Effects of Different Packaging Methods on the Shelf Life of Cashew Nuts and Kernels

Abstract

Cashew, *Anacadium occidentale* is a nut crop considered essential simply because it provides food and employment to millions of people in developing nations. It is cultivated mainly for its nut; a very important export commodity. Dried cashew nuts and kernels that are improperly packaged and stored are prone to spoilage and rejections both in local and export markets. This study was conducted to assess the effects of different packaging methods on the quality of cashew nuts and kernel. Two hundred (200) kg of cashew nuts were procured each, from four states, Oyo and Osun (Southwest); Kwara and Kogi (North Central) Nigeria. The nuts were dried using parabolic solar dryer fixed with data logger for three days. One kg sample in three replicates was taken from each State's lot and analyzed for initial quality parameters using Nut count (NC) and Kernel Output Ratio methods (KOR). Two hundred kilograms kg of dried raw cashew nut (RCN) (10% MC) taken from 50 kg each from across the States were thoroughly mixed and divided into two lots of 100 kg each. The first lot of 100 kg was processed into kernels (PCK) while the remaining 100 kg was used for RCN storage studies. Physical, chemical microbiological and entomological analyses were evaluated on RCN and PCK at 0, 2, 4, 6, 8, 10 and 12 months. RCN was stored using three different types of packaging; Jute bag, paper-lined jute bag and paper-lined carton, while cashew kernels (PCK) were stored using five different types of packaging methods; Polythene, Polythene lined polypropylene, paper lined polyethylene, polythene lined carton and paper lined carton. Paper lined jute bag was the best packaging method for nut storage while, polythene lined polypropylene was the best for kernel storage. Cashew kernels are easily stored in smaller spaces than the nut (ratio 1:5).

Keywords: Packaging methods, product quality, storage stability, microbiological quality, export market

Introduction

Cashew (*Anacardium occidentale*) is a native of Brazil and the Lower Amazons and has been introduced in the Americas, the West Indies, Madagascar, India, Malaysia and Nigeria. It is an important nut crop that provides food, employment and hard currency to many in developing nations [1]. The traditional method of sun drying and storage has been followed in cashew processing industries for Raw Cashew Nut (RCN) storage. Cashew nut is the most economic part of the cashew tree providing foreign exchange earnings for producer countries. In Nigeria, cashew nuts exports represent 7 to 8% non-oil export earnings, with a production of 820,000 tons, the second largest in the World after Vietnam's production of 1 Million tons, spreading to about 27 states of the country FAOSTAT [2]. It supplements the income of farmers and additional people employed down its' value chain [3].

The major cashew growing areas in the different parts of Nigeria in the order of the level of productivity with respect to the different regions of the country are: Enugu, Abia, Imo, Anambra, Ebonyi and Cross River States in the east and southern parts, Oyo, Osun, Ondo, Ekiti and Ogun States in the western part, Kwara, Kogi, Nassarawa, Benue, Taraba, Niger, Federal Capital Territory (Abuja), Kaduna and Plateau in the Middle Belt and Sokoto and Kebbi States in the North-western part of the country [3].

Among the limiting factor for good pricing of Nigerian cashew includes: low quality, small nut and kernel size, and more importantly poor kernel peel-ability (that is, the difficulty in the removal of the testa from the kernel) which adds more to the cost of processing. Poor peel-ability may possibly be resulting from the single or complex effect of poor harvest, poor post-harvest handling of the Nigerian cashew among others [4].

Improper post-harvest handling and storage of nuts, such as high moisture due to improper drying, temperature and insect or mechanical damage can influence the incidence of the fungus that produces toxins like aflatoxin and deterioration of kernel nutrients and rancidity can occur [4].

Improvement in harvest and post-harvest handling protocols through extension programs will increase the global acceptability and better pricing of Nigerian cashew. The management of cashew post-harvest has been the problem of high quality cashew availability for local and export markets. Moisture migration in already dried cashew nut due to improper packaging methods has contributed to the low quality cashew. Cashew producers have largely been selling the nuts, neglecting the advantage of processing into kernels which can also be stored in large tonnages, using limited storage space due to lack of limited information on this practice. This research was carried out to provide a solution to the packaging problems of both the nuts and the kernels with the view to achieving better post-harvest management of cashew. Therefore, this study was conducted to assess the effects of different packaging methods on the shelf life of cashew nuts and kernel quality.

2. MATERIALS AND METHODS

2.1 Material

Materials used are: cashew nuts, cashew nut cutter, cashew nut cracker, Steamer, polythene bags (0.10 mm and 0.05 mm), polypropylene bags, brown paper bags (0.2 mm), jute bags, Paper cartons (3.0 mm), Digimatic caliper (Mitutoyo Corporation, Japan).

2.2 Methodology

Two hundred kilograms (200 kg) of fresh cashew nuts were procured each from four states from two geopolitical zones of Nigeria. Kwara and Kogi States in the North-central, and Osun and Oyo States in the South West geopolitical zones. The nuts were brought to NSPRI and dried using the Parabolic solar dryer fixed with data logger. This was done for three days.

2.3 Processing and Packaging

The RCN was processed into kernels following the flow chart in Figure 1.

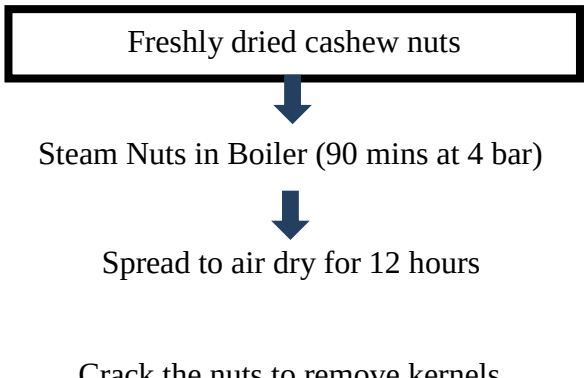

Figure 1: Flow chart for processing raw cashew nut into kernels

2.4 Storage of cashew using different packaging methods

Two hundred kilograms (200 kg) of dried RCN (10% mc) taken from 50 Kg each from across the States were thoroughly mixed and were divided into two lots of 100 kg each. The first lot of 100 kg was processed into kernels while the remaining 100 kg was used for Raw Cashew Nut (RCN) storage studies.

2.5 Assessment of nuts quality

The quality of the nuts was assessed by taking samples from each state and analyzed for their quality standards by cutting through using the cashew nut cutter. The following parameters were assessed;

2.5.1 *The Nuts Count*

The nuts count was assessed by taking 1.0 kg sample of RCN in three replicates from each state. This was counted, and the number of cashew nuts was noted and recorded.

2.5.2 *Out-Turn Count or Kernel Output Ratio (KOR)*

This was assessed by cutting into half the 1 kg nuts and assessed for the quality of the kernels. The parameters observed were: Diseased, immature, void and spotted.

2.5.3 *Diseased or Mouldy*

This includes all nuts which when cut reveal the presence of fungi growth or a milky patch or a spread of brown or black spots on the split kernel. This is often caused by high moisture for several days prior to proper drying, wrong packing and improper storage.

2.5.4 *Brown Rancid Rotten (BRR)*

This includes all brown, rancid, rotten and discolored kernels which are light yellowish in color. This is caused by similar factors listed above.

2.5.5 *Void*

These are nuts that showed emptiness or absence of kernels of useful size.

2.5.6 *Immature/shriveled*

These are nuts when cut contain space between the kernel and the shell, shrink or contain kernels that are not fully developed, caused by harvesting immature nuts.

2.5.7 *Spotted*

All nuts show black or brown spots on the kernel.

2.5.8 *Insect Damage (weevilled)*

The nuts when cut show a state of insect attack, the presence of thread-like or powdery substance; kernel output ratio (KOR) was calculated using equation 1

$$KOR = \frac{Wt.\,of\,good\ kernels + Wt.\,of\,diseased\ or\ spotted}{2} + \frac{WtImmerature\ kernels}{2} X\ 0.176 \quad (1)$$

Where; 0.176 is a constant

2.6 Storage studies

2.6.1 *Raw cashew nut storage*

The raw cashew nuts (RCN) were stored using three different methods of packaging namely; Jute bag (J), Paper- Lined - Jute bag (PaJ) and Paper- Lined- Carton (PaC), Eighteen 4.0 kg lots of RCN were packaged in each of the packaging materials (stated above) and arranged on the laboratory floor of the Nigerian Stored Products Research Institute on pallets. Destructive samples were taken once in two months for analysis.

2.6.2 *Cashew kernel storage*

Processed cashew kernels (PCK) (Figure 1) were stored using five different packaging methods namely; Polythene (Pt), Polythene - Lined – Polypropylene (PtPr), Paper- Lined-

Polythene (PaPt), Polythene – Lined – Carton (PtC) and Paper- Lined – Carton (PaC).18 packs of one (1) kg of the kernels packaged in each of the various packages stated above were also stored on the laboratory bench of NSPRI. Low gauge polythene lined polypropylene (LGptPr) stored kernels served as the control. The same sampling procedure was done for the kernel storage as was done for the RCN.

2.6.3 *Physical, chemical, microbiological and entomological analyses*

Physical, chemical and entomological analyses were evaluated on raw and processed cashew nuts. Before storage and subsequently bi-monthly during the 12 months storage. Physical test such as weight changes was evaluated using an electronic balance (DLARK: DT1000). Insect infestation was carried out using the methods of Otitodun *et al*. [5]. Proximate composition was determined using the AOAC [6] methods. Microbiological analysis was done at the beginning and at the end of the study. Aflatoxin analysis was carried out at the end of the study, according to the methods of AOAC [6], and the quantification was done using Rapid Quick Scan (RQS).

2.6.4 *Determination of total viable, bacterial and fungal counts of packaged cashew nuts*

Total viable count (TVC), total bacteria count (TBC) and fungal counts (TFC) were determined by the dilution plate technique [7]. One gram of each blended nut was added to 9 ml of sterile water in a test tube and the solution was decimally diluted. Twenty milliliters of sterilized molten nutrient agar and Potato Dextrose Agar (PDA) plates supplemented with 0.01% chloramphenicol were cooled to 45°C and poured separately into plates containing 1 ml aliquots of each sample. The plates were gently swirled and allowed to solidify. The nutrient agar plates were incubated at 30°C for 48 h for determination of TVC and TBC. Potato Dextrose agar plates were incubated at 28°C for 48 h for the determination of TFC [7]. Microbial counts were determined using the formula:

$$\text{CFU/ml} = \frac{\text{No. of colonies x dilution factor}}{\text{volume of inoculum}} \qquad (2)$$

2.7 Data analysis

Data obtained were analyzed using one-way Analysis of Variance (ANOVA) using GenStat Statistical Package 12.1. Means were separated using Student-Newman-Keul's Test (S-N-K). Significance differences were accepted at 95% confidence level (p=0.05)

3. Results and Discussion

The quality of cashew kernels is usually determined by the use of nut count and the Kernel Out -turn Ratio (KOR). From this study, the nut count across the candidate states are as stated in Table 1. The nut count of Kwara, Osun and Oyo States were within the standard for good kernel. However, when the nuts were mixed together, the mean nut count of 176.00 was within the good quality, simply because count between 170 – 210 nuts is usually the benchmark for good exportable raw cashew nuts level (Table 2). In real life, aggregators do not separate nuts from one State but are mixed together; before being supplied to exporters. Further analyses of the nuts from the various states, showed that, the percentage weight of kernel from Oyo State was significantly higher than from other States, while kernels from Kogi and Kwara were not significantly different but were higher than kernels from Osun State, being the lowest. It was also observed that shell from Osun cashew was significantly higher than from other states, with Oyo having the least percentage shell weight (Table 1).

This may be due to the effects of the variety cultivated, the age of the cashew tree in the states and environmental interaction (4). Most of the trees in Kogi State were aged

There was a trend of increase in the nut count as the storage progressed up to the tenth month. There were no significant changes in the nut count in cashew nuts stored with the different packaging methods until the fourth month when the counts in nut stored in paper-lined jute was observed to be higher significantly than others. Jute and paper-lined carton storage methods maintained similar nut count. The results of Kernel Outturn Ratio (KOR) showed the significantly better performance of paper-lined carton and paper-lined jute sacks over use of jute sack only after the twelfth month (Table 3). Similarly, there were no significant changes in the weight of stored cashew using the different methods both between the methods and the months of storage up to the fourth month, when there was reduction in the weight from the sixth month (Table 4). After the sixth month, there was no significant reduction in weight as the storage progressed to the twelfth month. However, all the packaging methods recorded nut counts that were within the good quality range. The methods of packaging for storage were able to prevent moisture gain into the nuts despite the fact that the storage period was during the wet and dry seasons (April 2021 – April 2022) and were also able to minimize weight loss.

Table 1: Mean nut count and percentage weights of cashew shell, kernel and testa to nut weight across the states

States	Nut count	Nut Wt. (Kg)	Shell	Kernels	Testa
Kogi	253	97.00	74.66[a]	19.11[a]	5.413[b]
Kwara	196	103.00	73.81[a]	19.07[a]	5.643[a]
Osun	216	108.00	79.18[b]	16.21[b]	3.687[c]
Oyo	185	90.00	70.56[c]	23.59[c]	6.387[d]
SED		± 1.291	± 2.112	± 0.308	± 0.0554
LSD		2.977	4.871	0.711	0.1278

Note: Means followed by the same letter within the column are not significantly different at 5%

Table 2: Mean nut count of cashew nuts stored in different packaging methods

Packaging	Months of storage						
	0	2	4	6	8	10	12
J	176.00[a]	177.00[a]	188.00[a]	205.67[a]	205.00[a]	207.00[a]	207.00[a]
PaC	176.00[a]	177.00[a]	180.00[b]	204.00[a]	204.33[a]	205.00[a]	205.00[a]
PaJ	176.00[a]	177.00[a]	179.00[b]	194.67[b]	194.67[b]	202.33[b]	202.33[b]
S.E.D	± 0.000	± 0.816	± 1.414	± 1.466	±1.563	± 1.785	± 1.981
LSD	0.00	1.998	3.460	3.586	3.826	4.367	2.401

Note:
1. Means followed by the same superscript letter within the column are not significantly different at 5%
2. 170 – 210 nut count is usually the benchmark for good exportable raw cashew nuts

Table 3: Mean kernel Outturn Ratio (KOR) of cashew nuts stored in different packaging

Packaging	Months of storage						
	0	2	4	6	8	10	12

J	47.69[a]	47.68[a]	47.68[a]	46.11[a]	46.24[a]	44.22[a]	43.47[a]
PaC	47.69[a]	47.67[a]	47.77[a]	47.77[b]	46.32[b]	45.11[a]	44.58[ab]
PaJ	47.69[a]	47.69[a]	47.69[a]	47.69[b]	46.62[b]	44.71[a]	45.76[b]
SED	0.00	± 0.077	± 0.358	± 0.485	± 0.1430	± 0.703	± 0.552
LSD	0.00	0.1874	0.875	1.186	0.3499	1.719	1.350

Note: Means followed by the same letter within the column are not significantly different at $p < 0.05$

48 – 54 lbs is the acceptable standard for KOR,
Less than 40 lbs quality is a poor grade and is usually rejected

This showed that although PaJ sack was the best method of storage in terms of the nut count, all the methods could be used for nut storage and still maintain the nut quality'.

Other quality parameters of cashew are the moisture content of both the nut and the kernels. Cashew with a moisture content of 5% or less is recommended for kernels. From the results of the kernel's storage with different methods, there were no significant changes in the moisture contents before storage and at the end of the twelve months storage period for all the methods except for kernels stored in PaC, with significantly higher moisture content (Table 5). However, considering the, the proximate composition of the kernels, PtPr stored kernels had the lowest moisture content due to their ability to prevent moisture gain. This could be likened to the performance of the hermetic storage method. Achieving quality kernels is possible if the moisture is controlled and will snowball into the stability of other proximate compositions of the kernels as moistly recorded in the study (Table 4).

There is a direct link between the spoilage of stored produce and their moisture contents [8]. High moisture contents of stored samples could be influenced by packaging materials [9]. Also, the presence of moisture above safe levels in food grains could aggravate the activities of insects and microorganisms including moulds [8].

Table 4: Weight (Kg) changes in cashew nuts stored in different packaging

Packaging	**Months in storage**						
	0	2	4	6	8	10	12
J	4.00[a]	4.00[a]	3.880[a]	3.880[a]	3.880[a]	3.870[a]	3.870[a]
PaC	4.00[a]	4.00[a]	4.000[b]	3.900[a]	3.880[a]	3.890[a]	3.880[a]
PaJ	4.00[a]	4.00[a]	4.000[b]	3.960[a]	3.890[a]	3.880[a]	3.880[a]
SED	0.00	0.00	± 0.0094	±0.0583	±0.024	±0.024	±0.0176
LSD	0.00	0.00	0.0231	0.1427	0.0588	0.0588	0.0432

Note: Means followed by the same letter within the column and rows were not significantly different at $p < 0.05$

The packaging methods for kernels were able to prevent the infestation of the kernels with insects. All the methods of packaged kernels prevented the infestation of insects, except the paper-lined carton method with infestation *Plodia interpunctulata* and *Tibolium confusum* (Table 6) occurring from the tenth month of storage. The control with kernels stored in low gauge (0.0125 mm) polythene lined polypropylene was infested with *Plodia interpunctulata* and *Tibolium confusum* from the fourth month of storage (Table 6). *Tribolium* sp was also

noticed at the sealing edge of the polythene lining of polyethylene polypropylene packaging; both could not gain entry due to the thick gauge of the polythene. These also being due to the fact that *Tribolium* sp. are secondary pests that come in after damage must have been initiated by the primary storage pests.

Table 6: Mean total insect infestation in stored cashew kernels

Packaging materials	Months of storage						
	0	2	4	6	8	10	12
PaC	0	0	0	0	0	0	0
Pt	0	0	0	0	0	0	0
PaPt	0	0	0	0	0	0	0
PaC	0	0	0	5	8	15	44
PtPr	0	0	0	0	0	0	0
Low gauge polythene	0	0	10	25	40	67	105

Table 7: Microbial load of differently packaged cashew kernels

Packaging method	TVC(cfu/g)		TFC(cfu/g)		TCC(cfu/g)		TBC(cfu/g)	
	Initial	Final	Initial	Final	Inital	Final	Inital	Final
Pt	3.0×10^2	3.0×10^2	2.0×10^2	2.0×10^2	NGD	NGD	2.0×10^2	2.0×10^2
PtC	1.0×10^1	1.0×10^1	2.0×10^1	2.0×10^1	NGD	NGD	1.0×10^1	1.0×10^1
PtPr	1.0×10^1	1.0×10^1	NGD	NGD	NGD	NGD	1.0×10^1	1.0×10^1
PaC	1.0×10^1	1.0×10^1	NGD	NGD	NGD	NGD	1.0×10^1	1.0×10^1
PaPt	NGD	NGD	NGD	NGD	NGD	NGD	NGD	NGD

Keys: TVC: Total viable count; TFC: Total fungal count; TCC: Total coliform count; NGD: No growth detected

The kernels subjected to various storage methods were found to be produced under good hygienic environment and processes. This was due to the fact that the microorganisms recorded were within tolerable limits (Table 7). Furthermore, the storage methods did not encourage the multiplication of the organisms all through the study period. This was further corroborated by the aflatoxin levels being less than 4ppb.

Conclusion

In conclusion, the use of paper lined jute sack (PaJ) was the best method of storage of cashew nuts, even though jute only (J) and paper-lined cartons (PaJ) were also useful in extending the shelf life of cashew nuts for a period of one year. Cashew kernels are better preserved using high gauge polythene lined with polypropylene (PtPr). It can also be concluded that storing cashew as kernels is easier with the possibility of being stored in smaller space than nuts. Cashew nuts and kernels can be stored for up to one year with the appropriate packaging.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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