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Effect of Packaging Material on the Quality Parameters of African Locust Bean Powder

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Abstract

African locust bean condiment popularly referred to as 'iru' among the Western part of Nigeria is derived from the fermentation of African locust bean (*Parkia biglobosa*) seeds. Its wide acceptance as a food condiment is owing to its nutritional composition in African diets. African locust bean powder was produced using a dehulling machine and was fermented for three days. The fermented locust beans were dried in a cabinet dryer at 60 ^oC for 4 days and milled into fine powder. The African bean powder was then packaged into three different packaging materials: nylon, plastic, and glass containers and stored for two months. Both fresh and stored samples were evaluated for quality parameters. The results for the chemical analyses were 18.84- 19.63%, 4.44- 4.58%, 1.72-1.90%, 3.50- 3.71%, 8.85-11.80%, 59.69-61.34%, 5.75-5.76 kcal/g, 0.57-0.58% and 7.39-7.87 mg/100 g for protein, fat, fibre, ash, moisture, carbohydrate, energy, total titratable acidity and vitamin c, respectively. According to the result of the chemical analyses, iru powder packaged in nylon container had significantly lowest value for all the parameters evaluated except moisture content where it had significantly highest value. The anti-nutritional properties ranged from 0.01-0.03%, 0.02-0.17%, and 1.42-1.61 % for phytate, oxalate and cyanide, respectively. Microbiological properties which include the total microbial and coliform counts ranged between 3.54-3.90×10^3 cfu/ml and 3.62-7.81×10^4 cfu/ml. The quality parameters of the locust bean powder packaged in nylon containers reduced significantly compared to glass and plastic containers. This implies that plastic and glass are better packaging materials for African locust bean powder.

Keywords: locust bean powder, packaging materials, quality, storage

Introduction

The multipurpose African locust bean tree (*Parkia biglobosa*), is a member of the Leguminasae family (Abdullahi and Akinyele, 2013). In the Nigerian savannah region, it is one of the perennial native leguminous trees that are not typically farmed but can be found in populations of two or more trees (Aborisade *et al.*, 2021). Almost all of the tree's parts are used, hence the trees are typically preserved because they are valuable economic fruit trees. Its seeds found within the luscious, yellow pulp of a brown pod make it so valued. The Yoruba ethnic group in Nigeria refers to the *Parkia biglobosa* seed as "*iyere*," whilst the fermented seed is referred to as *"iru*" or "*dawadawa*" as called by the Hausas.

In Nigeria and other West African nations, *iru* is a widely consumed and nutrient-dense condiment. In their cuisine, fermented locust bean seeds provide nutrients and a pleasant aroma that consumers love (Ajayi *et al.*, 2015). Fermented foods are typically a great source of fat, protein, and minerals including phosphorus, calcium, and iron. They are also a vital component of both young and old people's diets due to their high vitamin content and essential amino acid content (Arise et al., 2019). Ibeabuchi et al. (2013) have reported that iru is abundant in vitamins and protein (Esenwah and Marcel, 2008; Badu et al., 2012). The seeds' nutritional and antioxidant qualities have been documented. Due to its high moisture content, it is susceptible to rapid deterioration, necessitating additional preservation procedures like drying.

Around the world, drying is crucial to the production or processing of food. The fermented locust bean is no different; food products have been preserved and then processed through extensive drying. It is frequently one of the last steps in food processing and significantly impacts the end product's quality (Ademade and Olaoye, 2014). Some consumers find locust bean seeds to be unpleasant therefore, the seeds are processed into powder in order not to deprive them of the nutritional benefits of the locust bean seeds. Food packaging is a crucial aspect of food processing that involves using certain materials to package foods. These materials include plastic, glass (bottles), aluminum foil, brick cartons, polythene and others.

According to Ihekoronye and Ngoddy (1985), packages provide protection, transit, guarantee, sales, and promotional services. Traditionally, leaves are still widely used for packaging iru and this might limit its acceptance in the international market. However, the type of packaging material may interfere with the attribute of African locust bean powder and its storability, hence, the need for the study. This study was designed to examine the impact of different packaging materials on the quality parameters of African locust bean powder.

Materials and Methods

Source of Materials and Production of ***Iru***

In Ogbomoso, Oyo State, the African locust bean was bought in a local market. All equipment was acquired from LAUTECH, Ogbomoso's Ibrahim Owodunni Food Processing Laboratory. The African locust bean seeds were manually cleansed to remove extraneous objects including cracked, broken, and damaged beans. A locally fabricated dehuller which has a boiling segment was used to boil one thousand grams (1000 g) of African locust beans for seven hours. After that, the beans were allowed to cool before being moved into the dehulling segment. After being dehulled to remove any remaining seed coat, the beans were put on stacked trays, covered with jute bags, and allowed to ferment for 48 hours. After fermentation, about 5 g of salt was added and mixed thoroughly as a preservative agent. The fermented African locust bean (iru) was dried at 50^{o} C with a cabinet dryer until constant weight was obtained, cooled, and ground into powder. The iru powder was packaged in nylon (low density), plastic and glass containers after which it was stored for two months.

Chemical Composition

Proximate analyses which include moisture, crude protein, ash, crude fiber, and crude fat were carried out following standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Total carbohydrate was estimated by difference: 100 – (% ash + % crude protein + % fat + % crude fiber + % moisture) and 100. The energy value of each sample was determined using the indirect calculation method which was based on the three main nutrients that supply energy to the body, which are carbohydrates, fats, and protein (Iombor *et al.*, 2014). The total titratable acidity was measured according to AOAC (2005). The vitamin C content in the sample was extracted with 20% trichloroacetic acid and thereafter determined by a titrimetric method using 2,6-chlorophenol indophenol dye (Sadasivam and Manickam,1996).

Anti-nutritional Properties

Tannin Content

Following a 20-minute extraction using 1% HCL in methanol at 30° C, the samples were centrifuged. For the assays, supernatants were kept at 30 °C. Using a UV spectrophotometer, the absorbance at 500 nm was measured in relation to a blank solution (1% HCL in methanol), which was created by mixing 1 ml of the extract with 5 ml of vanillin reagent. Following that, the reaction mixture was kept at 30 °C for 20 minutes. Tannin levels were determined using a catechin standard curve ranging from 0.00 to 0.10 mg/ml. (Price *et al.*, 1978).

Phytate Content

Maga's (1982) approach was employed to ascertain the phytate content. 200 cc of 2% HCl was added after around 8 g of the material had been finely pulverized. After vortexing for three hours, it was filtered, and 10 milliliters of 0.3% NH_4SCN were added to make 50 milliliters of filtrate. Then, distilled water (10 ml) was added to get the proper acidity. The solution was titrated against a solution containing 0.00195 g/ml ferric chloride in order to produce a persistent brownish-yellow hue, and the amount of phytic acid was determined.

Oxalate Content

The powdered sample (1 g) was combined with around 75 ml of 3.0 M H_2SO_4, which was then agitated and filtered. A hot (80-90° C) titration of 25 ml of the filtrates (extract) against a 0.05 M $KMnO_4$ solution was performed until a faint pink color developed and remained for at least 30 seconds. (Jrand and Underwood, 1986).

Cyanide Content

To release all of the bound hydrocyanic acid, a combination of 40 milliliters of distilled water and 2 milliliters of orthophosphoric acid was added to the sample (4 g), stirred, sealed, and allowed to sit at room temperature for the whole night. 40 ml of distilled water with 0.1 g of NaOH pellets were mixed with 5 ml of the resultant mixture. A mild but persistent turbidity served as the endpoint for titrating 20 milliliters of the distillate—made up to 50 milliliters with distilled water against a 0.01 M silver nitrate solution using 1.0 milliliter of 5% potassium iodide solution (AOAC, 2000).

Microbiological Properties

To create a stock culture, 1 g of iru powder was weighed into 10 ml of diluent water. This process was known as serial dilution. In nutrient agar plates, 1 mL of the suitable diluents was cultured for 24 hours at 37 ^{o}C Using a pour plate approach, the bacterial populations in the locust bean samples were estimated. For later usage, stock cultures from this source were produced in nutrient agar slants and refrigerated at 40 ^{o}C. Standard microbiological techniques were used to identify the bacterial isolates (Ajayi et al., 2015).

Statistical Analysis

Analysis of variance (ANOVA) was performed on the data acquired for all analyses, and the sample treatments showed a significant difference ($P \leq 0.05$) when the means were separated using Duncan's multiple range test.

Results and Discussion

Effect of Packaging Materials on the Chemical Properties of African Locust Bean Powder

Following two months of room temperature storage, Table 1 displays the chemical properties of African locust bean powder. The powdered locust bean has protein levels ranging from 18.84 to 19.63%. In comparison to the other samples, the powder enclosed in nylon packaging had the lowest protein value. The reduction in protein content seen in locust bean powder stored in a nylon container is consistent with the findings of Chandru et al. (2010) regarding finger millet storage. The enhanced proteolytic activities caused by the nylon's higher relative humidity may have contributed to this decline (Butt et al., 2010).

Glass containers and unpackaged locust bean powder had the greatest fat level, whereas plastic containers had the lowest fat content. The fat percentage of African locust beans dropped from 4.58 to 4.44%. Lipid oxidation may be responsible for the significant reduction in fat content seen in the locust bean powder contained in the plastic container. This indicates that when fatty acids interact with oxygen, lipids oxidatively deteriorate (Forsido et al., 2021).

African locust beans' fiber content drops from 1.90 to 1.72%, with the nylon container having the lowest value. The sample housed in other materials showed no change in fiber content. Adebowale et al. (2017) have reported on the decrease in fiber observed in water yam flour when it is packaged using various materials. Nylon is more porous to moisture; hence this might be explained by the increased moisture content. According to Achi and Akubor (2000), dietary nutrients may disintegrate when there is an increase in moisture.

The locust bean powder's ash level varied from 3.50 to 3.50.71%. When compared to alternative packaging materials, which had the same ash level as the control, nylon packaging showed a considerable reduction in ash content, with the lowest value. According to Olayemi et al. (2015), smoked fish stored in various composite packaging materials had an ash content drop from 1.3 to 0.5%. Food's ash content conveys information about the minerals it contains.

When compared to the control, the moisture content of the nylon containers was the lowest (8.85–11.80%), while there were no appreciable differences in the plastic and glass containers. The elevated moisture content percentage of the locust bean powder kept might perhaps be attributed to the elevated humidity levels in the storage environment (76.5±3% mean relative humidity). It is possible that the nylon's permeability to water vapor contributed to the higher moisture content. Microbial activity that is detrimental to shelf stability would be encouraged by the higher moisture level.

While there is no discernible difference between plastic and glass containers, the carbohydrate content drops from 61.34 to 59.69%, with nylon having the lowest figure. The findings are similar to those published by Ajayi et al. (2015), who also found patterns in their data indicating that items packaged in various materials had varying amounts of carbohydrates. In proportion to the environment's relative humidity, the hydrophilic molecules in carbohydrates absorb moisture. According to Akinoso and Raji (2011), this characteristic promotes moisture absorption and a noticeable decrease in the proportion of carbs. The powder's gross energy varies from 5.75 to 5.76 kcal/g, with nylon having the lowest figure. The glass and plastic container is equal to the control in terms of value. Given that fat and carbs are sources of energy, the drop may have occurred because there was no discernible difference in their decline.

Glass and plastic containers had the same TTA level as the control, whereas nylon had the lowest value. The TTA content of the powder varied from 0.57 to 0.58. But there was no discernible difference between the control group and the packing materials. These support the findings of studies that demonstrated a significant drop in the titratable acidity (mostly citric acid) of fresh orange samples during the first and fourth weeks of storage (Anin et al., 2011). The powder's vitamin C concentration ranged from 7.39 to 7.87 mg/100 g, with nylon having the lowest value while the glass and plastic containers kept their value. Using various packing bottles and storage times resulted in a notable variation in the vitamin C content of orange juice, according to Muhammad et al. (2013). Additionally, roselle-mango juice mixes held over time showed a decline in their vitamin C concentration, as noted by Mgaya-Kilima et al. (2015). Both enzymatic and non-enzymatic catalysts may readily oxidize vitamin C when oxygen is present (Jawaheer et al., 2003). The labile nature of vitamin C may be the cause of the decline.

Table 1: Effect of Packaging Materials on Chemical Analysis of African Locust Beans Powder

Sample	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	CHO (%)	Energy (kcal/g)	TTA (%)	Vit. C (mg/100 g)
A0	19.63±0.06[b]	4.58±0.02[c]	1.90±0.028b	3.71±0.03[b]	8.85±0.03[a]	61.34±0.04[b]	5.76±0.00[a]	0.58±0.03[a]	7.87±0.021[b]
A1	18.84±0.06[a]	4.46±0.02[a]	1.72±0.01a	3.50±0.03[a]	11.80±0.04[b]	59.69±0.04[a]	5.75±0.00[a]	0.57±0.00[a]	7.39±0.02[a]
A2	19.63±0.06[b]	4.48±0.02[b]	1.90±0.03b	3.71±0.03[b]	8.85±0.04[a]	61.34±0.04[b]	5.76±0.00[a]	0.58±0.00[a]	7.87±0.02[b]
A3	19.63±0.06[b]	4.44±0.02[b]	1.90±0.03b	3.71±0.03[b]	8.85±0.04[a]	61.34±0.04[b]	5.76±0.00[a]	0.58±0.00[a]	7.87±0.02[b]

Values are means ± standard deviation of triplicate determinations. Means in the same column with different superscripts differ significantly

($p<0.05$). A0: Initial value before packaging; A1: nylon; A2: glass; and A3: plastic. TTA: Total Titrable Acid; CHO: Carbohydrate

Anti-nutritional Properties of African Locust Bean Powder

African locust bean powder's anti-nutritional qualities are shown in Table 2. About the packaging and storage of the African locust bean powder, there was no discernible change in the percentage of tannins. According to Orhevba et al. (2019), a similar outcome was noted, with the packing material having no discernible impact on its tannin concentration. In glass containers, the phytate concentration ranged from 0.01 to 0.03%, correspondingly. Following the duration of storage, the phytate content in glass containers decreased. Orhevba et al. (2019) noted a comparable pattern in the anti-nutritional characteristics of soybean flour as a result of various packing combinations. For containers made of plastic and nylon, the oxalate percentages varied from 0.02 to 0.17%. According to Orhevba et al. (2019), packing has no discernible impact on the amount of oxalate in soybeans. This directly contradicts their finding. 1.42 to 1.61% of the total was extracted as cyanide. The cyanide level of the powdered locust bean in the nylon decreased.

Table 2: Effect of Packaging Materials on Anti-nutritional properties of African Locust Beans Powder

Samples	Tannin (%)	Phytate (%)	Oxalate (%)	Cyanide (mg/kg)
A0	$0.01{\pm}0.00^a$	$0.03{\pm}0.00^a$	$0.02{\pm}0.00^b$	$1.61{\pm}0.03^a$
A1	$0.01{\pm}0.00^a$	$0.03{\pm}0.00^a$	$0.17{\pm}0.00^a$	$1.42{\pm}0.01^b$
A2	$0.01{\pm}0.00^a$	$0.01{\pm}0.00^b$	$0.02{\pm}0.00^b$	$1.61{\pm}0.04^a$
A3	$0.01{\pm}0.00^a$	$0.03{\pm}0.00^a$	$0.02{\pm}0.00^b$	$1.61{\pm}0.04^a$

Values are means ± standard deviation of triplicate determination. Means in the same column with different superscripts differ significantly ($p < 0.05$). A0: Initial value before packaging; A1: nylon; A2: glass; and A3: plastic

According to Ezekiel et al. (2022), anti-nutrients are recognized to negatively impact the bioavailability and utilization of nourishment. Nonetheless, Olagunju et al. (2018) observed that the African locust bean's anti-nutrient effects yielded values significantly lower than those of fermented tamarind extract.

Microbiological Properties of African Locust Bean Powder

Figure 1 depicts the microbiological characteristics of powdered African locust bean. The range of the total microbial count (TMC) was 3.54×103 to 3.90×103cfu/ml. With a TMC that was higher than the others, the sample in the nylon container stood out from the others. In addition, Olatoye and Lawal (2016) found that DodoIkire, an overripe plantain snack, had greater microbial counts in its low-density polyethylene bags than in its high-density plastic packaging. For samples contained in nylon and glass containers, the coliform count varied from 3.62×104 to 7.81×104 cfu/ml. There was a significant difference ($p< 0.05$) between every sample and the others. The variance in the microbiological counts of precooked cowpea flour packaged in high-density polyethylene, aluminum foil, and polypropylene may be caused by variations in their rates of moisture permeability, according to Abiodun et al. (2020).

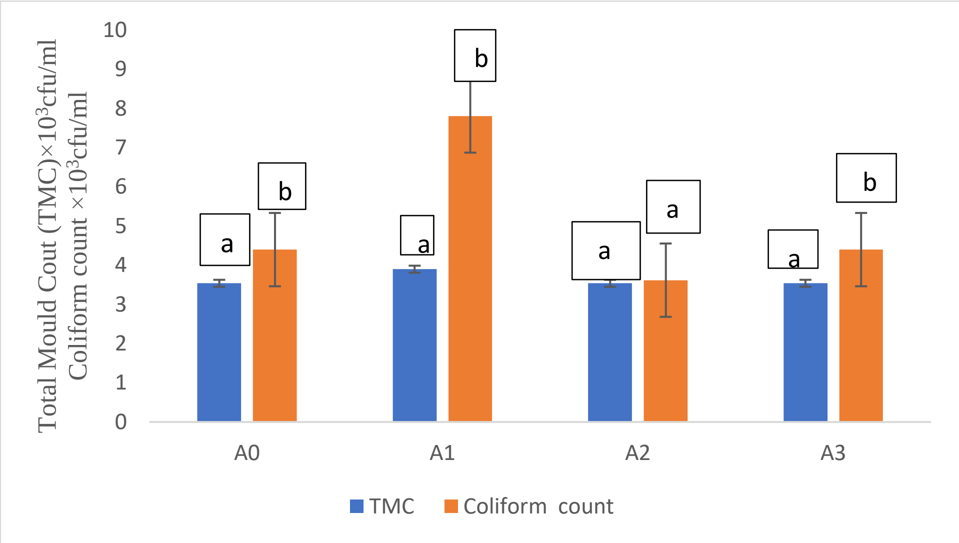

Figure 1: Effect of packaging materials on microbiological properties of ALB powder
A0: Initial value before packaging; A1: nylon; A2: glass; and A3: plastic

Conclusion

The length of time and effectiveness with which the quality standards of African locust bean powder may be upheld depends greatly on the type of packing material used. In comparison to nylon containers, this study demonstrated the usefulness of plastic and glass containers for keeping nutrients. The nylon allowed its contents to interact with the surroundings, which resulted in a considerable loss of nutrients and an increase in moisture absorption.

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