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Influence of rural processing methods and postharvest storage treatments on quality characteristics of kola nut (*acuminata* Schott & Endl.)

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Quality changes of kola nut (*Cola acuminata*) as affected by processing methods and short-term storage environments were investigated. The experiment was conducted at the Teaching and Research Laboratory of the Department of Crop Science, University of Nigeria Nsukka, Nigeria. The treatments comprised of: three different colour plastic buckets – red, green, white and three inner linings - *Newbouldia laevis* leaves, *Spondias mombin* leaves and Black polyethylene sheets giving a 3 × 3 × 3 treatment combinations. The *N. laevis*, *S. mombin* and Black polyethylene sheets were laid inside the buckets as beddings for the kola nuts. About 0.45 kg of kola nuts (coated and uncoated) numbering 20 nuts were put in each storage container. Sensory quality of the nuts after storage was determined with quantitative descriptive analysis in expert panel, using six quality attributes. Physical parameters measured were; weight loss, pest incidence and sprouting incidence. Weight loss was significantly lower in white plastic storage container for coated kola nut while green plastic container reduced weight loss for uncoated. Black polyethylene sheet as inner-ling of the storage container significantly (P≤ 0.05) reduced weight loss and pest incidence in coated kola nut compared to uncoated. *N. laevis* and *S. mombin* significantly reduced weight loss in kola nuts. It is evident in this study that coated kola nut genotype were kept better than the uncoated kola nut.

Key words: Processing methods, kola nut, storage treatments, quality characteristics.

INTRODUCTION

Kola nut (sterculiaceae) is mostly produced in Africa and cultivated to a large degree in West Africa. Annual production from these countries alone is in excess of 250,000 tons, while the world production is about 300,000 tones (American Horticultural Society, 2002). There are three species of kola which are mostly grown in Nigeria. These are *Cola nitida*, *Cola acuminata* and *Cola verticulata. C. nitida*, which is referred to as" true kola of commerce" has featured in the internal trade of West Africa for a number of centuries. Kola nuts are

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common sight in Nigeria markets, cities and villages. They are often sold by street vendors, at motor parks and train depots.

Many Nigerians consume kola nuts regularly, even daily, for its medicinal and stimulating value. The kola nut also has social and traditional significance as it also has industrial usage in pharmaceuticals for the production of soft drinks, wines and confectionaries (Ogutuga, 2001). Kola is offered as gifts in several ceremonies such as betrothal ceremony, wedding ceremony, naming ceremony, burial ceremony, taking of a new chieftaincy title and therefore regarded as an entertainment item which is used to demonstrate hospitality to guest in homes and social functions especially in Southeastern Nigeria (Russel, 2000). The kola nut pod husk, a by- product from processing the nut, is widely used for feeding animals because of its high nutritive quality. According to Babatunde and Hamzat (2005) broilers fed with kola nut pod husk meal diet exhibit outstanding growth performance.

It has been observed that Kola nut producing farmers are faced with the problem of pest and diseases, which adversely affect their rate of storability for export (Daramola, 2000). In most cases the farmers are forced to sell their produce at very low prices immediately after harvest to avoid total loss of the whole harvested nuts.

The important role *C. acuminata* plays in social cultural, economic and religious lives of people in southeastern Nigeria call for critical study and discovery of what must be done to keep the seed in good order until the next season of harvest. Traditionally, the use of *Newbouldia laevis* (leaves) called “Ejuruosisi” in Igbo language and *Spondias mombin* (leaves) called “Echikara” also in Igbo language have been used to preserve and keep Kola nut safe by the local people. The scientific basis for using these plants in preservation of Kola nut has not been established and because of the high premium value attached to *C. acuminata*, therefore, the need to investigate the preservation method that will keep the Kola nut available all year round.

Therefore, the objective of this study was to evaluate the effects of green, red and white coloured plastic containers inner-lined with two plant leaves, *S. mombin, N. laevis* and black polyethylene sheet on the quality indices of kola nut genotypes.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Laboratory of the Department of Crop Science, University of Nigeria, Nsukka. The area is located by latitude 6° 52’ N and longitude 7° 23’ E, altitude 400 m above sea level. The mean annual rainfall ranges from 1600 to 2000 mm. The temperature is uniformly high throughout the year but the annual mean maximum temperature does not exceed 35°C. The soil is sandy loam and has been classified as Typic Kandpaleustult or Dystric Nitosol, belonging to Nkpologu series (Nwadialor, 1989) and the vegetation has been described as derived savannah.

The matured pods of kola nut *(C. acuminata*) were obtained from Afor Opi main market in Enugu state, Nigeria. Fresh leaves of *N. laevis* and *S. mombin* were collected and identified at the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka. Uniformly sized plastic buckets with lids and black polyethylene sheets were purchased from Nsukka main market. Two openings of 3 × 4 cm were made on each bucket to let out excess heat from the container during the storage. The height of the bucket was 45 cm and the openings were made directly opposite each other 35 cm from the base of the buckets. The buckets were red, green and white in colour. The fresh leaves of *N. laevis* and *S. mombin* and the black polyethylene sheets were used as beddings for the kola nuts inside the buckets/storage containers.

Processing and storage

The pods of *C. acuminata* were carefully and longitudinally cut open with razor blade. The nuts were removed and those nuts with slight razor cut, disease or pest symptoms were discarded. The clean nuts were soaked in clean water in a basin and allowed to stay on a laboratory bench for 24 h and the nuts were then pressed out of the creamy or white coat or testa that covered the nut and washed in sterilized water. The nuts were then spread in a wide perforated wooden tray in order to drain off water. They were air dried for 48 h. Defective /infested nuts were picked out during this curing process that usually involved considerable sweating that reduced the moisture content of the nuts. The nuts were separated into two genotypes and termed coated and uncoated. The coated were those nuts which skins are covered with thin brown inner testa while uncoated had no inner testa.

Experimental design and treatment application

The storage experiment was a factorial laid out in completely randomized design (CRD) with three replications. The treatments comprised of: three different colour plastic buckets – red, green, white and three inner linings: *N. laevis* leaves, *S. mombin* leaves and Black polyethylene sheets giving a 3 × 3 × 3 treatment combinations. The *N. laevis*, *S. mombin* and Black polyethylene sheets were laid in the buckets as beddings for the kola nuts. Each bucket was labeled using a tag identifying the treatment combinations. The kola nuts were weighed and carefully put in the storage containers according to the design. Each experimental unit contained twenty (20) kola nuts (coated and/or uncoated) weighing about 0.45 kg. The storage containers were opened at intervals of 2 weeks for physical measurements while sensory analysis was conducted at the end of the storage period.

Physical measurements

The sprouts were periodically removed with a pin to slow down the emergence rate and prevent the splitting of the nuts. The duration of dormancy was determined by calculating the number of days from the start of storage to the time 50% of the nuts showed visible sign of sprout. Percentage weight loss was determined by the difference between the initial weight and successive weight loss divided by the initial weight, and multiplied by 100. These physical measurements were calculated thus: Dormancy (days) = Number of days from start of storage to the time 50% of nuts showed visible sign of sprout.

$$\text{Pest/disease symptoms (\%)} = \frac{\text{Number of nuts with symptoms earlier scored}}{\text{Original number of nuts stored}} \times 100$$

Table 1. Definitions of sensory attributes used in the qualitative descriptive analysis.

Attribute	Definition	Anchoring points
Skin blemish	Impression of black spots on the skin	None – very high
Nut firmness	Impression of loose or tight lobes	Loose – very tight
Lobe blemish	Visual observation of spots or insect burrows	None – very high
Lobe hardness	Degree of force needed to chew lobe	Soft – very hard
Nut skin colour	Visual evaluation of nut colour	Light-dark brown
Taste	Basic taste	Slightly sweet - bitter
Texture	Mouth-feel of homogeneous texture	Very fine - coarse
Overall quality	Score for general sensory impression	Low – high quality

Each attribute was assessed on 0 to 4 points hedonic scale where 0 is the lowest score and 4 the highest.

Table 2. Main effects of colour plastic storage container on the percentage weight loss, pest incidence and seed germination of coated and uncoated kola nut genotypes after 16 weeks in storage.

Container colour	Coated kola nut			Uncoated Kola nut		
	Weight loss (%)	Pest incidence (%)	Seed germination (%)	Weight loss (%)	Pest incidence (%)	Seed germination (%)
Green	23.2	16.1	55.6	15.7	16.4	22.3
Red	23.0	20.3	56.0	17.6	16.5	33.1
White	22.1	20.4	48.5	20.1	25.0	23.2
LSD $_{0.05}$	0.02	0.04	.69	0.09	0.17	0.43

$$\text{Weight loss (\%)} = \frac{\text{Difference between initial and successive weights} \times 100}{\text{Initial weight of nuts at the start of storage}}$$

Visual quality assessment was performed using a four point hedonic scale: where 1 = dull appearance, 2 = slightly bright, 3 = bright and 4 = very bright

Sensory analysis

Sensory evaluation of the nuts after storage was performed in a closed door room to avoid distraction from outside. The nine member panel of judges was selected from the University communities based on their experiences in the use and application of kola nut in various functions. For the evaluation proper, the quantitative descriptive analysis (QDA) was applied. At the first part of QDA procedure, 'brainstorming' sessions were run to select attributes for the stored kola nuts. It was a group action and an interactive session among the judges. The set of 7 quality attributes and overall sensory quality were selected (Table 1). The second part was individual assessment by each of the judges. The samples of the kola nuts genotypes (coated and uncoated) were placed on to uniform sized milky coloured saucers and served to the judges in a manner kola nut is served in occasions and gatherings. Each assessor was given randomized samples. The sitting arrangement of the assessors was such that there were no communications between or among the assessors. The assessment protocols were performed according to Eze et al. (2012) method.

Statistical data analysis

For the variance analysis, the general liner model (GLM) of the Statistical Analysis Software, SAS procedure (SAS, 1999), was used. Least significant Difference (LSD) test was used to determine which mean differed significantly at the P ≤ 0.50 probability level. The degree/intensity of each quality attribute score was determined in a polar plot using Excel chart wizard.

RESULTS

The colour of plastic storage container did not affect weight loss in coated kola nut but significantly (P≤0.05) influenced pest infestation and seed germination. The rate of development and emergence of the adult weevil greatly reduced in red plastic container (Table 2). White and green plastic container significantly (P≤ 0.05) increased weight loss and rate of seed germination in both coated and uncoated kola nut compared with red plastic bucket container. Genotype significantly (P≤ 0.05) reduced weight loss, pest infestation and seed germination in coated kola compared to uncoated.

Black polyethylene sheet as inner-ling of the storage container significantly (P≤ 0.05) reduced weight loss and pest infestation in coated kola nut (Table 3). Similarly, fresh leaves of *N. leavis* and *S. mombin* significantly reduced weight loss and pest incidence in both coated and uncoated kola nuts compared to polyethylene sheet.

The interaction of inner-lining and container colour was significant (P≤ 0.05) where *S. mombin* leaves were inner-lining material in green plastic bucket for both coated and uncoated kola nut genotypes (Table 4). On the average,

Table 3. Main effects of inner-lining of the storage container on percentage weight loss, pest incidence and seed germination of coated and uncoated kola nut genotype after 16 weeks in storage.

Inner-lining material	Coated kola nut			Uncoated kola nut		
	Weight loss (%)	Pest incidence (%)	Seed germination (%)	Weight loss (%)	Pest incidence (%)	Seed germination (%)
Polyethylene sheet	15.8	21.4	55.6	14.7	18.4	24.3
Spondias mombin	21.3	19.4	56.7	16.6	17.2	31.1
Newbodias leavis	21.7	16.2	46.5	19.1	23.2	22.2
$LSD_{0.05}$	0.18	0.25	0.53	0.10	0.19	0.55

Table 4. Effect of container colour and inner-lining material interaction on visual quality (Physical appearance) of coated and uncoated kola nut genotype sixteen weeks after storage.

Container colour	Coated kola nut			Uncoated kola nut			
	Inner-lining material			Inner-lining material			
	S. mombin	*N. leavis*	Polyethelene sheet	*S. mombin*	*N. leavis*	Polyethelene sheet	Mean
Green	4.0	3.6	2.3	3.0	2.6	2.2	2.95
Red	3.2	2.5	2.2	2.4	2.1	1.8	2.37
White	2.3	2.4	2.1	2.6	1.9	2.0	2.22
Mean	3.1	2.8	2.2	3.0	2.1	2.0	2.25

LSD 0.05 for comparing any 2 container colour means = 0.14, LSD 0.05 for comparing any 2 inner-lining material means = 0.19, LSD 0.05 for comparing any 2 container colour x lining material means = 0.25

S. mombin consistently maintained the best physical appearance across all the variable container colours for both coated and uncoated kola nuts followed by *N. leavis* leaves. Similarly, colour of the plastic container was important in keeping quality of kola nuts. Kola nut stored in green plastic container significantly (P≤ 0.05) showed better physical appearance than what were obtained in the other container colours.

Results of the experiment showed that the short term storage in those conditions significantly (P≤ 0.05) affected some of the quality attributes of kola nuts. Generally, changes in quality characteristics appeared mostly in the uncoated kola nut genotypes compared with the coated. Laying black polyethylene sheet inside plastic bucket appeared to have increased blemishes on both lobe and whole nut firmness, and also reduced taste, texture and overall quality attributes of the stored coated kola nuts genotype after sixteen weeks of storage (Figure 1). After storage, uncoated kola nut genotype had low rating taste, (slightly bitter), some spots on the skin and loose lobes under this storage condition. The overall quality of coated kola nut genotype stored under this condition was generally higher than the uncoated by rating in all the attributes.

Using *N. laevis* leaves as inner-lining or beddings inside plastic bucket irrespective of the colour of the bucket for storage affected the sensory qualities of Kola nut genotypes (Figure 2). There were lower blemishes on coated kola nut genotype whereas ratings for taste, skin colour and firmness were higher than the uncoated kola nuts. The overall quality was also rated highest among the attributes in coated kola nut. Similarly, application of *S. mombin* leaves as inner-lining for storage of kola nut improved the sensory quality of kola nut (Figure 3). Nut firmness, skin colour, taste and texture of coated kola nut rated higher that the uncoated. The overall quality rating for coated kola was also higher than for the uncoated. The coated Kola nut genotype were stored better than the uncoated with respect to physical appearance after 16 weeks of storage (Plate i). Using fresh leaves of *S. mombin* and *N. leavis* as inner-lining in the storage containers protected the kola nuts better than polyethylene sheets (Plates ii). The kola nuts stored in black polyethylene lined plastic buckets showed symptoms of heat borne after 16 weeks of storage as shown in Plate iii.

DISCUSSION

Kola is yet to be granted a full export status by the Federal Government of Nigeria, unlike cocoa, coffee, cashew, palm kernel and others, which enjoy favourable market prices in the international markets probably due to

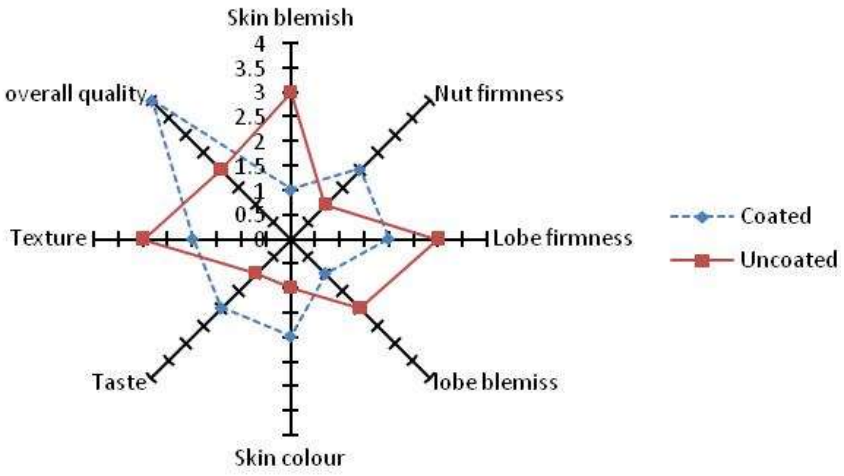

Figure 1. Sensory quality profile of kola nut stored in black polyethylene lined plastic bucket.

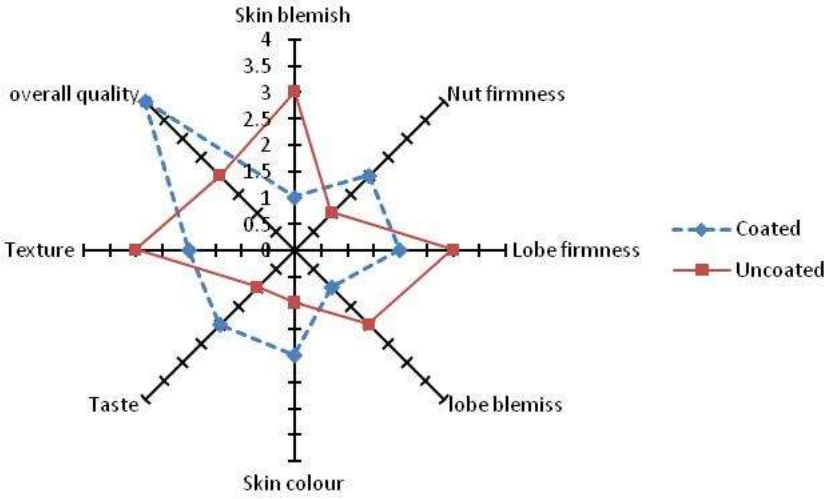

Figure 2. Sensory quality profile of kola nut stored in *Newbouldia laevis* leaves lined plastic bucket.

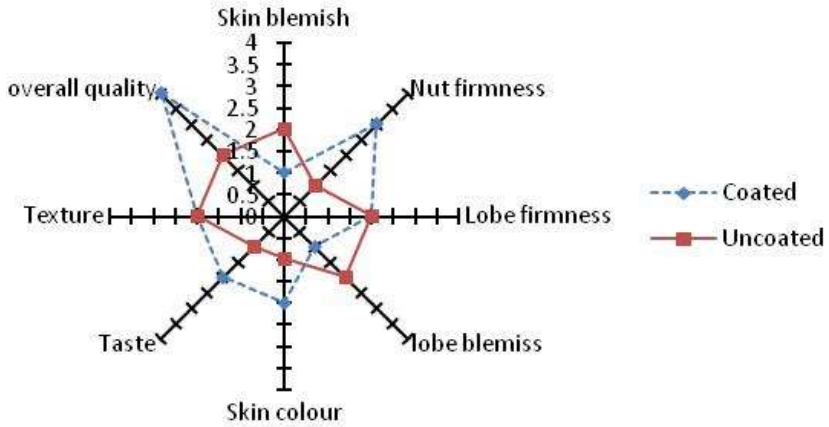

Figure 3. Sensory quality profile of kola nut stored in *Spondias mombin* leaves lined plastic bucket.

Plate i. Physical appearance of coated kola nut irrespective of the type of storage container six weeks after storage (original).

Plate ii. Physical appearance of uncoated kolanut stored with fresh *Newbouldia laevis* leaves six weeks after storage (original)

Plate iii. Physical appearance of uncoated kolanut stored in polyethylene sheet sixteen weeks after storage (original).

non-availability of kola nut all the year round. This is probably because Kola nut in the storage are attacked by storage pests which are usually controlled by application of synthetic pesticides by rural processors. It is evident in this study that cheap, harmless and local materials are good alternatives to synthetic pesticides in kola preservation. Except for industrial uses of kola nut, it is consumed raw and the application of synthetic pesticides for preservation would always pose health risks on the consumers and environment (Alexandratos, 2000).

In this study, application of *N. laevis* and green plastic storage container effectively reduced losses of kola nut in storage. This result suggests that storage environment with or without external storage treatment has important role in the activities of kola weevil, a notorious pest of kola nuts in southeastern Nigeria. This approach can be quite practical and preferable over other methods such as fumigation which lose effectiveness after some time, leaving the stored commodity vulnerable to re-infestation (Singh, 2000). The kola weevils are said to be field to store pest as their infestation is usually initiated in the field and persists in storage (Daramola, and Ivbijaro, 1999).

The use of white plastic storage container appeared to have attracted more weevils and also increased seed germination. The high incidence of weevil pest in kola nut inside white plastic storage container could be related to refraction of infrared light through the transparent plastic container. However, the frequency of shoot emergence in green plastic container treated with *S. mombin* could be due to the high water content of the fresh leaves in the presence of air thereby creating necessary conditions for seed germination and shoot emergence. Weight loss significantly reduced in black polyethylene sheet especially with the coated kola nut genotype. Similar studies carried out by Korie, (2000) on the effect of packaging materials on *C. nitida*, confirmed the keeping ability of polyethylene sheet over other materials. Korie (2000) noted that kola nuts stored in polyethylene sheet rated first, followed closely by those stored in botanicals in terms of firmness, freshness and crunchiness during chewing. Result for this experiment rated *N. laevis* first, followed by storage with black polyethylene sheet and *S. mombin*.

Organoleptic assessment of kola nut after 16 weeks of storage revealed that uncoated kola nuts stored in green bucket inner-lined with black polyethylene sheet had low rating taste (slightly bitter), high blemishes and dark spots on the skin. This poor physical appearance and change in taste could be related to heat buildup inside black polyethylene sheet which probably affected the sensory quality particularly visual appearance. Wills et al. (1998) in their study of fruit storage life noted that storage environment was probably the most important factor affecting the development of their post-harvest quality. Again, Baiyeri (2001) reported that environmental variables that impact the green-life, in plantain, rate of weight loss, and development of postharvest diseases are the storage temperature and humidity. It was evident in this study that colour of storage container played a significant role in the postharvest behavior of kola nut in storage. This was probably due to differences in light intensity transmitted by the different colours of the storage containers. Variability in the intensity of light transmitted could also account for heat buildup in the different storage containers. There are empirical facts that different colours reflect different wave lengths of light with consequent effects on physiological behaviuor of plant. White plastic container in this study enhanced activities of kola weevils probably because of refraction of infra red light wave lengths. In contrast to our finding, Brown et al. (1989) reported a reduction of fungi virulence using black polyethylene mulch. The heat borne observed on the skins of kola nut stored in black polyethylene lined bucket could be attributed to retained heat in the container. Similarly, application of coloured plastic mulches in vegetable crops production systems have resulted in both plant and pest responses.

Conclusions

Post-harvest losses arising from the rural processing and storage method of kola nut is a major problem limiting its availability at affordable prices all the year round in Nigeria.

Evidence from this study showed that modified atmosphere storage of kola nut using botanical leaves, significantly enhanced the postharvest and culinary qualities of the nuts when compared with the polyethylene (which represent the modern storage system). Nut weight loss and rate of skin changes were higher in polyethylene sheet sample than in those nuts stored inside *S. mombin* or *N. leavis*. After sixteen weeks of storage, nuts stored in green plastic bucket were better in physical appearance and culinary quality than those stored in red or white buckets. Coated kola nut genotype keeps better than the uncoated kola nut. It is therefore, recommended that kola nut processors should use fresh leaves of botanicals in long term storage of kola nut while polyethylene may be used for short term storage. Plant breeders are also advised to develop more of coated kola nut genotype on the basis of its good post-harvest characteristics compared with the uncoated.

Conflict of interests

The authors did not declare any conflict of interest.

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