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EFFECTS OF PACKAGING MATERIALS AND STORAGE PERIOD ON THE NUTRITIONAL QUALITIES OF DRIED FERMENTED SLURRY (*OGI*) MADE FROM SORGHUM, MILLET AND SOYABEANS MIXTURE

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Abstract

This study was carried out to investigate the effects of packaging materials (plastic container, nylon and paper envelopes) and storage period (50 days) on the nutritional qualities (carbohydrate, protein, crude fibre, fat, vitamin A, vitamin C and calcium) of dried ogi made from sorghum (Sorghum bicolor)-(60%), millet (Pennisetum glaucum)-(20%) and soya beans (Glycine max)-(20%) mixture. A small sized rectangular wooden storage structure was developed as part of the study to store the dried packaged product. Drying of the fermented slurry was done at a temperature of 50^0C in a convective dryer (Model DHG-9030) for a period of three (3) hours. Samples were taken at interval of 10 days of storage and analyzed for the stated nutritional qualities. Results obtained revealed that the interaction of each of the three packaging materials (plastic container, nylon and paper envelope) with storage period (10-50 days) had significant effect on the nutrients of the dried packaged product at $P \leq 0.05$. Protein, vitamin A, vitamin C, calcium and moisture contents decreased with increase in storage period for each of the packaging material. Carbohydrate, fat and crude fibre contents displayed irregular pattern of combining increase, decrease or maintenance of constant values at different stages of the storage period. Generally, plastic container got the highest values of carbohydrate, crude fibre, vitamins A and C; and nylon envelope got the highest values of protein and fat contents; but the lowest values of moisture content, and paper envelope retained the highest calcium content at each stage of the storage period. Comparatively, the packaged products stored outside the storage structure slightly retained nutrients better than those stored in the storage structure in most cases at the 50^{th} day of storage. However, for secured keeping, prevention of insects and rodents attack, and harsh effect of sudden change in ambient weather condition on the stored product, the storage structure which is similar to pantry or cupboards in kitchens should still be used.

1.0 Introduction

The need to improve the nutritional qualities of processed foods through addition of other food materials that are rich in the nutrients they are deficient in; and the retention of optimum qualities while the processed foods are undergoing storage have become necessary. This is due to the fact that what the body really needs for growth, development, maintenance, rejuvenation and energy are indeed nutrients present in foods. Some of these nutrients are sometimes lost as a result of poor handling, side effects of processing and its conditions, interactions of packaging materials with environmental conditions of the storage, period of storage and so on. Packaging was reported in [1] as an integral part of food processing that is capable of providing the proper environmental conditions for long shelf life; with protection of products against microbiological, chemical or physical deterioration.

Ogi is one of the staple foods among Nigerians and some Africans. It is usually derived from fermented cereals and it is very rich in carbohydrate; however, other products like soya beans, ginger, egg, melon, garlic, groundnut and vegetables can be added to it during processing for nutritional quality improvement. Some of the important unit operations in the processing of *ogi* are: washing of raw materials, steeping, milling (to form the wet slurry), sieving (optional) and fermentation. The fermented slurry can be dewatered, dried and packaged for value addition and shelf life extension. The wet slurry, also known as gruel [2] or its dried form can be reconstituted with water and cooked in hot water to form a jelly-like finished food known as pap which is popularly called *eko, akamu, agidi* or *koko* in some Nigerian native languages [3]. The cooked food (which may be eaten with beans cake, cheese, cooked vegetable, beans, fish and meat; groundnut, groundnut cake, milk, sugar and some non-alcoholic beverages) was reported by [4] as a good weaning food for infants, breast milk production enhancer for lactating mothers, breakfast food for children and a convenient food for people recovering from sickness. Also, it is a suitable food for the aged because it digests faster. Nutrients present in *ogi* and their levels are functions of factors like type of raw materials used, percentages or ratios of raw materials and method of processing the product. Important information on drying of food and agricultural materials were reported by [5]. Some studies on *ogi* can be found in [2, 3, 4, 6, 7, 8, 9 and10]; however, none of the research considered the combination of sorghum, millet and soya beans to produce *ogi* with a view to improving its nutritional qualities. Also, there is no information to compare the effects of plastic container, nylon and paper envelopes packaging materials on the nutritional qualities of dried *ogi* for the purpose of selecting the most suitable packaging material. Furthermore, wet *ogi* has a very short shelf life; the fermentation process will continue until it is not fit for consumption again due to the increased population of microbes and higher concentration of lactic acid. In areas where cold storage is a great challenge, the possible alternative is to stop the fermentation process of wet *ogi* through drying. Therefore, the sole objective of this research was to investigate the effect of three packaging materials (plastic container, nylon and paper envelopes) and storage period (50 days) on the nutritional qualities of dried *ogi* made from sorghum, millet and soya beans mixture. This research provide information on the extent to which dried *ogi* from mixture of the three raw materials can be stored in three different packaging materials with reference to product nutritional qualities during storage; and the choice of the most suitable packaging material for the product based on the scope of the research.

2.0 Materials and Methods

Preliminary experiment was conducted to establish the mix ratio of raw materials with the highest nutrients in terms of carbohydrate, protein, fat, crude fibre, vitamin A, vitamin C and calcium with [11] standard. Five mix ratios were used, these were, Sample A: 40% sorghum, 40% millet, 20% soya beans; Sample B: 50% sorghum, 30% millet, 20% soya beans; Sample C: 30% sorghum, 50% millet, 20% soybean; Sample D: 20% sorghum, 60% millet, 20% soya beans and Sample E: 60% sorghum, 20% millet, 20% soya beans. Sorghum (*Sorghum bicolor)*, millet (*Pennisetum glaucum)*, soya beans (*Glycine max)* were procured from Oyo State Agricultural Development Programme (OYSADEP) in Saki and Ipata Market in Ilorin, both in Nigeria. Steeping was done for the two cereals at room temperature for 48 hours, followed by milling with burr mill (Alpak, D100L, Nigeria) to form the slurry. The slurry was sieved with clean muslin cloth and allowed to ferment in water for 15 hours. The Soya bean was soaked for 12 hours, milled and was added at the end of the fermentation of the two cereals. A drying temperature of 50^{o}C was used for the drying the wet product inside a convective dryer (Model DHG-9030); other procedures are stated in [4]. After the preliminary experiment, it was discovered that sample E (60% of sorghum: 20% of millet: 20% of soya beans) had the highest nutritional values with 0.55% of fat, 8.42% of protein, 87.37% of carbohydrate, 0.31% crude fibre, 0.65mg/100g of vitamin A, 2.96mg/100g of vitamin C and 8.86 mg/100g of calcium. This established mix ratio was then used for the main experiment with the consideration of the three packaging materials and five storage periods (50 days with 10 days interval).

2.1 Main experiment

Design Expert 6.0.6 version Computer Software was used to design the main experiment. General factorial type of experimental design was used. Three levels of packaging materials (plastic container (3031 cm^3), nylon envelope (15 by 7.5cm with thickness 0.015 mm) and paper envelope (14cm by 13cm with thickness 0.03 mm) and five levels of storage periods (10, 20, 30, 40 and 50 days) were combined. The established mix ratio (60% of sorghum: 20% of millet: 20% of soya beans) was used as a constant factor. After drying the dewatered fermented slurry at 50^{o}C for approximately three hours to 6.88 % (db) moisture content, 30g of dried powdered samples were measured with the electronic balance (OHAUS CL Series, Model CL 201, China) and placed in all the three packaging materials and stored for 50 days inside a designed and constructed small size rectangular wooden storage structure (350 mm by 460 mm by 700 mm) (Figures 1 and 2). The storage structure was designed to withstand the critical load conveniently without any failure throughout the storage period and beyond it in line with the steps in [12]. Digital thermohygrometer (Acurite-00613, China) was used to monitor the internal temperature and relative humidity of the storage structure throughout the period of storage. The average temperature and relative humidity of the storage structure were 32°Cand 64% respectively. Samples were taken to the laboratory at interval of 10 days up to 50 days for analysis of nutritional qualities using [11] standard procedures. All the data obtained were substituted back into the experimental design interface of the software. Data analysis was done according to the procedures of the software. Analysis of variance (ANOVA) and multiple comparisons with Least Significant Difference (LSD) plots were used to interpret the results obtained from data analysed as research findings.

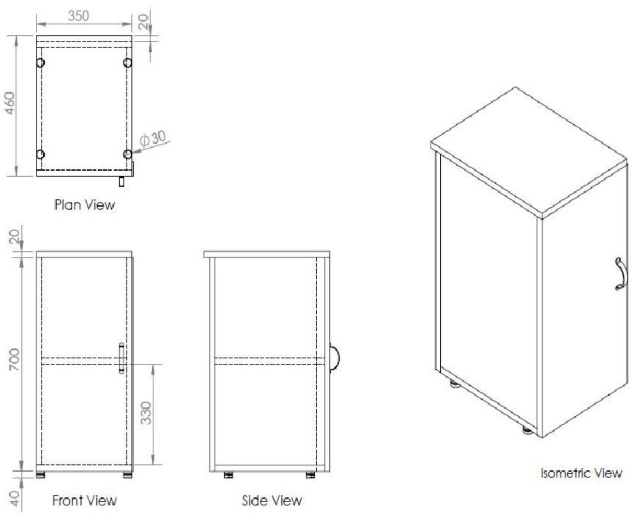

Figure 1: Orthographic and Isometric Views of the storage structure

Figure 2: Packaged Product during Storage

3.0 Results and discussion

3.1 Nutritional Qualities of the Product for Zero day and the Control Samples

Table 1 shows the results of the nutritional qualities of the product for zero day and control samples. The table shows some variations between the values under zero day and the control samples.

Table 1:Results of Nutritional Qualities of the Product for Zero day and the Control Samples

		Control Samples		
Nutritional Qualities	Zero day	Nylon Envelope	Paper Envelope	Plastic Container
Carbohydrate (%)	78.67	78.91	78.87	78.84
Protein (%)	8.96	8.94	8.96	8.98
Crude Fibre (%)	0.56	0.57	0.56	0.58
Fat (%)	2.58	2.59	2.60	2.59
Vitamin A (mg/100g)	0.79	0.52	0.55	0.58
Vitamin C (mg/100g)	9.66	9.67	9.68	9.68
Calcium (mg/100g)	3.39	3.67	3.65	3.68

Zero day- after drying, before packaging and storage.

Control Samples- packaged products kept outside the storage structure at the 50th day of storage.

Results of Analysis of Variance (ANOVA)

Table 2 shows the result of ANOVA of effect of input factors (packaging materials (A) and storage period (B)) on output factors (nutritional qualities). From the table, packaging materials as single factor have significant effect on fat, crude fibre and calcium content of the product; whereas, storage period did not have significant effect only on the calcium content at P ≤0.05. The interaction of packaging materials and storage period has significant effect on all the nutritional qualities of the product at P ≤0.05. The interpretation is, packaging materials and storage period will either have positive or negative effect on flagged (*) outputs. Hence, a suitable multiple comparison is needed to separate the means in order to know the kind of effect and the level(s) of factor (s) with the most outstanding effect.

Table 2: Results of ANOVA of the Effect of Packaging Materials (A) and Storage Period (B) on Nutritional Qualities the Product

	Inputs		
Outputs (Nutrients)	**A**	**B**	**A x B**
Carbohydrate (%)	0.0575	0.0750*	0.0000*
Protein (%)	0.6508	0.0001*	0.0000*
Fat (%)	0.0001*	0.0279*	0.0000*
Crude Fibre (%)	0.0216*	0.0001*	0.0000*
Vitamin A (mg/100g)	0.2726	0.0123*	0.0000*
Vitamin C (mg/100g)	0.3643	0.0001*	0.0000*
Calcium (mg/100g)	0.0033*	0.2714	0.0000*
Moisture Content (% db)	0.2671	0.9997	0.0000*

*Significant at P ≤0.05. **A**-Packaging materials, **B**-Storage Period

3.2 Effect of Packaging Materials and Storage Period on Carbohydrate Content (%) of the product

Figure1 shows the effect of packaging material and storage period on carbohydrate of the dried *ogi*. From the figure, the overlapping nature of the three LSD bars of the three packaging materials is an indication that the three packaging materials did not cause the mean values of carbohydrate to be significantly different from one another at each stage of the storage period (10, 20,30,40 and 50 days). It can be further interpreted that, irrespective of the packaging materials used among the three, the same effect will be imposed on the carbohydrate content of the product at each stage of the storage period. Also, the mean values of carbohydrate increased from first stage of storage (10 days) to the third stage of storage (30 days), after which it decreased and maintained a constant value from 40 to 50 days of storage. This trend could be attributed to some yet to be established factors governing the behaviour of carbohydrate of dried packaged product in storage. The highest value of carbohydrate (81.1894%) was obtained at the 30th day of storage inside the plastic container. Hence, it implies that for better retention of carbohydrate of the packaged product within the scope of this research, plastic container is the most suitable packaging material. The earlier mentioned highest value of carbohydrate obtained is more than 62.38-66.92% obtained by [13] for dried mixture of maize, millet and soybean *ogi* packaged with polyethylene bag and stored for 13 weeks at ambient condition of 30 ± 2^{o}C

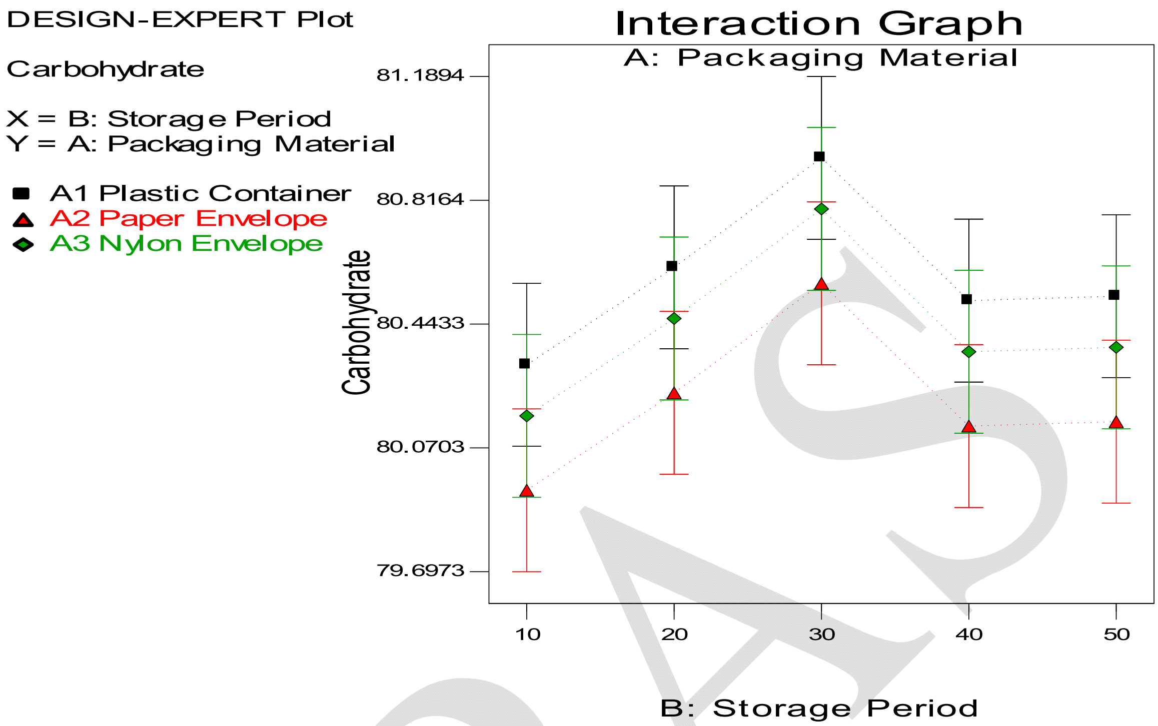

Figure 1: Effects of Packaging Material and Storage Period on the Carbohydrate Content of the Product

3.3 Effect of Packaging Materials and Storage Period on Protein Contents (%) of the Product

The effect of packaging materials and storage period on the protein content of the product is presented in Figure 2. The protein content decreased progressively from the first stage of storage (10 days) to the last stage (50 days).This pattern in the behaviour of protein of the stored product could be due to the continuous hydrolysis of protein as a result of the moisture content (even though low) of the product[14].Although the mean protein content of the product decreased (from 8.9973%) as the storage day increases in all the three packaging materials, however, the nylon envelope got the highest values of protein at each stage of the storage period. This value is slightly above the range of mean value (7.45 - 7.46 %) obtained by [1] for twelve (12) weeks of storing (inside a wooden cupboard) packaged *ogi* powder made from yellow maize. Protein content between of 14.91-17.08% was obtained by [13] from dried ogi made from maize, millet and soybean. The product was packaged with low density polyethylene bag and stored at ambient temperature of 30 ± 2^{o}C for 13 weeks.

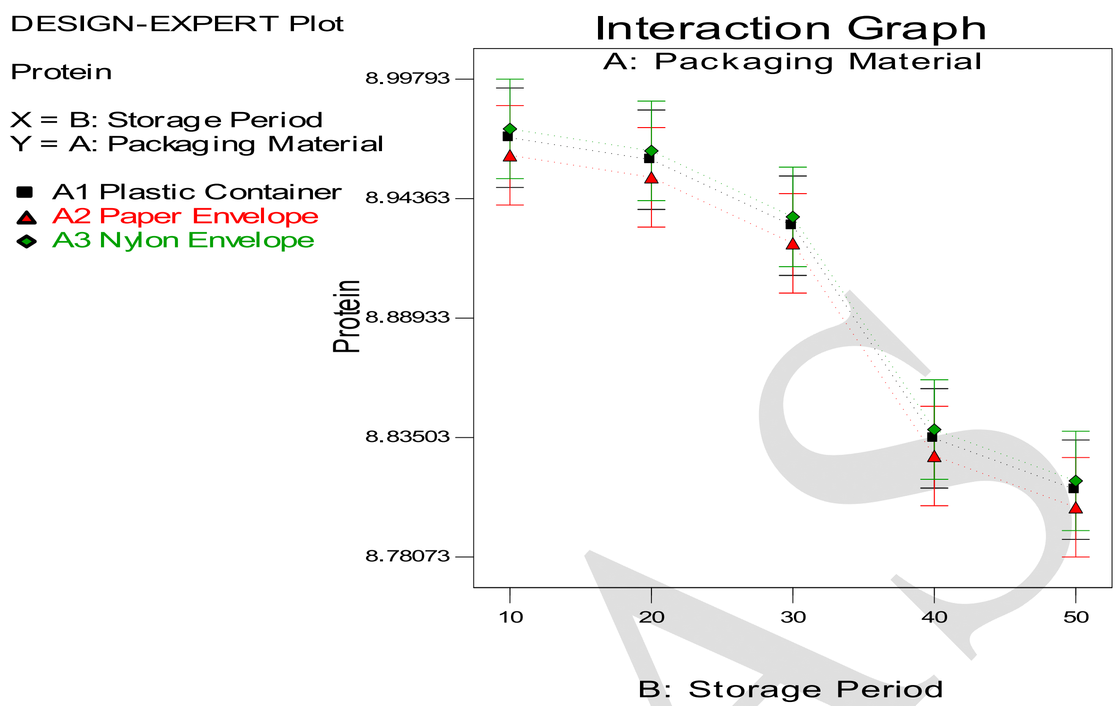

Figure 2: Effect of Packaging Material and Storage Period on Protein content of the product

3.4 Effect of Packaging Materials and Storage Period on Fat Content (%)of the Product

Figure3 is an illustration of the effect of packaging materials and storage period on the fat content of the product. It can be interpreted from the figure (no overlapping LSD bars) that the three packaging materials led to significant difference in the mean values of fat content of the product at each stage of the storage period. The further interpretation of this is that, each packaging material has different effect on the fat content of the product. Also, the fat content slightly reduced from the first stage of storage period to the third stage, but later increased along the fourth stage after which it dropped with extension of the storage period to 50 days. This observed trend could be due to the mild effect of oxidation of fat (lipid compound) as a result of its reaction with some oxygen that probably escaped into the packaged product. The highest value of fat content (2.6518%) was obtained at 10 days of storage for nylon envelope. Fat content in the range of 0.46 – 0.47% was reported by [1] from *ogi* powder made from yellow maize, packaged in high-density polyethylene bag (HDPE), a polypropylene woven sack (PP), and a polyvinyl chloride container (PVC),and stored for twelve (12) weeks inside a wooden cupboard under ambient condition. Crude fat of 7.69-8.77% was obtained by [13] for dried *ogi* (maize-millet-soybean mixture) packaged with LPDE bags stored for 13 weeks under the condition of 30 ± 2^{o}C ambient temperature.

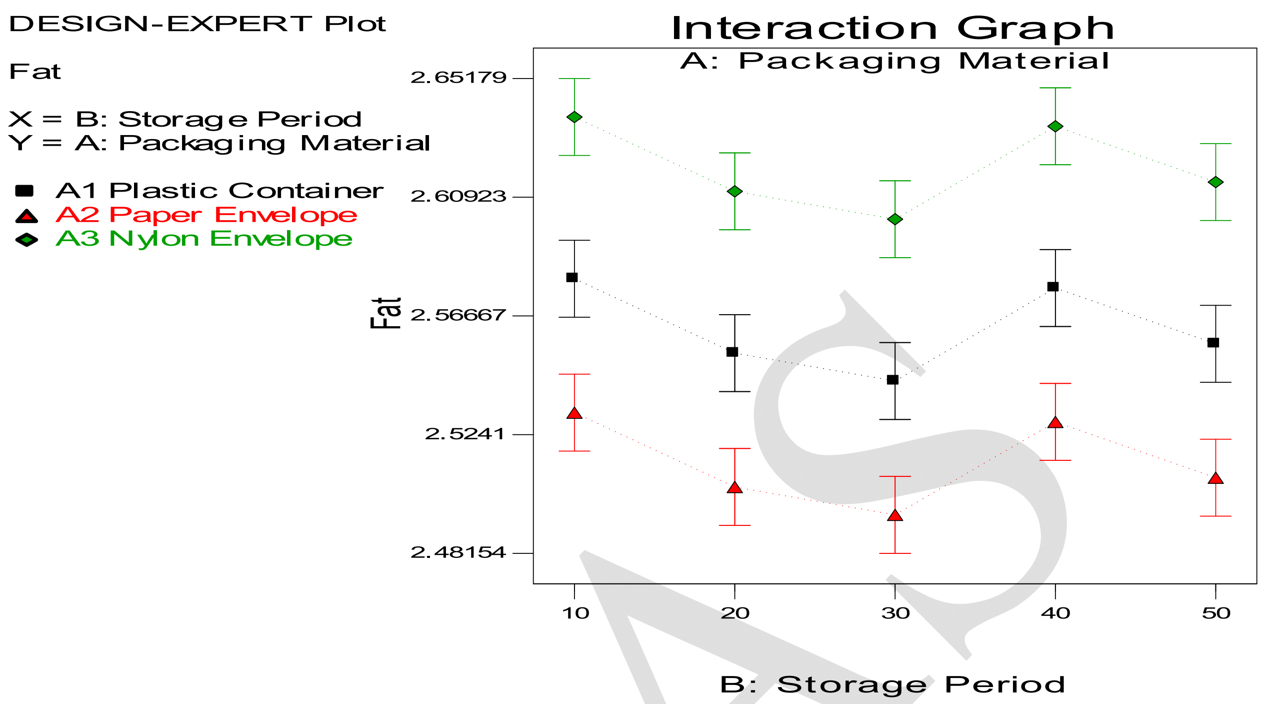

Figure3: Effect of Packaging Material and Storage Period on Fat Content of the Product

3.5 Effect of Packaging Materials and Storage Period on Crude Fibre (%) of the Product

The effect of packaging materials and storage period on the crude fibre of the product is presented in Figure 4. The crude fibre content of the product reduced from the first stage of storage (10 days) to third stage of storage (30 days). Increase in value was however obtained along the 40th day of storage and constant value was maintained from 40th to 50th day of storage. Plastic container retained the highest value of crude fibre at all the stages of the storage period. From the point of view of functional properties of food, a food with high fibre content (a nutritional quality of food) will digest faster than foods with low fibre content. The highest value of 0.5768% of crude fibre was obtained at the 10th day of storage for the plastic container and was not significantly different from the value obtained at 20thday of storage. However, the values of crude fibre obtained at the 30th, 40th and 50thdays of storage were not significantly different from one another, but were significantly different from those at 10th and 20th days of storage. The simple interpretation is that, for each of the packaging material, 10th and 20th days of storage only had the same effect on the crude fibre irrespective of the difference in the mean values obtained. Likewise, 30th, 40th and 50thdays of storage had the same effect on the crude fibre; but totally different from the effect noticed under 10th and 20th days of storage. Dried *ogi* made from the mixture of maize, millet and soybean; packaged in LPDE bags and stored for 13 weeks was reported to contain about 1.96-3.07% of crude fibre [13].

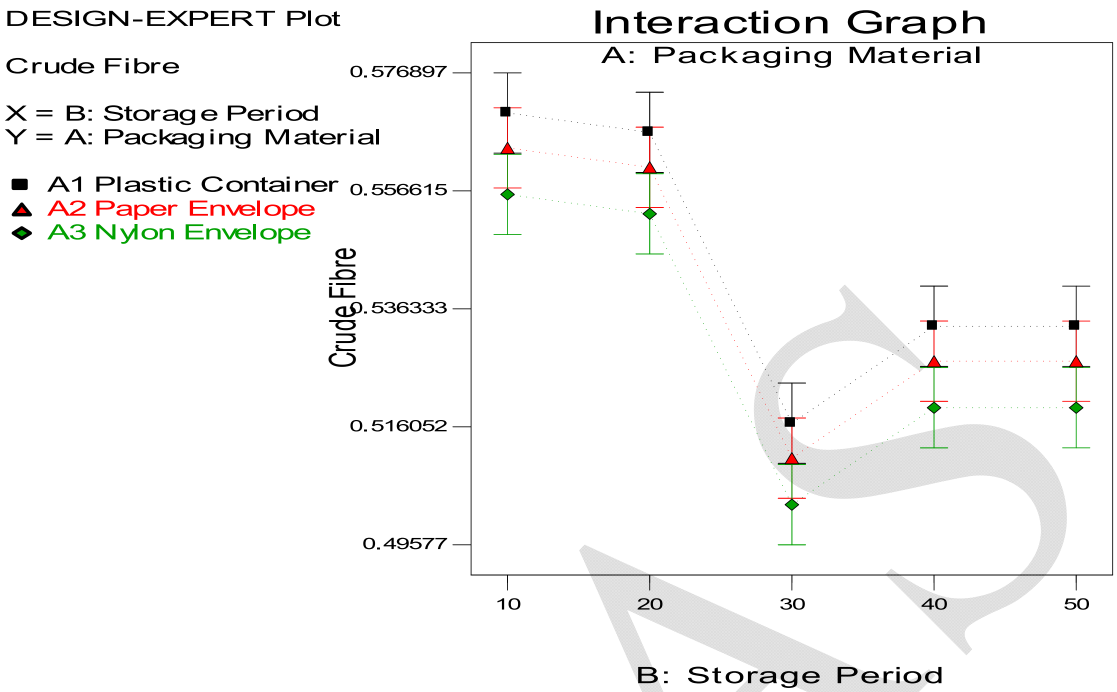

Figure 4: Effect of Packaging Material and Storage Period on Crude Fibre of the Product

3.6 Effect of Packaging Materials and Storage Period on Vitamin A Content (mg/100g) of the Product

The effect of packaging materials and storage period on the vitamin A content of the product is presented in Figure 5. The vitamin A content of the product gently decreased from the beginning to the last stage of the storage period. The plastic container got the highest value of vitamin A (0.7009 mg/100g) at the 10th days of storage; although, the mean values were not significantly different from each other with increase in storage period up to the 50th day. This is an indication that irrespective of the stage of storage, each packaging material imposed the same effect on the vitamin A content of the stored product even though the mean values obtained at each stage of storage for each packaging material are different from each other. It could also be further explained that storing the packaged product for 50 days did not cause a serious defective change in its vitamin A content in comparison with the first stage of storage (10th day). The better values obtained for the plastic container (which is blue in colour) could be due to the somewhat opaque nature of the container (in comparison with other two packaging materials which are white paper and transparent nylon) that prevented light from causing much adverse effect on the light sensitive Vitamin A present in the packaged stored product. Food containing Vitamin A should be stored in dark places [15].

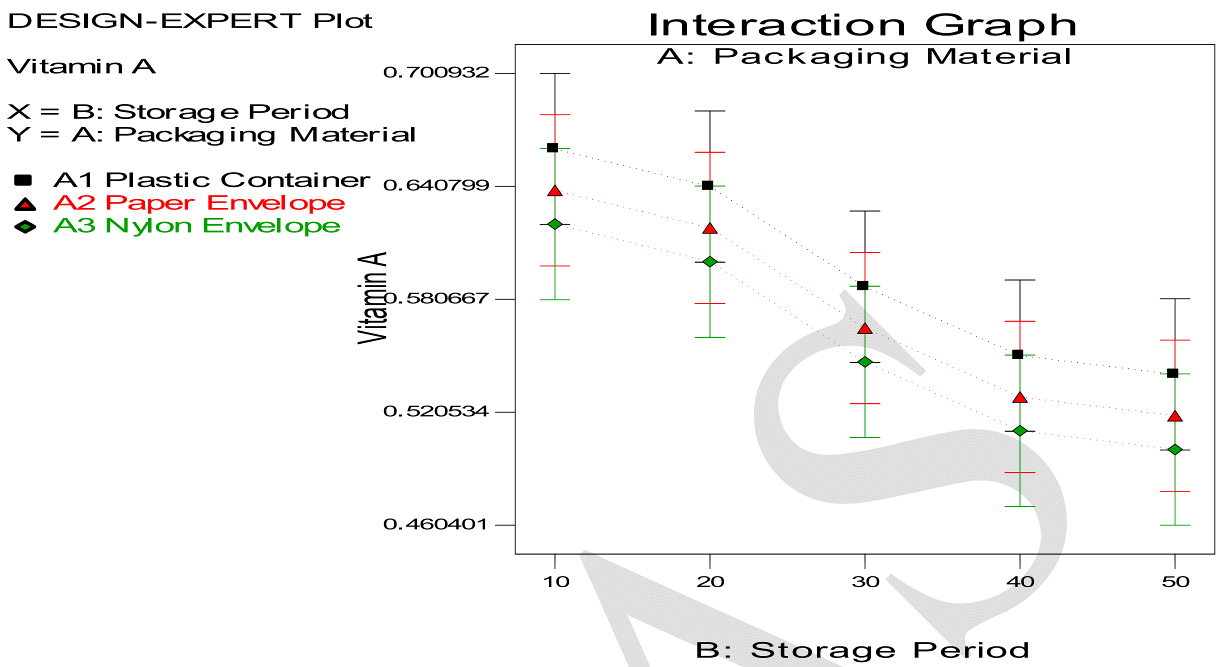

Figure 5: Effect of Packaging Material and Storage Period on the Vitamin A Content of the Product

3.7 Effect of Packaging Materials and Storage Period on Vitamin C Content (mg/100g)of the Product

Figure 6 presents the effect of packaging materials and storage period on vitamin C content of the product. Initially, there was a decrease in the vitamin C content up to the 30th day of storage and it later increased sharply up to the 40th day. Constant values were maintained from the 40th day up to the 50th day of storage. Just like the vitamin A content, the plastic container got the highest value of vitamin C (9.4806 mg/100g) but at the 40th and 50th days of storage. Conversely to previous observations, the mean values of Vitamin C at 40th and 50th days were significantly different from those at 10th, 20th and 30th days of storage. Similarly, mean values at 20th and 30th days of storage were significantly different from that of 10th day of storage. The reason for the instability in the values vitamin C could be due to its characteristics of being the most sensitive vitamin in foods, and its stability varies markedly as a function of environmental conditions[16].

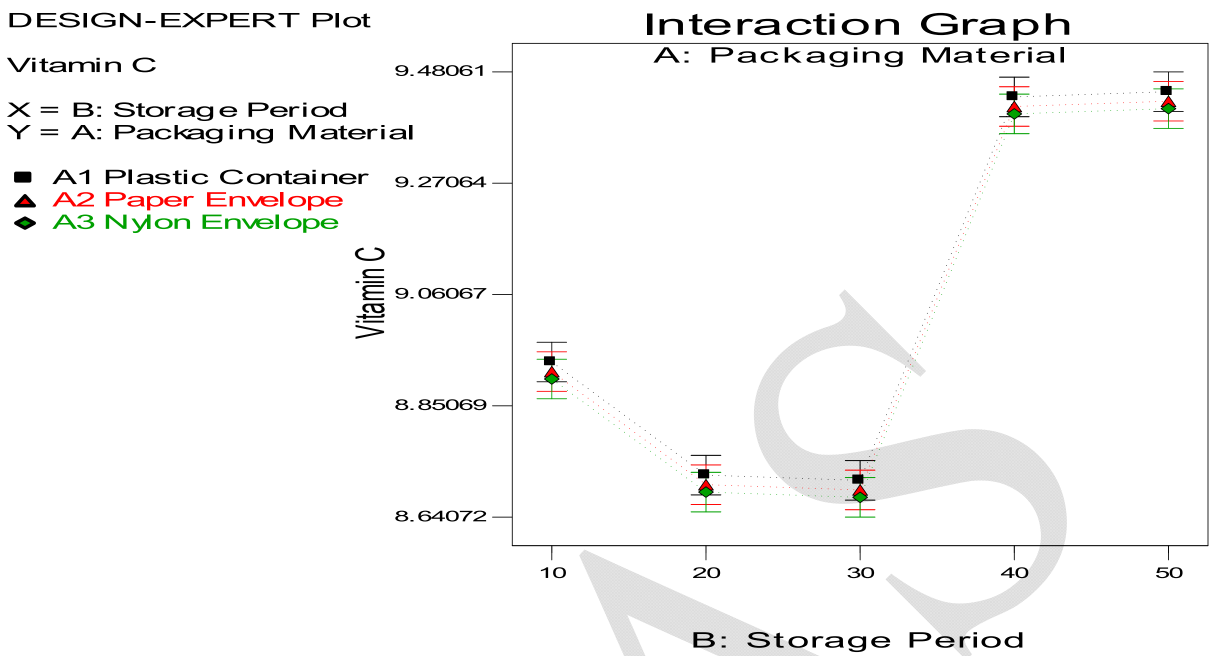

Figure 6: Effect of Packaging Materials and Storage Period on the Vitamin C content oftheProduct

3.8 Effect of Packaging Materials and Storage Period on the Calcium Content (mg/100g)of the Product

The effect of packaging materials and storage period on the calcium content of the product is presented in Figure 4. The mean values of calcium content for paper and nylon envelopes are not significantly different from each other; however, they are both significantly different from the mean value of plastic container. The calcium content of the product gently decreased from the beginning to the last stage of the storage period. The highest value of 3.6907 mg/100g of calcium was obtained at the 10th day of storage for paper envelope. The slight changes that occurred in the value of the calcium content of the stored product may be attributed to changes that might have occurred to the ash content of the samples [17].

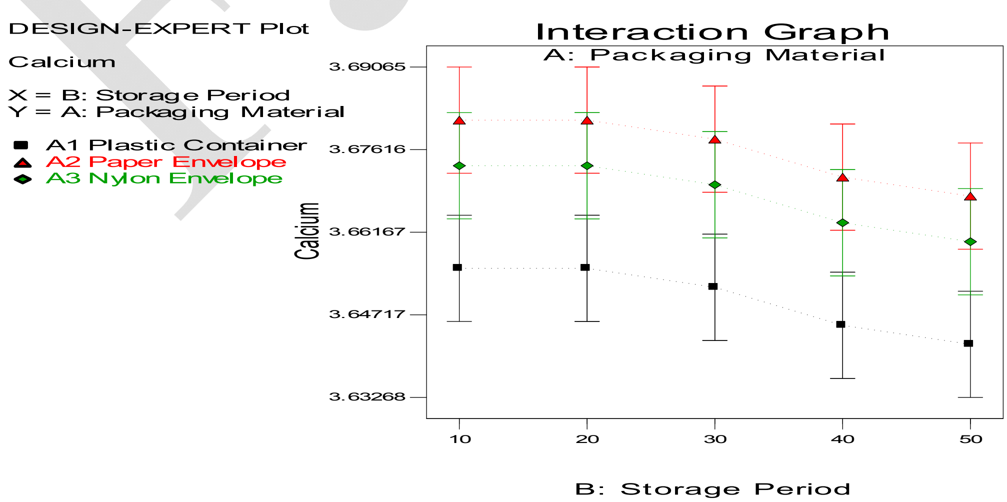

Figure 7: Effect of Packaging Materials and Storage Period on Calcium Content ofthe Product

3.9 Effect of Packaging Materials and Storage Period on Moisture Content (% db) of the Product

The effect of packaging materials and storage period on moisture content is shown Figure 8. From the figure, the moisture content of the product slightly decreased with increase in storage period. The paper envelope caused the stored product to retain the highest value of moisture at each stage of the storage period. This aforementioned observation was not totally unexpected because the paper used for making the envelopes did not have water proof surface, hence, the tendency for some moisture to pass through it to the product is very possible. The implication of moisture migration into the product through the paper envelope is that, with time, the product will attain a moisture content value that will encourage the growth of spoilage microorganism; this reduce its shelf life and make it unfit for human consumption. Furthermore, all the mean values of moisture content obtained for the paper envelope at each stage of the storage period were significantly different from those of plastic container, but not significantly different from those of nylon envelope. In all, the plastic container performed best due to the lowest value of moisture in the product at all the stages of the storage period.

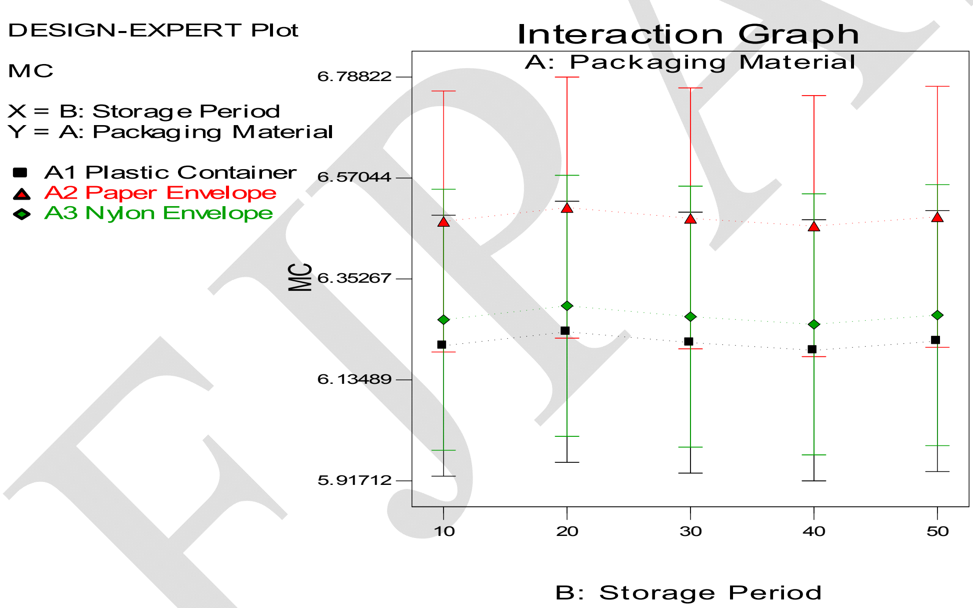

Figure 8: Effect of Packaging Material and Storage Period on Moisture Content of the Product

4.0 Conclusion

The interaction of each of the three packaging materials (plastic container, nylon and paper envelope) with the storage period (10-50days) had significant effect on the carbohydrate, protein, fat, crude fibre, vitamin A, vitamin C and calcium contents of the dried *ogi* made from sorghum, millet and soya beans at P $\leq$0.05. Protein, vitamin A, vitamin C, calcium and moisture contents decreased with increase in storage period for each of the packaging material. Carbohydrate, fat and crude fibre contents displayed irregular pattern of combining increase, decrease or maintenance of constant values at different stages of the storage period.

Generally, plastic container got the highest values of carbohydrate, crude fibre, vitamins A and C; and nylon envelope got the highest values of protein and fat contents; but the lowest values of moisture content, and paper envelope retained the highest calcium content at each stage of the storage period. Hence, the plastic container may be considered as the most suitable packaging material for storing the product. Comparatively, the packaged products stored outside the storage structures lightly retained nutrients better than those stored in the storage structure in most cases at the 50th day of storage. However, for secured keeping, prevention of insect and rodent attacks, and harsh effect of sudden change in ambient weather condition on the stored product, the storage structure which is similar to pantry or cupboards in kitchens should still be used. For Future research, the effect of packaging materials and storage period on the moisture content of the product should be put into consideration.

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