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Maintenance of Qualities of Two Nigerian Local Flours and Protection against Insect and Microorganisms Using Different Packaging Materials

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Abstract: *A study was conducted in the laboratory at ambient temperature of 28±2^{0}C and 75±5% relative humidity to evaluate the ability of different packaging materials to maintain qualities of two Nigerian local flours. Harvested yam tuber and cassava root were locally processed into yam flour (Elubo) and cassava flour (Lafun) and was separately packaged with polyethylene, plastic, craft paper and hessian sack. The proximate composition, mineral content, physico-chemical parameters, organoleptic properties, presence of microorganism and insect infestation was recorded after three months of storage. The highest moisture content was recorded in cassava flour stored inside craft paper 15.59 and was significantly ($p<0.05$) different from others except cassava flour stored inside hessian sack. The value of acid, peroxide, iodine and FFA was high in flour stored inside craft paper and hessian sack. The physico-chemical properties were higher in cassava flour than the yam flour in different packaging materials. It was noted that the flours stored inside craft paper and hessian sack recorded highest value of microorganism and insect. Therefore, to maintain the quality of yam and cassava flour for long period in storage, plastic and polyethylene bag could be used since they offer better protection than others.*

Keywords: *Packaging materials, yam flour (elubo), cassava flour (lafun), proximate composition, organoleptic properties, physico-chemical properties.*

1. INTRODUCTION

Agriculture is a major sector of the Nigeria economy, it contributes more than 30% of the total annual GDP, employs about 70% of the labour force, accounts for over 70% of the non-oil exports and, perhaps, most importantly, provides over 80% of the food needs of the country (Adegboye, 2004). To reduce the importation of flour and increase the production of locally made flour, government of Nigeria have encouraged farmers to increase their production of cassava and yam as this could increase the farmers' income as well as government annual GDP. The intervention of Nigerian government have resulted in the increase of domestic cassava production since late 1990s, rising 44% in seven years to attain 44 million tonnes in 2009 and yam production stood at around 35 million tonnes in 2008. Despite the effort of farmers boost the economy of the country, most of their produces are lost at post-harvest stages. The post-harvest technological scenario in cereals, grain legumes, oilseeds, fruits, vegetables, tubers, roots etc. of Nigerians present a dismal picture and are mostly comprised of traditional techniques practiced by growers, traders and the processors resulting in considerable deterioration of physical and nutritional qualities of harvested crops (Oni and Obiakor, 2002). Post-harvest losses of these crops ranges between 20-40%, because harvesting, processing/storage techniques are inefficient; as a result, supply is unstable (Mrema and Rolle, 2002). In under-developed and developing tropical countries, both quantitative and qualitative losses of agricultural products occur at all stages in the post-harvest chain, from harvesting, through handling, storage, processing packaging, transportation and marketing until crops are delivered to the final consumers. Post-harvest losses are not only of perishable crops but also grains, livestock and fish. It is estimated that as much as 25% of fruits, 40% vegetables and 15-20% grains are wasted after harvest. Hence, the elimination of post-harvest losses of agricultural products is important to boost food security and availability in these countries (Mremaand Rolle, 2002). Processing of these crops had been noted to reduce losses and to maintain the quality of these processed foods; moreover, good packaging materials are required. Food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food (Nada *et al.*, 2012). In doing so, packaging provides protection from three major classes of external influences: chemical, biological, and physical. Packaging materials, depending on the nature of the material and production technology, show different protection properties like permeability of water vapor, gases and light. Fadamiro and Odeyemi (1998), reported that polythene-in-polythene bags were better than polythene in hessian and polythene in paper containers for the storage of cocoa powder at 15, 25 and 40°C over a period of three months storage and weight loss was found to increase with increase in temperature of storage while Idowu (2005), reported a higher moisture uptake and greater vitamin C and colour losses for okra (orunla) powder stored at 40°C than those stored at 30°C. In joining government of Nigeria in their quest to promote local product and to fight against food insecurity, this present work evaluated the ability of different packaging materials to maintain the qualities of two Nigerian local flours and to protect them against microorganisms and insect.

2. Materials and Methods

2.1. Collection of Materials

Ten tubers and roots of yam (*Dioscorearotundata*) and cassava (*Manihot esculenta*) were collected from the farm of agricultural development programme. The collected yam and cassava were brought to the laboratory.

2.2. Processing of Yam and Cassava Flours

The yam tubers were peeled, washed and sliced to about 1cm thick. This sliced yam was blanched overnight and sun-dried on clean iron sheet covered with polyethylene material. On the other hand, the fresh roots were peeled, washed and cut into large longitudinal slabs, soaked in cold water for three days and sun-dried on clean iron sheet covered with polyethylene material. Both the dried yam and cassava were then milled into fine powder known as Elubo and Lafun respectively. The flours were then weighed into different packaging materials for observation. The two flours were replicated three times in different packaging materials.

2.3. Packaging and Storage

Four types of packaging material were used for this research. These packaging materials include plastic container, polyethylene, craft paper and hessian sack. Three hundred grammes of the two flours were separately weighed into these containers and tightly sealed. They were all stored in a cage made of wire mesh; the stand of cage were place in plastic containing water to which drops of kerosene were added to prevent entrance of insect into the cage. The experiment was set up in a complete randomized designed and each sample was replicated three times. The set up was maintained at temperature of 28 ± 2^{0}C and relative humidity of 75±5%.The proximate, mineral, physic-chemical and organoleptic properties of the flours were observed before storage and after storage for three months.

2.4. Proximate Composition Analysis

The proximate composition and mineral content analysis of the samples was determined using the standard method described by (AOAC, 1990). The parameters determined for proximate composition were moisture content, protein, ash, crude fibre, fat and carbohydrate while Cu, Zn, Fe, Pb, Mn, K, Na and Mg was also determined for mineral content analysis.

2.5. Determination of pH

A pH meter (Teledo, MP: 220) was used to measure the acidity and alkalinity of a given solution. It was first standardized using standard buffer solution of pH 4 and pH7. The electrode was the rinsed with distilled water and then immersed into the samples after which the samples have been dispersed (10g each of the yam and cassava flour) into 100ml of distilled water. The analysis was done separately for each sample and the pH were noted. This was done three times for the samples.

2.6. Determination of Physico-Chemical Parameters

2.6.1. Acid Value Determination

A sample of 25ml diethyl ether was mixed with 25ml ethanol and 1ml of 1% phenolphthalein solution was added and neutralized with sodium hydroxide solution. 1.20g of each sample were dissolved in the neutralized solvent mixture and titrated with 0.1M sodium hydroxide solution. The colour change was from colourless to pink. This was carried three times and the formular below was used for calculation

$$\text{Acid Value} = \frac{\text{Titre Valuex } 5.61}{\text{Weight of sample}}$$

2.6.2. Iodine Value and Peroxide Value Determination

The iodine value and peroxide value of the samples was carried out using the procedure of Manual of chemical methods of food analysis (Amoo, 2004). The determination was carried three times for each of the sample. The formular below was used to calculate these two values:

$$\text{Iodine Value} = \frac{(\text{b} - \text{a})1.269}{\text{Weight of sample}}$$

Where a=titre

b=blank titre value

$$\text{Peroxide Value} = \frac{\text{V x } 0.002\text{x}1000}{\text{Weight of sample}}$$

Where V=titre value

2.6.3. Determination of Free Fatty Acid (FFA)

The titre values obtained from the acid value determination were used for the determination of free fatty acid (FFA) for each sample. The formular below was used for the calculation

$$\text{FFA (as \% oleic acid} = \frac{0.282 \text{ x Titre value}}{\text{Weight of sample}}$$

2.7. Organoleptic Properties

This was carried out before and after twelve weeks on the samples to evaluate the level of acceptability and best packaging material for each of the flour. This was done to rate the samples for aroma, texture, colour, mould ability and overall acceptability.

2.8. Microbiology Experiment

Microbiological analysis was carried out on yam flour (Elubo) and cassava flour (Lafun) after three months of storage. All the four packaging materials were subjected to microbiological test to isolate and identify the fungi associated with the both flour packaged with different packaging materials using Potato Dextrose Agar (PDA) with lactic acid.

2.9. Identification of Fungi

When the fungal growth became obvious, they were sub-cultured several times until a pure culture was obtained. The isolated fungi were characterized by observing the morphological appearances including the spores and mycelium. A small piece of mycelium was transferred using inoculating needle onto a glass slide containing a drop of lactophenol cotton blue and the mycelium was spread properly with another needle. The preparation was covered with a cover slip and observed under monocular microscope using medium power and later at high power magnification. They were identified as described by Barnet (1960).

2.10. Analysis of Data

All the data in this work were subject to one way analysis of variance at 0.05 significant level using the using and means were separated using Duncan Multiple Range Test, SPSS version 17.

3. RESULTS

3.1. Proximate Composition of Yam Flour (Elubo) and Cassava Flour (Lafun) after Three Months of Storage

The proximate composition of the two flours was presented in Table 1. There were significant ($p<0.05$) difference between flours stored in different packaging materials. Cassava flour (Lafun) in craft paper has the highest %moisture content of 15.59 while yam flour (Elubo) in hessian sack has the highest %protein of 8.40 and fat content (4.62) and they were significantly ($p<0.05$) different from others. The yam flour stored inside polyethylene has the highest %fibre content of (0.39) while highest ash content of 3.89 was observed in cassava flour stored in hessian sack and they were significantly different from others. In addition, the cassava flour stored inside polyethylene has the highest %carbohydrate of 84.89. Moreover, the %carbohydrate content of cassava flour stored in polyethylene was not significantly ($p>0.05$) different from cassava flour in plastic and cassava flour before storage.

Table1. *Proximate composition of yam flour (Elubo) and Cassava flour (Lafun) after three months of storage.*

Flours in different packaging material	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
Yam in plastic	13.31±0.16^{cd}	5.00±0.01^{e}	1.08±0.02^{a}	0.33±0.02^{b}	2.10±0.01^{e}	79.23±0.01^{c}
Yam in polyethylene	13.64±0.02^{d}	4.76±0.03^{cd}	1.11±0.01^{ab}	0.39±0.02^{c}	2.07±0.02^{e}	79.22±0.01^{c}
Yam in craft paper	14.35±0.19^{e}	6.73±0.01^{g}	2.86±0.01^{e}	0.30±0.02^{b}	1.59±0.01^{d}	50.69±3.32^{a}
Yam in hessian sack	14.27±0.02^{e}	8.40±0.01^{h}	4.62±0.01^{f}	0.37±0.02^{c}	0.94±0.01^{a}	71.50±0.01^{b}
Cassava in plastic	11.60±0.03^{a}	1.18±0.01^{a}	1.25±0.01^{b}	0.15±0.03^{a}	1.28±0.01^{c}	84.28±0.01^{e}
Cassava in polyethylene	11.67±0.19^{b}	1.16±0.01^{a}	1.30±0.01^{b}	0.13±0.01^{a}	1.27±0.01^{c}	84.89±0.01^{e}
Cassava in craft paper						
Cassava in hessian sack	15.59±0.01^{f}	3.87±0.01^{b}	1.67±0.01^{c}	0.14±0.01^{a}	3.27±0.03^{f}	82.69±6.67^{d}
Yam before storage	15.18±0.02^{f}	6.02±0.01^{f}	2.64±0.01^{de}	0.15±0.02^{a}	3.89±0.07^{g}	80.30±0.01^{c}
Cassava before storage	13.67±0.01^{d}	4.31±0.01^{c}	1.08±0.01^{a}	0.37±0.01^{c}	1.19±0.01^{b}	79.38±0.01^{c}
	11.60±0.01^{a}	1.19±0.01^{a}	1.25±0.01^{b}	0.13±0.01^{a}	1.28±0.01^{c}	84.55±0.01^{e}

Each value is a mean ± standard error of three replicates. Means followed by the same letter are not significantly different ($p>0.05$) from each other using Turkey's Test.

Table2. *physico-chemical properties of yam flour (Elubo) and cassava flour (Lafun) after three months of storage.*

Flours in different packaging material	Acid Value	FFA Value	Peroxide Value	Iodine Value
Yam in plastic	10.05±0.03^{a}	0.53±0.02^{a}	0.47±0.03^{a}	7.94±0.01^{cd}
Yam in polyethylene	10.03±0.01^{a}	0.56±0.01^{b}	0.45±0.03^{a}	7.92±0.01^{c}
Yam in craft paper	12.53±0.01^{c}	1.60±0.01^{d}	1.48±0.01^{c}	6.45±0.01^{b}
Yam in hessian sack	12.26±0.01^{b}	1.59±0.01^{d}	1.73±0.01^{d}	6.40±0.01^{a}
Cassava in plastic	14.40±0.02^{e}	0.73±0.01^{c}	3.87±0.01^{e}	16.50±0.01^{i}
Cassava in polyethylene	13.25±0.06^{d}	0.74±0.01^{c}	3.88±0.01^{e}	16.51±0.01^{i}
Cassava in craft paper	16.42±0.01^{h}	1.89±0.01^{g}	5.02±0.01^{h}	14.20±0.01^{f}
Cassava in hessian sack	15.20±0.01^{g}	1.73±0.01^{f}	4.55±0.01^{g}	15.00±0.01^{g}
Yam before storage	10.05±0.01^{a}	0.51±0.01^{a}	0.60±0.01^{b}	7.98±0.01d^{e}
Cassava before storage	14.50±0.01^{ef}	0.73±0.01^{c}	3.99±0.01^{f}	15.14±0.01^{h}

Each value is a mean ± standard error of three replicates. Means followed by the same letter are not significantly different ($p>0.05$) from each other using Turkey's Test.

3.2. Physico-Chemical Properties of Yam Flour (Elubo) and Cassava Flour (Lafun) after Three Months of Storage

The result obtained for physico-chemical properties of yam and cassava flour stored in different packaging materials were presented in Table 1. There were significant ($p<0.05$) differences in physico-chemical properties the flours stored in the different packaging materials. The cassava flour stored in craft paper has the highest value of acid, free fatty acid and peroxide of 16.42, 1.89 and 5.02 respectively. Moreover, there value of acid, free fatty acid and peroxide obtained from the cassava flour stored in craft paper was significantly ($p<0.05$) different from other flours in other packaging materials. The cassava flour in polyethylene has the highest value of iodine and was significantly different from other flours in other packaging material except cassava flour in plastic.

3.3. Mineral Composition of Yam Flour (Elubo) and Cassava Flour (Lafun) after Three Months of Storage

Table 3 presented the mineral composition of yam flour and cassava flour after storage. Cu, Pb and Mn were not detected in all the flours in different packaging materials. Also, Ca was not detected in the yam flour stored in different package materials. Moreover, there significant ($p<0.05$) differences in the composition of Zn, Fe, K, Na and Mg that present in the flour stored in the different packaging materials.

Table3. *Mineral composition of yam flour (Elubo) and cassava flour (Lafun) after three months of storage*

Flours in different packaging material	Ca	Cu	Zn	Fe	Pb	Mn	K	Na	Mg
Yam in plastic	ND	ND	6.26±0.01^{g}	6.65±0.01^{f}	ND	ND	160.72±0.01^{f}	99.46±0.01^{c}	200.52±0.01^{b}
Yam in polyethylene	ND	ND	6.13±0.01^{f}	6.66±0.01^{f}	ND	ND	161.02±0.01^{f}	99.44±0.01^{c}	200.72±0.01^{b}
Yam in craft paper	ND	ND	6.08±0.01^{e}	7.02±0.01^{g}	ND	ND	153.65±0.01^{d}	99.32±0.01^{c}	200.15±0.01^{b}
Yam in hessian sack	ND	ND	5.75±0.37^{d}	6.62±0.01^{d}	ND	ND	153.06±0.01^{d}	90.41±0.01^{b}	219.02±0.01^{c}
Cassava in plastic	10.10±0.01^{d}	ND	5.15±0.01^{c}	5.52±0.01^{b}	ND	ND	140.02±0.01^{c}	170.01±0.01^{d}	240.02±0.01^{e}
Cassava in polyethylene	10.10±0.01^{d}	ND	5.16±0.01^{c}	5.54±0.01^{c}	ND	ND	140.03±0.01^{c}	170.04±0.03^{d}	241.68±0.06^{e}
Cassava in craft paper	10.00±0.00^{c}	ND	3.92±0.01^{a}	6.61±0.01^{d}	ND	ND	139.62±0.01^{b}	189.90±0.01^{g}	259.02±0.01^{f}
Cassava in hessian sack	9.59±0.01^{b}	ND	5.16±0.01^{c}	5.51±0.01^{b}	ND	ND	135.54±0.03^{a}	181.01±0.01^{f}	258.84±0.01^{f}
Yam before storage	ND	ND	6.25±0.01^{g}	6.55±0.01^{e}	ND	ND	156.85±0.01^{e}	89.46±0.01^{a}	199.52±0.01^{a}
Cassava before storage	9.29±0.01^{a}	ND	5.13±0.01^{b}	3.25±0.01^{a}	ND	ND	140.71±0.01^{c}	173.04±0.01^{e}	239.74±0.01^{d}

Each value is a mean ± standard error of three replicates. Means followed by the same letter are not significantly different (p>0.05) from each other using Turkey's Test.

3.4. pH Composition and Organoleptic Properties of Yam Flour (Elubo) and Cassava Flour (Lafun) after Three Months of Storage

The pH composition and organoleptic properties of the flours in different packaging materials were presented in Table 4. There were significant differences among the flours in different packaging materials in term of pH composition. Yam flour in craft paper had the highest pH composition of 5.70 while cassava flour in craft paper has the lowest pH composition5.15. However, all the packaging materials except craft paper maintained the organoleptic properties of the flours in term of colour, texture, acceptability and aroma.

Table4. *pH composition and organoleptic properties of yam flour (Elubo) and cassava flour (Lafun) after three months of storage*

Flours in different packaging material	pH	Oganoleptic properties			
		Texture	Colour	Aroma	Acceptabilty
Yam in plastic	5.47±0.01^{d}	5	5	5	5
Yam in polyethylene	5.44±0.01^{d}	5	5	5	5
Yam in craft paper	5.70±0.02^{f}	2	2	2	2
Yam in hessian sack	5.47±0.02^{d}	3	3	3	3
Cassava in plastic	5.37±0.01^{c}	5	5	5	5
Cassava in polyethylene	5.38±0.01^{c}	5	5	5	5
Cassava in craft paper	5.15±0.01^{a}	2	2	2	2
Cassava in hessian sack	5.24±0.01^{b}	3	3	3	3
Yam before storage	5.59±0.01^{e}	5	5	5	5
Cassava before storage	5.39±0.01^{c}	5	5	5	5

Each value is a mean ± standard error of three replicates. Means followed by the same letter are not significantly different (p>0.05) from each other using Turkey's Test.

Key for organoleptic properpties

5=Excellent

4=Good

3=Satisfactory

2=Fair

1=Bad

3.5. Number of Insect and Microorganism Found in Each of the Flour after Three Months of Storage in Different Packaging Material

Table 5 and 6 presented the number of insect and types of fungi that present in each of the flour stored in different packaging materials respectively. *Triboliumcastaneum* and *Lasiodermaserricorne*was the only insect found in the yam and cassava flour stored in craft paper and hessian sack. However, the number of insects found in yam flour was lower than those found in cassava flour. It was also observed that the number of *Triboliumcastaneum* was higher in cassava flour (60) than in yam flour (52) stored in craft paper. Also, the number of *Lasiodermaserricorne* was higher in cassava flour (56) than in yam flour stored in hessian sack (Table 5).Moreover, it was only *Rhizopussp* that was found present in the yam and cassava flour stored in craft paper and hessian sack while the flour stored in plastic and polyethylene are free from microorganism as well as insect.

Table5. *Number of insect found in each flour after three months of storage in different packaging material*

Types of flour	Packaging material	Number of insects found	Species of insect found
Yam(Elubo)	Plastic	-	-
	Polyethylene	-	-
	Craft paper	52	*Triboliumcastaneum*
	Hessian sack	50	*Lasiodermaserricorne*
Cassava (Lafun)	Plastic	-	-
	Polyethylene	-	-
	Craft paper	60	*Triboliumcastaneum*
	Hessian sack	56	*Lasiodermaserricorne*

Each value is a mean of three replicates. Means followed by the same letter are not significantly different ($p>0.05$) from each other using Turkey's Test.

Table6. *mould found in each flour after three months of storage*

Flours in different packaging material	Fungi				
	Fusariumsp	*Rhizopussp*	*Aspergillussp*	*Mucorsp*	*Peniceillumsp*
Yam in plastic	-	-	-	-	-
Yam in polyethylene	-	-	-	-	-
Yam in craft paper	-	+	-	-	-
Yam in hessian sack	-	+	-	-	-
Cassava in plastic	-	-	-	-	-
Cassava in polyethylene	-	-	-	-	-
Cassava in craft paper	-	+	-	-	-
Cassava in hessian sack	-	+	-	-	-

Key

+ =*present*

- =*not present*

4. DISCUSSION

Packaging plays an important role in protecting food products from outside influences and damage. Packaging does not only ensure that food contains and maintains the amount and form of the required ingredient and nutrients but also improves sensory quality and color stability (Baley*et al.*, 2011). It has been demonstrated that food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life and maintain or increase the quality and safety of food (Marsh and Bugusu, 2007; Singh and Goyal, 2011). Consumers demand for food products with high quality is on the forward trend. In this front, packaging is critical in maintaining product quality while offering protection from microbial and chemical contamination, as well as from oxygen, water vapor and light (Silva *et al.,* 2004; Rajkumar*et al.,* 2007; Bibi*et al.,* 2008; Adetunji and Chen, 2011). The extent of food protection by packaging, however, is dependent on type of materials used which varies between countries. For instance, the major packaging material for potato crisps in Kenya has been polyethylene bags and only recently has aluminium foil packs been introduced (Abong*et al.*, 2010b).

The result obtained from this research showed that cassava flour in craft paper had the highest moisture content followed by the one stored in hessian sack. Cassava flour stored in plastic container had the lowest moisture content after three months of storage. However, yam flour stored in plastic and polyethylene as well as cassava flour in polyethylene also had low moisture content. The high moisture content of flour stored in hessian bag and craft paper may be as a result of absorption of moisture from external environment due to the fact that the materials are porous or permeable to moisture. This finding agreed with earlier result of Clauses and Weber (2000) that increased in the moisture content of cowpea stored in craft paper may be attributed to gas and moisture permeability as well as the hygroscopic nature of the craft paper and stored cowpea seed. The high moisture content in the yam and cassava flour stored in craft paper and hessian sack could be the major factor that responsible for the presence of microorganism in them. Moisture content is an important shelf-life determinant; the higher the level of moisture the higher the rate of microbial spoilage of food products and the faster the breakdown of oils in stored products. This was in agreement with the work of George *et al* (2011) in which increase in moisture content of potatoes crisp result in high microbial growth. This also agreed with the work Navarro and Donahaye (1989) which opined that polyethylene bag and plastic container offer good resistance against moisture, insect infestation and retained the proximate composition of grain flour in six months of storage. The increase in percentage moisture content of four packaged with craft paper and hessian sack could be attributed to the respiratory activities of insects and storage fungi that attacked the stored flours. This was in agreement with the report of Dharmaputra*et al.* (1994) that increasing number of adult *Sitophilus zeamais* and storage fungi contributed to high percentage moisture content of stored maize.

In addition, there was increase in the acid value of flours stored in craft paper and hessian sack. Moreover, there was no significant increase in the acid value, peroxide value, free fatty acid value and iodine value of yam and cassava flour stored in plastic container and polyethylene bag if compared to their initial values. The acid value and FFA are very important in determining the quality acceptance of .food for industrial or consumption purpose (Patterson, 1992). The peroxide value is an indication of deterioration of food which may result to rancid taste.

The result obtained from this work was not in agreement with the work of George *et al.* (2011) in which there was an increase in the value of these physico-chemical properties present in potato crisp. Also this result was in contrary to the result of Naqi*et al.* (2012) in which cereal bran incorporated biscuits were found to increase in these physico-chemical properties over time of storage.

5. Conclusion

The maintenance of excellent texture, colour and acceptability of flours packed with plastic and polyethylene is as a result of the material not permeable to water and air, hence the materials are hermetic in nature these retained the organoleptic properties of the food. Therefore, to maintain the quality of yam flour (Elubo) and cassava flour (Lafun) for long period of time in storage, plastic and polyethylene bag can offer a better storage. Moreover, plastic container could be recommended for better storage since it offers more protection against insect and fungi.

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