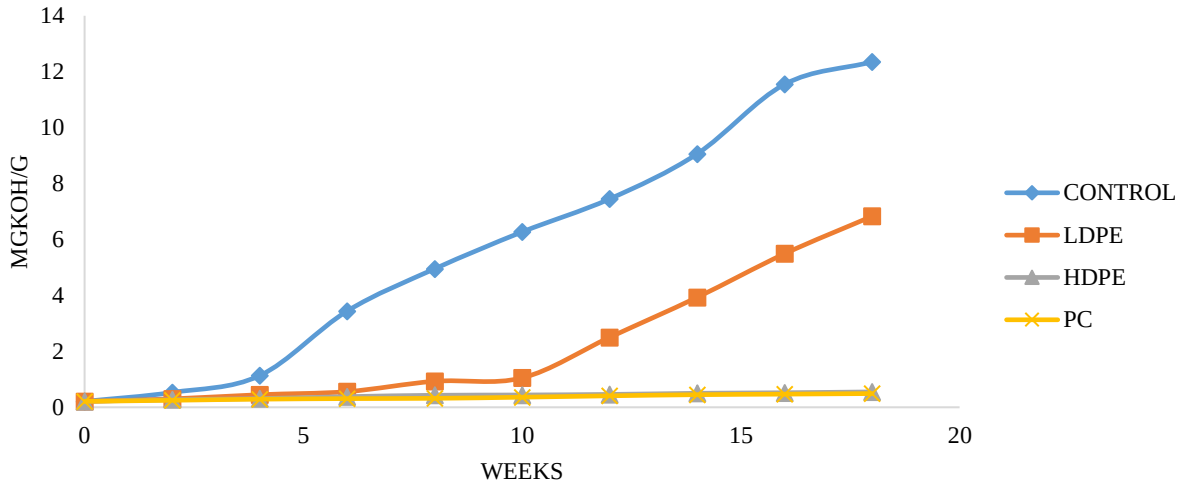

Figure 3. Effect of packaging material on the acid value of the samples

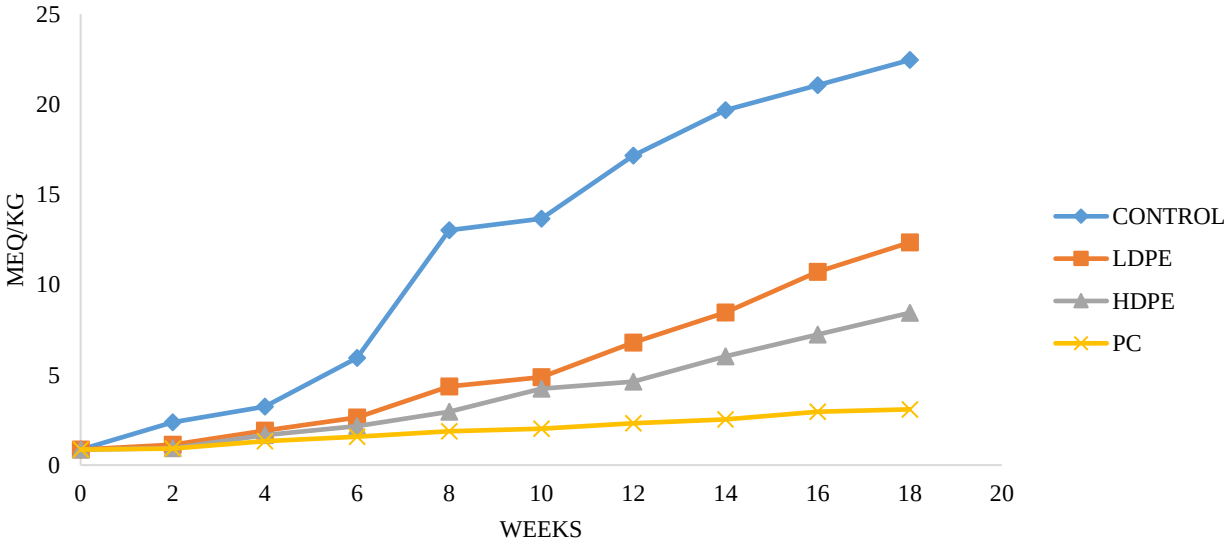

Figure 4. Effect of packaging material on the peroxide value of the samples

Effect of packaging materials on the Sensory properties of packaged *aadun* samples

The effect of packaging material on the sensory properties of the snack and their interaction was only marginal. It means whatever decrease in scores could be credited to the effect of duration of storage. There was no significant difference ($p>0.05$) in all the sensory analysis during the storage period.

The appearance score decreased in all the storage materials due to the colour of the snack gradually changed during the storage period. The decrease in appearance score was due to oxidation of brown compounds resulting in slight fading of colour. The samples stored in the HDPE was most preferred after 18 weeks of storage duration when compared to other storage materials used. While there was no significant difference ($p>0.05$) in the appearance of the *aadun* samples during the storage period, samples stored in the HDPE had the highest mean score for appearance (6.30), next was PC (6.2), control (6.10) while the samples in the LDPE recorded the least score of (5.80) after 18 weeks of storage.

The samples stored in PC scored the highest (6.20) in taste followed by HDPE (6.10) after 18 weeks of storage, from an initial score of 7.80. The high taste score in these storage materials might be as a result high barrier to external factors during storage. The taste investigation for both the control and the LDPE ended at eighth and tenth week respectively as a result of high microbial count, insect infestation and the occurrence of off-flavour as a result of increased rancidity. The final test scores of the samples in control and LDPE were 5.40 and 6.00 respectively.

The texture was scored 7.90 by the panellists prior to storage. The textural scores decreased during storage; this might be as a result of the increase in moisture content of the samples during storage. The final score at the end of storage in samples stored in PC was 6.50 (the highest), followed by HDPE (6.40) and LDPE (6.10) while the least score for the texture attribute was found in samples stored in the control (5.50). The low score in texture of samples stored in the control might be as a result of high moisture content and presence of foreign matters (from part of the shrank leaf and microorganisms).

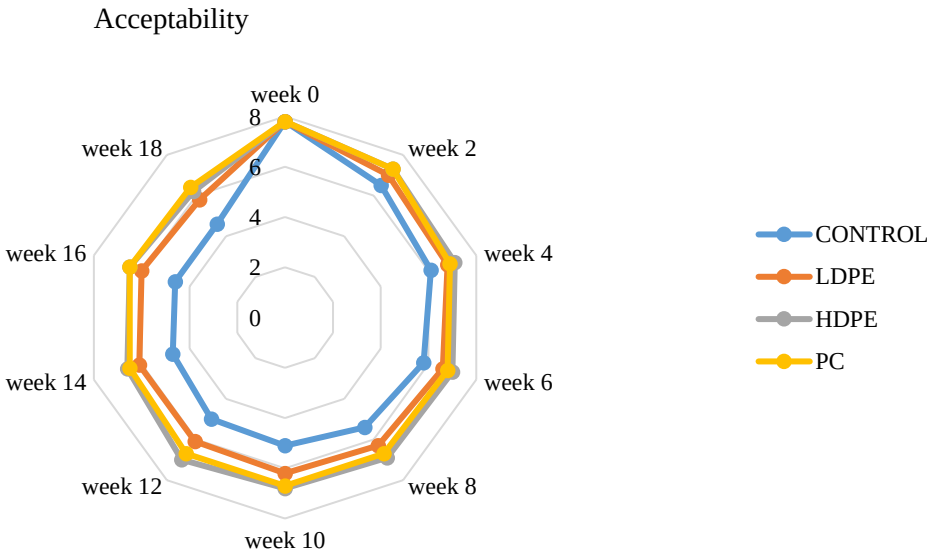

Figure 5. Effect of storage duration on overall acceptability of the samples

The aroma scores were also affected but only marginally (that is, decrease in scores could be attributed to the effect of duration of storage). The aroma scores awarded to the snack stored in control and LDPE was 4.9 for each, HDPE and PC were 6.20 and 6.30 respectively at the end of the storage period. Aroma score was high in PC for it has good barrier properties to moisture and volatile flavour elements (Adedeji and Oluwalana, 2018). The accessible oxygen content might be attributed to development of aerobes affecting the aroma in the control and LDPE. The reduction in the taste and aroma scores of the control and LDPE samples might be due to increased rancidity level of the snack.

The overall acceptance of the stored *aadun* was also affected because of the changes in other sensory attributes. The overall acceptance scores gradually diminished (Figure 5), yet at the end of storage period of 18 weeks, the samples stored in the PC, HDPE and LDPE remained acceptable by the panellists. However, the control samples had the lowest score. The statistical mean scores of overall acceptances of the samples packed in the control, LDPE, HDPE and PC were 4.60, 5.80, 6.20 and 6.30 respectively. The least overall acceptance score was awarded to the control sample while the PC sample has the maximum level of acceptability as a result of its better aroma, taste and texture in relation to other samples.

Conclusions

This study examined the impact of different packaging materials on the energy content, oxidative properties, and sensory analysis of enhanced aadun snacks made from maize and groundnut paste. Results showed that energy content decreased in all samples, with the slowest decline in PC, followed by HDPE and LDPE, while the control sample experienced the fastest decrease. Free fatty acid, acid value, and peroxide value increased in all samples during storage, but only those stored in PC and HDPE remained within FAO's recommended limits. Rancidity was tolerable for two weeks in the control, six weeks in LDPE, and samples in HDPE and PC were still safe at the end of the storage period. Sensory quality of the control sample was acceptable for up to 12 weeks, whereas samples in other materials remained acceptable throughout the storage period. PC samples had the highest acceptability score, followed by HDPE samples.

Declarations

All authors contributed to the study design, data collection, analysis, and interpretation of results. All authors read and approved the final manuscript.

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