

Changes in Nutrient Composition and Quality Characteristics of Peeled *Citrullus Lunatus*, Preserved in Different Packaging Materials.

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Abstract

Peeled melon seeds are widely consumed and are export items for several countries. The present research was conducted to establish the appropriate packaging materials for nutrient retention and shelf stability of peeled melon seeds (*Citrullus lanatus*). Fresh melon seeds were peeled and stored in three packaging materials- (Hessian Brown Bag (HBB), Propylene Bag (GSB) and Transparent Polyethylene Bag (TPB) for three months. Functional properties, physiochemical properties and nutrient composition of the samples were determined at the onset and after 3 months using standard AOAC methods. There was no significant difference ($p > 0.05$) between the fresh and samples stored for 3 months in all the functional properties. Emulsion capacity decreased after 3 months, while emulsion stability increased. All the vitamins, minerals and approximate nutrients determined (except carbohydrates) decreased as the storage period increased. The indices of fat deterioration increased with the storage period. Both the storage period and the packaging material did not affect the magnesium and zinc contents; iron, manganese, vitamin B6 and vitamin A contents decreased with storage period. Melon seeds packaged in Hessian bag retained the highest amount of nutrients and was the least susceptible to deterioration by fat rancidity.

Keywords: Decorticated *Citrullus Lunatus* Var *Lunatus*, Shelf Stability, Functional Properties, Physicochemical Properties Packaging Materials, Indices of Fat Deterioration.

1. Introduction

Melon belongs to the family Cucurbitaceae and is nutritious [1]. It is of economic importance as a global source of biodiesel [2]. The common names of *C. lunatus* are: egusi in Yoruba egwusi in Igbo; Mann's cucumberopsis and white-seed melon in English and agushi in Hausa. It is an annual creeping crop, extensively used as protein source and thickening ingredient in local diets. Melon originated from West and Central Africa and belongs to the same family as watermelon, which is related to the cantaloupe variety of melon seed used in this study [3,4]. Melon seed is used as soup condiment and for medicinal purposes [5,6]. In Asia and the Middle East *C. lunatus* (egusi) plants, fruits, and seeds are used to treat a variety of illnesses including urinary tract infection, hepatic congestion, abnormal blood pressure, intestinal disorders, bacterial infections, jaundice, asthma, and diabetes [7]. The residual cake of egusi could be fried and consumed as a snack [8]. Melon dishes are popular in West African countries. Each region has its own prepa-

ration methods including the use as a condiment. The seeds may be dry-roasted and eaten as a salted snack or eaten as a pudding. In the West they are associated with health food, savoury bakes and vegetarian recipes and may be sprinkled onto bread loaves. In Central and South America, China and India, the seeds are used for preparing delicious sweets like the halwas and fudges and savoury snacks. Also, the melon seed can be used as a mouth freshener when mixed with nuts and spices. Melon seeds paste is added to spicy meat dishes to thicken its consistency [9]. One major problem that besets melon seeds is that peeled, and ground melon seeds deteriorate quickly in storage due to microbial infection [10]. This decreases its nutritive value, causes change in color, reduces seed germination, and leads to mycotoxin production [10]. Melon seeds are often peeled before they are sold in the markets in Nigeria to reduce labour for the consumers. There are on-going research efforts to mechanize the dehulling process [11]. This research was conducted to investigate the effects of packaging materials and

period of storage on the shelf-stability and nutrient retention of peeled melon seeds.

2. Material and Methods

The Cataloupe variety of melon seeds were bought from Ikwo local government, Ebonyi State, peeled, divided into 3 portions of 1 kg each, and put into three-packaging materials: Hessian Brown Bag (HBB), Propylene Bag (GSB) and Transparent Polythene Bag (TPB). Functional and physiochemical properties, and nutrient composition were determined on the fresh samples and were repeated after 3 months of storage.

2.1 Determination of Functional properties

Bulk density, foam capacity, foam stability, emulsification stability and capacity were determined using the method described by [12].

2.2.1 Determination of free fatty acid

Free fatty acid was determined according to the AOAC method (969.33 [13].

2.2.2 Determination of peroxide value

Peroxide value was determined according to the method of AOAC (AOAC 965.33) of 2005.

2.2.3 Determination of Acid Value

Acid value was determined according to AOAC 17th edn, Official method 920.212 [14].

2.2.4 Determination of Iodine value

Iodine value was determined according to the method of AOAC Method 933.20 [13].

2.2.5 Determination of P-anisidine

AOAC, Official Method 965.33 was used [13].

2.2.6 Determination of Totox value

This was determined through calculation using the formula:

$$\text{Totox value} = (2 \times \text{Pv}) + \text{Anisidine value}$$

Where Pv is peroxide value

Av = Anisidine value

2.2.7 Determination of Saponification value (SV)

Saponification value was determined by the method described by Onwuka [16].

2.3.0. Proximate composition

The moisture content, crude protein, crude fat, crude fibre, ash was determined using standard AOAC methods (AOAC, methods) [14].

2.3.1 Determination of carbohydrate content

Carbohydrate content of the samples was determined by difference. % carbohydrate = 100 – (% Ash + % protein + % moisture + % fat + % fibre). Carbohydrate was determined by difference [14]. Energy was determined according to FAO [15].

2.4.0 Determination of minerals

Calcium and magnesium content of the sample extract were carried out by Versanate EDTA complexometric titration, described by AOAC [14].

2.4.2 Determination of trace element

An atomic absorption spectrophotometer (AAS) was used to determine the concentration of (trace elements) as described by AOAC [14]. The solution (digest) from the ash was used. Solution containing metal ions was aspirated into a flame in which they were converted to a free atom vapour. A monochromatic light source was directed through the flame, and the amount of radiation of a specific energy absorbed by the solution was recorded. A calibration graph was then prepared for the element and from this, the amount of the element present in each sample were read. The final computation was based on the relationship.

$$C \times V / \text{weight of sample used}$$

Where: C = concentration of the metal from the sample detected by the AAS

V = Volume of which the solution was diluted.

2.5. Determination of water-soluble vitamins

Vitamins B1, B2, B3, B6, were carried out according to the methods described by AOAC [14].

2.6 Determination of fat- soluble vitamins

The vitamins C, D and E contents of the samples were determined using AOAC methods [14].

2.7 Statistical Analysis: Data obtained were subjected to one-way Analysis of Variance (ANOVA), using SPSS version 23 and means were separated using Duncan's Multiple range test.

3. Results and Discussion

PACKAGING MATERIAL	BULK DENSITY (g/ml)	EMULSION CAPACITY (%)	EMULSION STABILITY (g/ml)	FOAM CAPACITY (%)	FOAM STABILITY (%)
HBB0	0.52 [±] 0.00	50.12 ^{b±} 0.04	38.93 ^{c ±} 0.03	13.66 ^{d ±} 0.03	7.03 ^{e ±} 0.04
GSB0	0.52 ^{a ±} 0.03	50.16 ^{ab ±} 0.01	38.72 ^{f ±} 0.01	13.92 ^{b ±} 0.01	7.16 ^{d±} 0.01
TPB0	0.52 ^{a ±} 0.02	50.18 ^{a ±} 0.02	39.17 ^{d ±} 0.02	13.76 ^{c ±} 0.02	6.93 ^{f±} 0.03
HBB3	0.50 ^{a ±} 0.00	48.40 ^{c±} 0.01	39.44 ^{c ±} 0.01	12.16 ^{e ±} 0.03	7.73 ^{e±} 0.03

GSB3	0.50 ^a ± 0.01	46.61 ^c ± 0.01	39.90 ^b ± 0.03	13.81 ^c ± 0.01	8.44 ^b ± 0.01
TPB3	0.51 ^a ± 0.01	47.27 ^d ± 0.02	40.19 ^a ± 0.01	14.05 ^a ± 0.03	8.93 ^a ± 0.02

Table 1: Effect of storage in different packaging materials on the functional properties of *C. lunatus* seeds

Values are mean ± standard deviation of duplicate determination. Means in the same column with different superscripts are significantly different at $P < 0.05$. HBB= Hessian Brown Bag; GSB = Polypropylene bag; TPB = Polyethylene bag; 0 = fresh sample; 3 = sample stored for 3 months

Table 1 shows the functional properties of fresh and stored mel-

on seeds in different packaging materials. Emulsion capacity was higher ($P < 0.05$) in fresh samples than in stored ones. Emulsion stability was higher in stored samples than in fresh ones ($p < 0.05$). Foam capacity and stability of stored samples were also higher than that of fresh samples ($p < 0.05$). TPB had the highest emulsion stability, foam capacity and foam stability ($p < 0.05$)

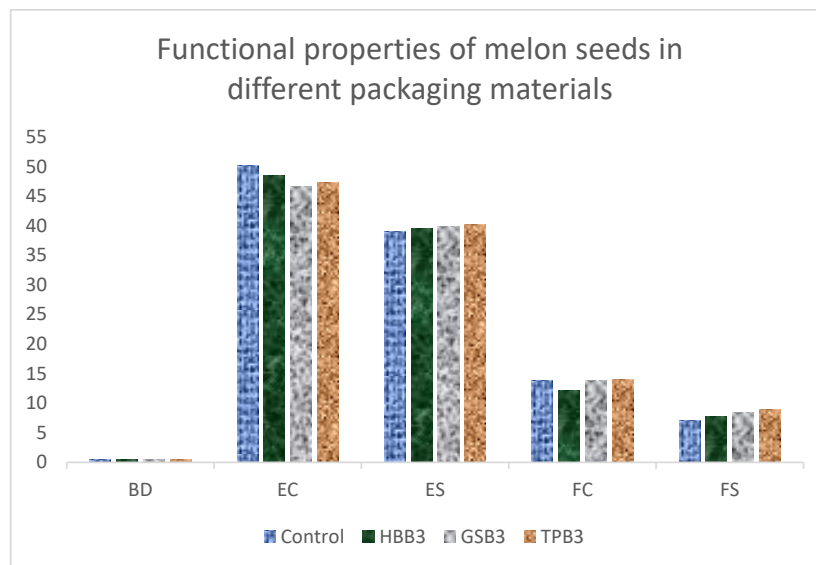


Figure 1: Changes in functional properties of melon seeds in three packaging materials after 3 months of storage.

There were no significant differences in bulk density due to storage period or packaging materials. The differences in emulsion capacity (EC) emulsion stability (ES), foam capacity (FC) and foam stability (FS) were also statistically insignificant ($P > 0.05$). Functional properties express the complex interactions between the structures, molecular conformation, compositions, and physicochemical properties of food components with the nature of the environment and conditions in which these are measured and associated [17]. They predict the behavior of food components in food systems. Had observed insignificant ($p > 0.05$) differences in functional properties of melon seeds and flours respectively [18,19].

3.1 Quality Indices of fat deterioration

3.1.1. Free fatty acid: Free fatty acid content of the samples in different packaging materials was significantly ($p < 0.05$) different after the 3-month storage period. TPB 3 were statistically higher (9.85%) in free fatty acid content indicating higher level of deterioration. Free fatty acid values ranged from 3.47-9.85 is like the free fatty acid (3.59-9.31) reported by [20]. High free fatty acid content of the samples after 3months suggest that the oil in the melon seeds might have gone rancid. Modern extraction methods conserve the oil quality of melon seeds [21,22].

3.1.2: Acid value: There was a significant difference in the acid value of samples after three months of storage. Acid values in the packaging materials after 3-month storage ranged from 1.19 – 1.20 mg/KOH/g/mol/kg and correlates with the acid value observed by which was in the range of 1.12-1.88 [19]. Observed acid values in this study were higher than the acid value of melon seed oil (3.03) reported but is within the recommended limit specified by FAO [23]. Acid value indicates age, edibility and suitability of oil [20]. It measures the content of free fatty acids formed after the hydrolytic degradation of lipid molecules and indicates the degree of rancidity.

3.1.3: Peroxide value: There was a significant difference in the peroxide values of samples in different packaging materials after 3-month storage: GSB3 (20.04), TPB3 (19.57) and HBB3 (18.22 mg/KOH/g/mol/kg) respectively. After 3-month storage, the range (18.22 – 20.04) was higher than the peroxide value of melon seed (12.30 -16.40) reported by, but lower than the value reported by for melon seed oil (26.00) [20,23].

Peroxide value is used as a measure of the extent to which rancidity have occurred during storage and as an indication of the

quality and stability of fats and oils [20]. High peroxide values are associated with higher rate of rancidity. Low peroxide values of oils may indicate lack of trace elements that trigger autoxidation [24]. During storage, peroxide formation is slow at first during an induction phase which precedes the propagation phase [23]. Peroxide value is the most common indicator of lipid oxidation, and the rancid taste begins to show up when the value is between 20 and 40mEq/kg [23].

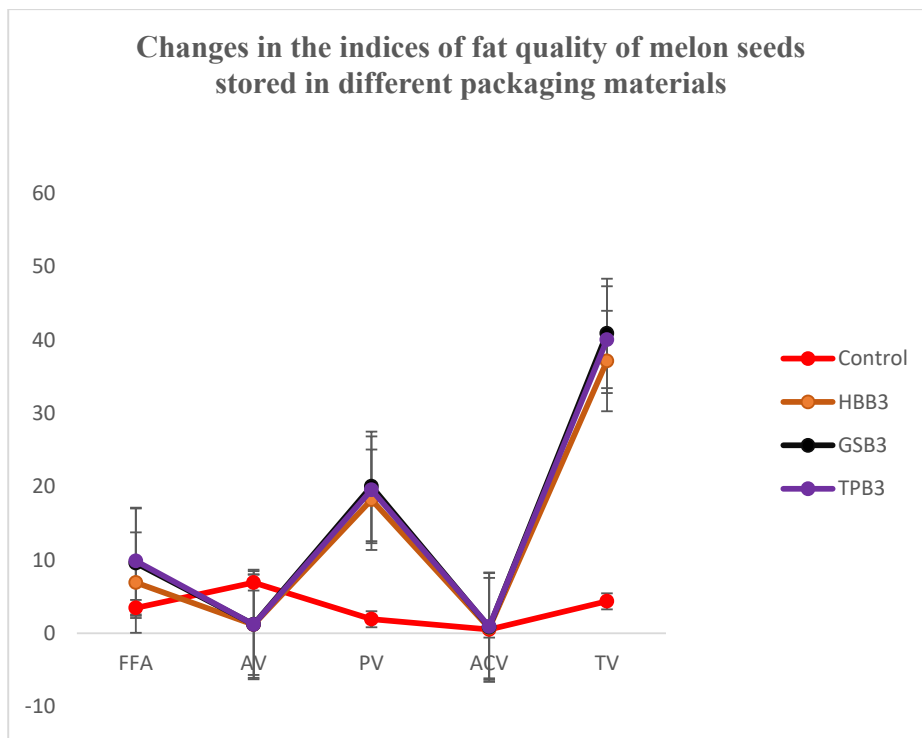
3.1.4: Iodine value: There were significant differences ($p < 0.05$) in iodine values of fat from melon samples stored in different packaging materials after 3-months of storage (HBB3 (28.72), GSB3 (27.37) and TPB3 (25.86 g/100g). The iodine value observed in this study which ranged from 25.86-55.81g/100g correlate with the iodine value in melon seed (26.70 – 57.20 g/100g) as reported by [20]. Iodine value indicate the level of unsaturation of oils. The higher the iodine value, the more unsaturated fatty acid bonds in an oil or fat [20]. Oils with iodine value less than 12g/100g of oil are non-drying oils, while good drying oil have iodine values of 130 and above.

3.1.5: Anisidine value: There was a significant difference in anisidine value after 3-month storage of samples and in the different packaging materials. Values were TPB3 (0.92), GSB3 (0.83) and HBB3 (0.71). Anisidine value (AV) measures the aldehyde levels in an oil or fat (especially the 2-alkenals). The P-anisidine value is a good measure of the secondary lipid oxidation of oil. Generally, aldehyde carbonyl bonds are formed during secondary lipid oxidation.

There was 40-80% increase in anisidine value within the 3-month storage period. Lipid oxidation is one of the major causes of quality deterioration of many foods, leading to the rancid flavor of oil.

3.1.6: Saponification value: There were significant differences in saponification value based on storage period and on packaging materials GSB3 (189.30), TPB3 (189.15) and HBB3 (189.09) respectively. Saponification value from this study (189.19) was higher than the saponification value of melon seed oil (116.83) as reported by [23]. Saponification value is an indication of chain length and a measure of both free and combined acids [23]. It is inversely related to the average molecular weight of the fatty acids in the oil fraction. During saponification, soap is usually formed, and a high saponification value indicates the suitability of an oil for industrial use (e.g., soap making) [23].

3.1.7: Total oxidation (totox) value: The Totox value indicates the overall oxidation state of the sample and enables oxidative deterioration to be monitored. There was a statistically significant difference ($p < 0.05$) in Totox value between fresh and stored samples as well as packaging materials: HBB3- 37.15; TPB3-40.05 and GSB3-40.91 within the 3-month storage period. The oil in the melon seed stored in HBB package had the lowest Totox value indicating that it had better quality than oil from seeds stored in other packaging materials. The changes in the indices of fat quality are shown in Fig. 2



FFA = free fatty acid; AV = Anisidine value; PV = Peroxide value; ACV = Saponification value; TV = Totox value

Figure 2: Changes in the indices of fat quality of fresh and stored *Citrullus lunatus* seeds.

From Table 4.1 There was a significant decrease ($p < 0.05$) in the moisture content of samples after 3 months of storage (HBB3-3.96 %; GSB3-4.08% and TPB3-4.53%. The moisture content of 5.7% before storage was lower than the recommended storage moisture content ranges (7% to 10%) of oilseeds [20]. The moisture content in this study is significantly close to the moisture content in the Egusi (3.86 %) as reported by [25]. Low moisture content helps to improve shelf life.

Crude protein content was quite high in the fresh and stored samples irrespective of the packaging material. There was significant difference ($p < 0.05$) between the crude protein of Egusi based on packaging materials in HBB3 (23.61 %), GSB3 (23.15 %) and TPB3 (21.84 %) respectively. The values are close to those observed for processed Egusi (22.98% and 24.60 %) as reported by [25].

The least value for crude fibre was observed for samples stored in TPB after 3 months (3.56%). The fibre content in this study is significantly higher than that which was reported by [25]. The fibre in this study is lower than that in Egusi (6.40%) as reported by [26].

There was a significant difference ($p < 0.05$) in the fat contents of the fresh and stored samples. For the samples stored for 3 months:

TPB3 (39.20%) was significantly higher ($p < 0.05$) than GSB3 (38.3%) and HBB3 (37.29 %) respectively. The fat content in this study is considerably lower than the fat content of processed Egusi as reported by and (49.05%). Fat provides the body with energy [25,26].

Melon seeds contained 1.86-2.14% ash. Period of storage and packaging material affected the ash content. The ash content was highest in HBB3 (2.14 %) and lower in GSB3 (2.03) and TPB3 (1.86) respectively. The Ash content in this study is significantly lower than that in Egusi (3.09%) as reported by and (6.7%) [25,26].

Carbohydrate was most abundant (29.2%) in HBB3. There was a significant increase in carbohydrate content ($p < 0.05$) after 3-month storage period and there were significant differences in the packaging materials used. Carbohydrates increased possibly due to the decreases in other nutrients. Carbohydrate in this study was significantly higher than that which was reported by (7.22%) [26]. The energy value in this study was significantly high and decreased as storage period increased. Other researchers also found melon to be a good source of energy as comparably to other legumes [25]. observed similar proximate composition for melon seeds [27,28]. The changes in approximate nutrients and energy due to storage are shown in Fig. 3.

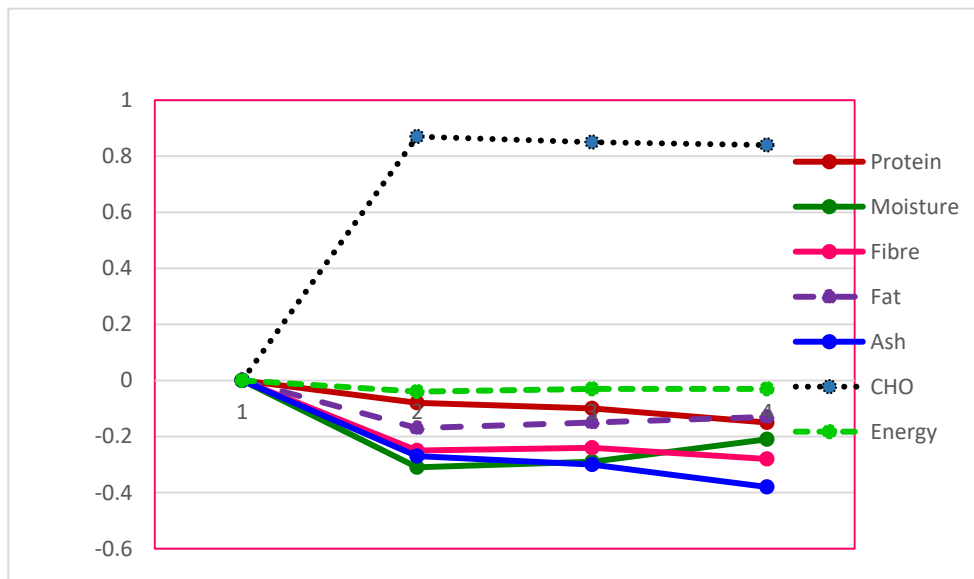


Figure 3: Changes in the proximate composition and energy content of melon seeds due to storage.

3.2. Mineral Content.

Fig 4 shows the mineral content of melon seeds in different packaging materials. There were no significant differences in the magnesium content of fresh samples and after storage: HBB3 (24.83 mg/100g), TPB3 (24.64 mg/100g) and GSB3 (23.55 mg/100g) respectively). The magnesium content was statistically higher than the value (20.46 mg/100g) reported by [26]. Magnesium deficiency leads to uncontrolled twisting of muscles and convulsion, which may result in death [26]. Magnesium is beneficial for

blood pressure control, prevention of heart attack, and stroke. It contributes to the structural development of bones. While calcium stimulates muscles, magnesium relaxes the muscles [26]. zinc is vital in protein synthesis, cellular differentiation and replication, immunity and sexual functions [29].

There was significant difference in the zinc content of fresh samples and stored ones. There was a significant difference between HBB3 (28.37mg/100g) and GSB3 (28.26 mg/100g) but no sig-

nificant difference between GSB3 (28.26 mg/100g) and TPB3 (28.30 mg/100g) respectively. Zinc concentration of the sample was higher (28.30mg/100g) than the zinc concentration of Egusi (21.05 mg/100g) reported by [26]. Zinc promotes carbohydrate and protein metabolism, proper functioning of the senses of taste and smell, metabolism of vitamin A and health of the hair. It facilitates the synthesis of DNA and RNA [26].

There were significant differences in the calcium contents of the fresh sample and those stored in different packaging materials af-

ter 3-month storage: HBB3 (8.78); G.S.B (8.45) and TPB3 (6.98) respectively. Calcium content value was statistically higher than that which was observed in Egusi (0.10 g/100g) as reported by (2015) [26]. Calcium is essential for blood clotting, bone and teeth formation and enzyme function.

There were no significant differences in the iron content of fresh and stored samples: HBB3 (4.16), GSB3 (4.04) and TPB3 (3.90) after 3 months of storage. Iron is required for cognitive functions, oxygen transport, and some enzyme functions [26,30].

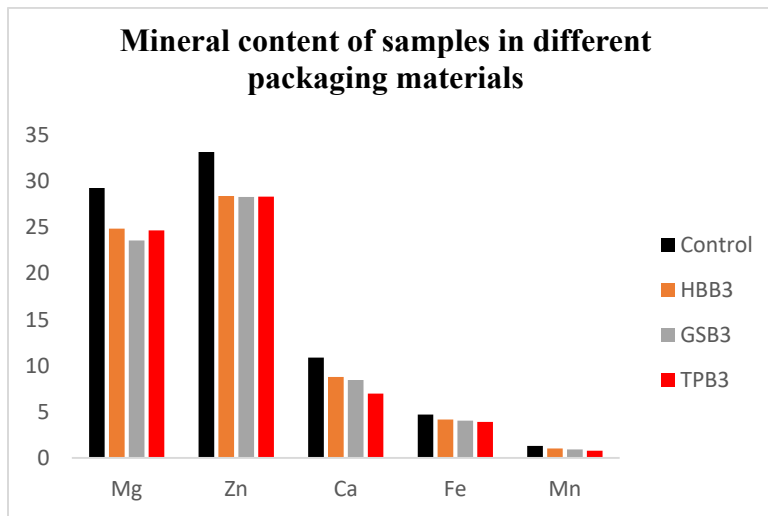


Figure 4: Mineral content of melon seeds stored in different packaging materials.

Fig. 5 shows a marked decrease in magnesium and calcium, when compared with the other micronutrients.

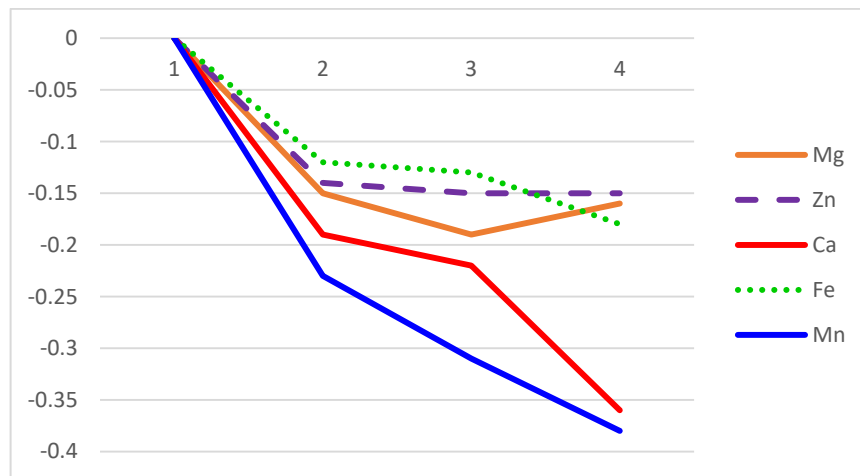


Figure 5: Changes in the mineral content of melon seeds due to storage

Vitamin Composition of *Citrullus Lunatus* (Egusi).

PACKAGING MATERIAL	vitamin B1(mg/100g)	vitamin B2 (mg/100mg)	vitamin B3 (mg/100g)	vitamin B6 (mg/100g)	vitamin E (mg/100g)	vitamin A (µg/100g)	vitamin D (µg/100g)
HBB0	1.12 ^a ± 0.01	0.62 ^b ±0.01	0.81 ^b ±0.01	3.31 ^a ±0.01	15.93 ^c ±0.03	5.63 ^a ±0.04	0.53 ^b ±0.03
GSB0	1.11 ^a ± 0.01	0.64 ^{ab} ± 0.00	0.82 ^{ab} ±0.00	3.29 ^a ±0.00	18.8 ^a ±0.00	5.69 ^a ±0.00	0.61 ^a ±0.03
TPB0	1.13 ^a ± 0.03	0.67 ^a ±0.01	0.85 ^a ±0.01	3.34 ^a ±0.01	16.92 ^b ±0.03	5.61 ^a ±0.04	0.60 ^a ±0.03
HBB3	1.09 ^a ± 0.03	0.53 ^c ±0.01	0.72 ^c ±0.03	2.24 ^c ±0.02	12.64 ^c ±0.03	3.98 ^c ±0.02	0.31 ^d ±0.01
GSB3	0.98 ^b ± 0.03	0.56 ^c ± 0.01	0.70 ^c d±0.00	3.05 ^b ±0.04	13.16 ^d ±0.03	4.08 ^{bc} ±0.04	0.34 ^d ±0.04
TPB3	0.92 ^c ± 0.03	0.54 ^c ± 0.03	0.67 ^d ±0.03	2.02 ^d ±0.02	12.57 ^f ±0.04	4.46 ^b ±0.04	0.42 ^c ±0.03

Table 2: Effect of packaging materials on vitamin composition of freshly peeled and stored Egusi.

Values are mean ± standard deviation of duplicate determination. Means in the same column with different superscript are significantly different at P<0.05. HBB= Hessian Brown Bag; GSB = Propylene bag; TPB = Polyethylene bag; 0 = fresh sample; 3 = sample stored for 3 months Table 2 shows the effects of packaging materials on the vitamin content of *Citrullus lunatus*.

There were no significant differences in vitamin B6 and E contents of fresh samples, but there was a significant difference after 3 months of storage in different packaging materials. The B6 val-

ue was significantly higher that obtained for Egusi (2.6) by [31]. There was a significant difference in the vitamin E content of samples after 3 months storage different packaging materials: GSB3 (13.16), HBB3 (12.64) and TPB3 (12.57) respectively. Vitamin E content of the fresh sample (16.92) compared well with the raw Egusi sample (16.1) as reported by [32]. There were no significant differences in vitamin A for samples stored in different packages. Fig. 6 shows the changes in vitamin contents as the storage period increased.

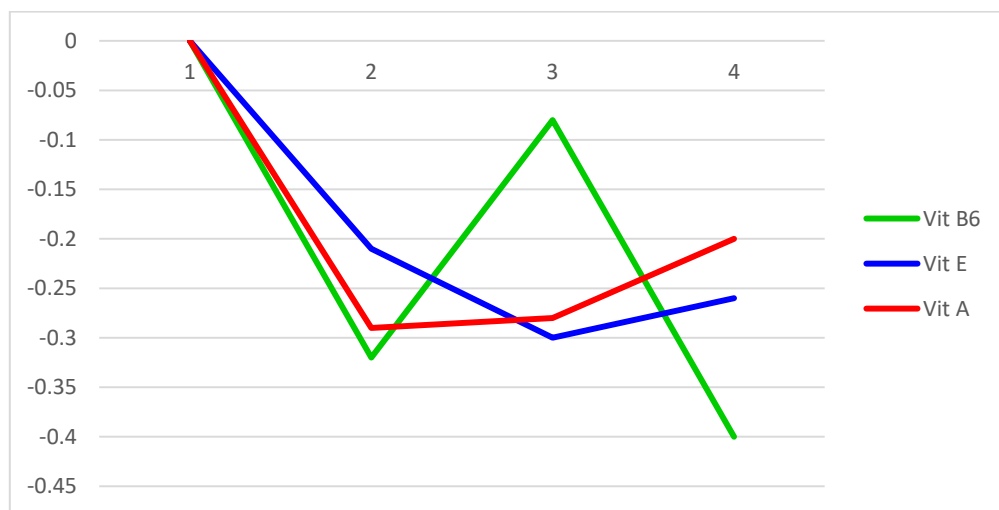


Figure 6: Changes in vitamin content of melon seeds due to storage

Observed that laminated high density polyethylene (LHPE) was the best packaging material for storing ground melon seeds for 4 weeks [33,34]. The samples showed the least changes in physico-chemical properties: Free fatty acid (0.90-2.18 mg KOH/g), peroxide value (2.40-4.20 mEq kg⁻¹) and water activity (0.31-0.49), compared to samples packaged in transparent high-density polyethylene (THPE) and amber coloured plastic bottle (APB).

4. Conclusion

Rancidity begins to show up in stored peeled *C. lunatus* seeds

within 20 days. The peroxide value of samples stored in HBB and TPB3 did not exceed the safe limit even after 3 months of storage. With the low p-anisidine value in this study, there is an indication of low production of rancidity in the sample. Peeled melon seeds lose nutrients (except iron and zinc) during storage but 3-month storage with Hessian brown bag (HBB) will best conserve the nutrients and lead to no loss in functional properties.

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