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# Effect of Processing and Packaging Materials on the Storability and Microorganisms Associated with *Garcinia kola* (Bitter kola)

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**Abstract:** The study on the effect of processing and packaging materials on the storability of *Garcinia kola*, Heckel, harvested from a local farm at Ngokpola was carried out in the green house of Federal University of Technology Owerri. It was laid out in a two factor factorial using Randomized Complete Block Design (RCBD) with 12 treatments and was replicated 5 times. The pods were processed by three different processing methods, which are, cut fresh pods immediately it was harvested, kept the pods outside on a shade and allowed to decay for one week and soaked the pods in water and allowed to ferment for 1 week. It was observed that the pods kept outside on the ground and those soaked in water were significantly different at 5% level of probability. The seeds extracted from the different processing methods were stored and packaged in polythene bag, dry plantain leaves and cocoyam leaves then control. It was found that polythene bag retained moisture than others. Alkaloid has high phyto-chemical content in the seeds that was processed by keeping the pods outside on a ground and allowed to decay and packaged in cocoyam leaves, which might be as a result of the processing method and packaging materials used. The seeds contain Saponin, Cyanide, Tannin and Ash which makes it to be an anti-oxidant and anti-nutrient. The pathogens isolated from the seeds are *Aspergillus sp*, *Penicillium sp* and *Diplodia sp*, affect stored seeds. The respondents from the 60 questionnaires administered to people in 3 different zones in Imo state, showed that 60% of the pods are harvested when fallen pods are picked, 30% harvest when someone climbed the tree and pluck it with hand, 10% when the fruits are plucked with sticks while the harvester is on the ground. 80% processed the fruits by keeping it outside on the ground and allowed to decay and 20% cut the fresh pods immediately it was harvested. Based on the findings, I recommend that farmers and marketers should engage in good processing method and packaging materials such as the ones used in this work for preservation.

**Keywords:** Processing, Packaging, Storability, Microorganisms, *Garcinia kola*

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## 1. Introduction

The seed of *Garcinia kola* Heckel is commonly called bitter kola in Nigeria, Aki ilu in Ibo, Orogbo in Yoruba and Namijiu goro in Hausa. According to (14), it is an indigenous medicinal tree belonging to the family of Clusiaceae formerly Guttiferae. It is mostly found in Central and Western Africa. As a tropical fruit tree species, it is characterized by slow rate of growth. It grows as a medium sized tree up to 12m high

and 1.5m wide. According to (3), it has been shown to possess a caloric value of 35.8kcal/g. The fruits are normally harvested from July - October. A mature fruit tree produces 85 to 1,717 fruits, with 208 to 6,112 annually, having mean values of 834 fruits and 2,627 nuts per tree. It produces 26 tones/ha/annum, with 278 trees/ha at 6m×6m spacing. The fruit is reddish-yellow and seeds contain 10% carbohydrates, 5% crude protein and >10% crude fats and sodium 215.10ppm (Seed Information Data Base, 2004). The fruit is about 6.25cm in diameter and each fruit contains two to four

brown seeds embedded in an orange coloured pulp (18).

Factors that have discourage farmers from growing *Garcinia kola* include difficulties encountered in attempting to raise seedlings in nurseries and long gestation period before flowering and fruiting. However, many of the germination difficulties have been overcome by methods developed by (23) and (16). The extracts from seed and dry powered seeds have been made into various forms, such as tablets, cream and tooth paste. *Garcinia kola* was initially consumed as a stimulant before the remarkable bioactivities were explored. The stems and twigs of the plants are used as chewing sticks in many parts of Africa. It has been commercialized for years in major cities and has offered natural dental care to human (28).

Traditionally, bitter kola holds a high position among all the Nigerian tribes, particularly the Yoruba and Ibo communities. The Yoruba use bitter kola as an important component of the material used in traditional naming and marriage ceremonies while the Ibos use it in their traditional 'Fetish' recipes. Traditional herbalists use bitter kola in various pharmacopoeia preparations for various ailments. *Garcinia kola* biflavones used in traditional Africa system of medicine have been found to be active against a wide variety of micro-organisms. The seeds are used as stimulant and to cure cough (30).

(26) stated that *Garcinia kola* seeds are used as extractive in dietary food supplement while FDA, (13) reported that they are used as flavor enhancer in the beverage industry and also as hop substitute in several indigenous alcoholic drinks. Medicinally, the seeds are used as antidote for *Strophantus gratus* infection. The seeds are used for the treatment of bronchitis throat infections, antipurgative and antiparasitic (21). Other known uses include guinea worm remedy, anti-atherogenic effects and anti-lipoperoxative effects (1).

According to (15) *Garcinia kola* is known to exhibit a complex mixture of phonetic compounds including possess' anti-inflammatory, anti-microbial, anti-diabetic and anti-viral properties. The indigenous practices used by farmers to protect the species include selective clearing, during land preparation for cropping sustainable bark, harvesting of stands in wild populations and recognition of individual property ownership on certain wild of the tree.

Traditionally, *Garcinia kola* is harvested by post-harvest methods, which are a deliberate action used to separate food stuff from its medium, ripping cereals, picking fruits and all succeeding actions at the farm. Post harvest period begins at the separation of food stuff item) from the medium of immediate growth or production. Fruits become post harvest after it has been picked, but fruits that falls from the tree and allowed to decay or rot on the ground, is not a post harvest losses because, it was never harvested. Farm should be kept in a state of good sanitation by removing and destroying fallen fruits which are infested by fruit fly larvae.

In developing countries, processing is one of the main problems of agricultural produce. Unfortunately, much of agricultural resources are wasted because of short shelf life of the fruits after harvest. Since over 85% of fruits are

harvested during fruiting season. (11), report that, there is a glut during the period of harvesting. The major consideration is how to ensure stable supply of agricultural produce all the year round.

Processing and sale of bitter kola is largely a family base home industry by which when the product is harvested at sustainable levels, has little negative impacts on the mother tree. Because of high demand of seeds in Nigeria, processing of bitter kola pulp should be effective so that, the seeds will be available in the market and for industry production.

According to some rural farmers, bitter kola are process faster by cutting it without ferment or soften which often results to physical damage of seeds and disease infestation. Soaked pulps leads to the improvement in seed quality but often result to micro-organisms that has well defined or potential commercial value.

When fruit ripe, the green pericarp turns a reddish yellow color and the fruit falls from the tree. The fallen fruits are collected and kept in an open, cool place till the pericarp and the pulpy mesocarp become soft. Once softened, the fruits are threshed to release the seeds which are thoroughly washed to remove the sticky mucilaginous materials that sheath the seed. According to (20), processing of bitter kola for international market is always required in two forms, which are fresh or dried. But most importers always want them dried. The drying must be done in a way that the colour is not affected.

(17) observed that packaging materials (leaves) which do not affect the colour, crispiness and marketable quality are *Dorax sp*, *Alchornea laxiflora* (Esin), are used to preserve bitter kola by placing the leaves inside a nylon which is wrapped within the bitter kola in a container. *Costus lucanisianus* is also used to preserve and package bitter kola and *Spondia Mombin* (Iyeye). *Garcinia kola* seeds do not exhibit orthodox storage behavior and should be treated as carefully as recalcitrant seeds. Because of the moisture content of the fleshy fruits harvested, the seeds should be stored properly and with good storage materials in a short time. If the seeds are to be stored in a moist condition, it is vital that the store areas are ventilated frequently. Most of the raw materials from tree crops get rotten during storage because they were not properly processed. This leads to wastage of the resources and time spent in collection.

Traditionally, bitter kola is stored in layers of red clay soil (22). But in ancient days, harvested bitter kola was stored in a pit dug inside the soil. The seeds are packed into the pit and later covered with soil till when the farmer needs them either for utilization or commercial purpose. For crops that do not produce seeds all the year round, it is important that the products are stored to make them available whenever needed. Many products are wasted during peak harvest and glut due to shelf-life of the seeds. Therefore, effective and adequate storage will ensure that the seeds consumed are of good quality. It reduces the usual wastage and loss of crops that are already produced due to poor processing and harvesting. It also ensures availability of raw materials to agro-based industries.

Pests and diseases attack *Garcinia kola* seed and pod by reducing its quality, market value and nutrient. The pests affect the seeds through piercing and sucking and method. They affect the pod when it is harvested late or when there are wounds or bruises on the pod. They cause microbial deterioration of the fruits when the fruits are not properly harvested: such as when the fallen fruits are left till when it rots or fly larvae affects it; then it will cause soil borne pathogenic fungi.

Some pests that affect bitter kola are:

- (i) Weevils: This is the major pest of kola which affects the fruit and the seed either during harvesting or storage. Examples of weevils include: *Sphororhinus divareti*, *S. quadricristatus*, *S. simiarum*, *Balanogastric kolae*, etc. The weevil penetrates through wound or damaged fruits. They lay eggs in the seeds. The weevil attack cause serious losses up to 50-70% (31). The weevils are controlled by removing the initial attack and thorough inspection of the seeds then removal of all infested seeds before storage.
- (ii) *Carattitis kolae*: This pest attacks the kola in the mature stage. It causes burrowing which create hole easy for penetration of weevils.
- (iii) Aphids (*Pseudococcus citra*)
- (iv) Scale insects (*Planococcoides njalesis*)

Diseases of *Garcinia kola* are:

- a) Fungal root (*Fusarium* sp): These disease attacks the plants suddenly on the leaves. It leads to plant death. The roots of the plants are covered with brown rhizomorphs and fruiting bodies may be formed at the base of the trunk. These diseases can be prevented and controlled by removing the logs, stumps and roots of the infected ones.
- b) Leaf spot disease: They attack only immature leaves, mainly on the later part of the rainy season. The symptoms are brown angular spots, especially on the tips of the leaf, bushy appearance of the plant. The fungus responsible is the *Pestolatia* sp and *Glomerella* sp.
- c) *Penicillin* spp, *Diplodia macnopyrens*, *Fusarium moniliform* var *Subblutinans*, *Fusarium solani*, etc are fungi disease resulting from fruit and nut.

*Fusarium* spp and *Penicillin* spp are common infection of nuts which can be prevented when the nuts are allowed to attain their restive stage and transpiration prior to storage.

The major chemical elements found in bitter kola are potassium and phosphorus. The seed has significant higher values for sodium, potassium, copper and cobalt. Due to the activity of flavonoids and other bioactive chemical compounds, they are used in folk medicine, therapeutic benefits (16), (27) and (29).

*Garcinia kola* is a non-timber forest that is mostly utilized in Africa (2). Virtually all the parts can be used for medicinal purposes. The fruit is used in the treatment of jaundice; the extract can prevent Ebola virus from replicating itself (8). The extract from the bark, stem and seed inhibit the growth of *Plasmodium falciparum* according to (33).

The seed is used in the treatment of bronchitis and throat infection, catarrh, abdominal, colicky pain, improving singing voice etc. When mixed with honey, it reduces and makes a cough syrup and they are highly medicinal (5). The split, stems and twigs are used as chewing stick in many parts of Africa, which offers dental care. The seed is believed to expel snake where they are kept. It posses aphrodisiac and purgative properties and has shown great potential as substitute for hop in tropical beer brewing (7).

Bitter kola holds a high position of cultural importance among all the Nigerian tribes and it has shown anti-inflammatory, anti-microbial and antiviral properties and posses anti-diabetic and anti-hepatotoxic activities and it is an effective plant that derived medicine alternative to synthetic drugs (6).

The objectives of this study are:

To determine different processing method of *Garcinia kola* in Imo State using questionnaire, to isolate and identify pathogen that affect *Garcinia kola* during storage, to identify the phyto-chemicals present in *Garcinia kola* using quantitative analysis and to determine the effect of processing on the storability of *Garcinia kola*.

## 2. Materials and Methods

The experiments were conducted to determine the best method *Garcinia kola* can be processed and packaged so as to extend its shelf life. The study was carried out in the laboratory of Federal University of Technology, Owerri, Nigeria under room temperature and relative humidity in the green house for a period of one week for processing and five weeks for storage and packaging. Fresh samples of *Garcinia kola* pulps harvested from a local farm at Ngokpola in Imo state were processed in three different ways:

- (i) The pulps were cut immediately as it was fresh. The seeds were extracted from the pod and stored for five weeks in different baskets, using 3 packaging materials and control was also set up.
- (ii) The pods were kept outside under a shaded and cool area. It was allowed to decay and soften for a week, before extracting the seeds and stored for five weeks, using different packaging methods and baskets with control as well.
- (iii) The pods were soaked in water for a week for it to ferment, then the seeds were extracted from the pulps and stored for five weeks using different packaging such as dry plantain leaves, dry cocoyam leaves, polythene bag and control (on package) was also set up.

The following was done during storage:

- a) The initial weight of the pods was taken before processing.
- b) The weight loss of the seeds was taken as they were processed and stored.
- c) The pathogens associated with the seeds were identified.
- d) The pyhto-chemical content of the seeds and pods

were also determined.

e) The percentage ash content was determined.

All equipments used in this project work were carefully sterilized. The Petri dishes were washed with distilled water and packed into a round metal box and put in the autoclave set at 121°C for 15 minutes. The inoculating needle used was sterilized by dipping it in a lacto phenol. The Petri dishes were taken to the fume chamber (autoclave), and allowed to stay for 15 minutes. They were allowed to cool and the medium was poured into them.

### 2.1. Preparation of the Medium

The medium used for this experiment was Potato Dextrose Agar (PDA). 125g of Irish potatoes was weighted against 500ml of water. It was washed with distilled water, then peeled and chopped into tiny pieces and then boiled for 30 minutes in a 1000ml beaker. The Irish potatoes were filtered using muslin cloth into a conical flask. 10g of glucose and 10g of agar were added into the supernatant and shake thoroughly for it to completely dissolve to a homogenous mixture. The supernatant in the conical flask was corked with cotton wool and wrapped with aluminum foil to avoid evaporation. The medium was heated for 20 minutes and allowed to cool for 40 minutes before pouring it into the sterilized Petri dishes.

### 2.2. Isolation and Inoculation of Pathogen

A small portion of sample from each treatment was cut and put into the Petri dishes (different) containing the medium, with an inoculating needle. The Petri dishes were carefully labeled and put into transparent polythene bags to avoid contamination, and put in an incubator (all these processes were carried out in an inoculating chamber) and allowed to stay for two days. Sub-culturing was done till pure culture was obtained. Different micro-organisms were isolated. The various isolates were assigned to their various genera using the illustrated genera of imperfect fungi manual (9). This was done by comparing characteristics of the isolates with those identified species.

### 2.3. Examination of Cultured Medium

A drop of lactic acid was placed at the center of a clean grease free microscope slide. A bit of the fungal organism was dropped on the slide with the aid of with the inoculating needle on a slide The slide was viewed under a super Tek microscope with 60 magnifications, under low light intensity. The associated micro-organisms were observed, drawn and identified. The entire microscopic colony were noted and differentiated.

### 2.4. Determination of Phyto-Chemicals

Four Phyto-chemicals were determined using quantitative analysis from different processed sample and pulp. They include:

a) Tannin: 1.0g of sample from each processed treatment and pulp was weighed and put into a conical flask that

contains 50ml of water which was used to dissolve the sample. It was filtered through no 44 Whatman filter paper into a 100ml volumetric flask. It was pipette with 50ml of distilled water and 10ml of diluted extract into a conical flask, followed by 5.0ml follin-Denins reagent and 10ml of saturated Na<sub>2</sub>CO<sub>3</sub> solution, and then it was diluted with distilled water to a volume.

The tannic acid was calculated, using the formula

$$\text{Tannic acid (mg/100g)} = \frac{C \times \text{extract volume} \times 100}{\text{Aliquot} \times \text{weight of sample}}$$

Where C = concentration of tannic acid

b) Alkaloids: 2.0g of sample from each processed treatment and pulp was weighed into a conical flask that contains 10% acetic acid. The weight of the filter paper was recorded before it was use to filter the supernatant, after ammonium has been add. The weight of the filter paper was recorded, after oven drying.

Percentage alkaloids were determined using the method of (24).

c) Cyanide: 1.0g of sample from each processed and pulp was weighed and grind. The sample was put into conical flask of 100ml distilled water to hydrolyze it for 1 hour. The sample was transferred into 250ml round bottom flask. 10ml of 2.5% NaOH was added and it was put in Soxhlet flask. The round bottom flask with condenser on top was mounting. 2ml of 6 molar ammonium hydroxide, 1ml of 5% potassium iodine and 25ml of the sample was titrate with 0.02 molar silver nitrate.

$$\text{Percentage cyanide} = \frac{T \times \text{Equivalent weight} \times 100 \times N}{\text{Aliquot weight of sample}}$$

Where T = Titre value and N = Normality

d) Saponin: 1.0g of each processed treatment and pulp was weighed and put into a container in an oven. It was brought out from the oven and crushed into a fine particle. The initial weight of filter paper was taken and recorded. The sample was put into a Soxlet to extract the fat, which contain petroleum spirit. It was filtered with a fresh 100ml of 20%ultra volume aqueous solution of ethanol and washed the organic layer twice and poured into a pre-weighed beaker and evaporates to dryness on a boiling water bath. It was allowed to cool and the weight was taken.

$$\text{Percentage saponin} = \frac{\text{Final weight}}{\text{Initial weight}} \times \frac{100}{1}$$

### 2.5. Determination of Ash Content

1.0g of sample from each processed treatment and control was weighed into a porcelain crucible of known weight. The crucible was place in a muffle furnace at 200°C and the temperature was gradually increased to 600°C. It incinerates for 5 hours and light grey ash was observed. It was allowed to cool in desiccators under room temperature and weigh.

Percentage ash content was calculated using the formula

$$\text{Percentage ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times \frac{100}{1}$$

## 2.6. Determination of Moisture Content

1.0g of sample from each processed treatment and control was weighed into a container of a known weight. It was put in an oven with a constant weight of 105°C for 4 hours. After drying, the sample was cooled in desiccators and re-weighed.

Percentage moisture content was calculated using % moisture = 
$$\frac{\text{Final weight}}{\text{Weight of sample before oven drying}} \times \frac{100}{1}$$

Questionnaires were administered to 20 people each in the 3 geo-political zones in Imo state, namely Okigwe, Orlu and Owerri. Within each zone, 20 people were split into 10 for packaging and processing in 3 local Government Areas. After this study, inferences were made based on package materials used; processing methods, storage, harvesting, gender, age etc and results obtained were analyzed through the use of percentage frequency. Some seeds were stored under the three different storage materials and control for five weeks. They were replicated, using weekly readings giving a total of 12 treatments in a 2 factor factorial experiment in randomized complete block design in the laboratory. The data was subjected to analysis of variance (ANOVA) at 5% probability level.

## 3. Results

From Table 1, results showed that harvesting method was statistically significant at 5% probability level. 60% of *Garcinia kola* was harvested by allowing it to fall on the ground and then picking the pulps, 30% by climbing the tree and harvesting, and 10% by plucking the fruits.

**Table 1.** Distribution of Respondents According to Harvesting and Processing Methods, Package And Storage Materials

Treatments	Frequency (%)
Harvesting Methods	
Fallen pulps that are picked	60
By climbing the tree	30
Processing Method	
Kept outside and allowed to decay.	80
Cut the pulp fresh	20
Packaging Materials	
Dry plantain leaves	25
Polythene bag	45
Cocoyam leaves	30
LSD <sub>0.05</sub>	4.725

Investigation revealed that 80% of the pulps are processed by keeping them outside on the ground and allowed to decay before extracting the seeds. They are washed and air dried in a basket, 20% for cases where the pulps are cut fresh, the mesocarp around the seeds scraped off with knife or hand and washed before drying. The result showed that 45% of the respondents use polythene bag as their packaging material, because it retains moisture and crispiness of bitter kola. 30% of the respondents use cocoyam leaves and 25% use dry plantain leaves Table 1.

Result also shows that fungal pathogens isolated from *Garcinia kola* seeds from the harvesting methods and packaging materials used were *Aspergillus sp*, *Penicillium sp*, *Diplodia sp* and *Fusarium sp* respectively and they attacked the seeds of stored products. More microorganisms were associated with the control treatments followed by those packaged with polythene bags and *Aspergillus* and *Penicillium* species were of high activity than all the other microorganisms. Also, fallen pulps that are picked and processed had higher organisms in comparison with those obtained from climbing the tree or by plucking. Table 2.

**Table 2.** Microorganisms Identified with *Garcinia kola* with Different Packaging Materials and Harvesting Methods

Different Package	Microorganisms <i>Aspergillus sp</i>	Identified <i>Penicillium sp</i>	<i>Diplodia sp</i>	<i>Fusarium sp</i>
Packaging materials	√√	√√		
Polythene bag				
Dry plantain leaves	√	√	√	
Cocoyam leaves	√			√
Control				
Harvesting methods	√√	√√	√√	√√
Method 1	√	√	√	√
Method 2	√	√		
Method 3	√	√		

KEY: Method 1 = Fallen pulps that are picked; Method 2 = By climbing the tree; Method 3 = By plucking the fruit; √ = Organism present; √√ = Organism highly present

**Table 3.** Effect of Storage Materials on Phyto-Chemical Constituents of Fresh Pods Cut Immediately At Harvest And Seeds Processed

Different Package	% Ash	% Tannin	% Alkaloids	% Cyanide	% Saponin
Polythene bag	3.375	23.01	70.08	37.53	50.78
Dry plantain leaves	2.614	23.08	70.26	37.74	50.54
Cocoyam leaves	2.961	23.10	70.32	37.61	50.72
Control	1.627	23.02	70.15	37.63	50.6

LSD<sub>0.05</sub> = 0.0125

**Table 4.** Effect of Storage Materials on Phyto-Chemical Constituents of Pods Kept on Ground Under Shade and Allowed to Decay

Different package	% Ash	%Alkaloid	%Tannin	%Cyanide	%Saponin
Polythene bag	3.264	70.36	23.13	37.33	50.53
Dry plantain leaves	2.844	70.01	23.32	37.64	50.85
Cocoyam leaves	2.585	70.58	23.09	37.55	50.70
Control	1.601	70.23	23.14	37.70	50.73

LSD<sub>0.05</sub> = 0.150

**Table 5.** Effect of Storage Materials on Phyto-Chemical Constituents of Pods Soaked In Water and Allowed to Ferment

Different package	% Ash	% Alkaloid	% Tannin	% Cyanide	%Saponin
Polythene bag	3.328	70.23	23.18	37.55	50.29
Dry plantain leaves	2.653	70.44	23.22	37.34	50.61
Cocoyam leaves	2.884	70.26	23.05	37.04	50.72
Control	1.732	70.31	23.30	37.80	50.66

LSD<sub>0.05</sub> = 0.172

Results of the phyto-chemical contents on processing methods and packaging materials revealed that the seed from pods processed by keeping outside under a shade and package with cocoyam leaves had higher Alkaloid contents of 70.58, while high ash content was obtained from pods that were processed by cutting immediately it was harvest and package with polythene bag 3.375. Table 3 – 5. Pods that was soaked in water and allowed to ferment recorded statistically significant difference on phyto-chemical constituents at 5% probability level. The ask content was lowest in controlled experiment followed by that packaged with dry plantain leaves when those with polythene bags were high. However, saponin content of control was highest, when that packaged with polythene bags were low Table 5.

The result of processing methods and packaging materials on moisture content at 5 weeks of storage shows that the pods processed by keeping outside on the ground under and allowed to decay as well as the pulp soaked in water and allowed to ferment before extracting the seeds, were statistically significant on moisture content at 5% level of probability. Table 6. The seeds packaged in polythene bag recorded highest moisture content irrespective of the processing methods, than that packaged with either cocoyam leaves or dry plantain leaves, when control was lowest. Result showed that there was a decrease in moisture value of the seeds with weeks of storage, while weeks of storage were statistically significant at 0.05 level of probability. Table 6.

**Table 6.** Means Value of Main Effect of Processing and Packaging on Moisture Content at 5 Weeks of Storage

Different processing	Polythene bag	Dry plantain leaves	Cocoyam leaves	control	Total package	Mean
Process 1	213.4	212.3	211.6	196.0	833.3	208.3
Process 2	226.8	222.7	222.5	210.9	882.9	220.7
Process 3	224.1	213.6	213.6	212.9	869.2	217.3
Total	664.3	648.6	625.7	619.8		
Mean	221.4	216.2	217.6	206.6		

LSD<sub>0.05</sub> = 0.7457

## 4. Discussion

The results obtained from the 3 different processing methods used in this project work shows that, the best ways

for processing *Gasinia kola* is to keep the pods outside on the ground for 1 week and allow it to decay before extracting the seeds and also soaked pods in water for 1 week and allow to ferment before extracting the seeds. These two processing methods are preferable because pest and diseases cannot penetrate into the seeds easily and they retain moisture.as proposed by (1).They are highly significant at 5% level of probability test. When the seeds are extracted from the pulps, it is easy to wash off the mesocarp sheaths (6). The two processing does not cause any wounds or bruises on the seeds, unlike when the pods are cut fresh, it will not be as smooth as those extract from decayed pod. The pods hat were cut fresh bring molds during storage on the seeds because the sheaths around them are not properly removed. Mean separation for blocks (weeks) using LSD at 5% level is significantly different at probability test for 5 weeks of storage.

The results of the moisture content as assessed for 5 weeks of storage shows that, the 4 different packaging materials used to store seeds extracted from the different processing used shows that those store in polythene bag, cocoyam and dry plantain leaves was highly preferable and were significantly different at 5% level of probability, the moisture content decrease within the weeks of storage. This is true because as the week progresses, the breakdown in physiological activities of the *Gasinia kola* increases and cells of cells break down and produce more accumulated fluids and water. Also microbial activities/ respiration increase and more water accumulate. (25); (10).

They act as a pigment against predator in the seed and pulp. Alkaloid, Tannin and Saponin act as an anti-nutrient which makes bitter kola to be good in treating stomach disorder and to stop vomiting. (10), (21). Cyanide is an anti-oxidant. It is poisonous in the body. It destroys cells when much of it, is in the system. It causes abortion, damage and disorder in the organ. The result does not mean that the phyto-chemical content (Alkaloid) will be high when packaged with cocoyam, because the chemical acts as a pigment against predator in the body. They impact colour to plant which enhance pollination. They act as an anti-nutrient which makes nutrients unavailable to disease infestation. These chemicals fight against any disorder in the stomach, stop vomit and used in food formulation (15) and (28). When bitter kola is eaten much, it is not good in the system due to cyanide content that act as an anti-oxidant. It is poisonous in the body and affects the male organ. Chemicals add value to the pulp, which hitherto is discarded, as a potential source of nutritionally valuable and industrial raw material (6).

The loss of viability of kola nut seeds due to reduction in moisture content is caused by poor storage materials, improper packaging and poor processing. Seeds package with cocoyam and dry plantain leaves stored well but there is a decrease in moisture within the weeks of storage.

Pathogen invades *Garcinia kola* seeds if the processing methods and packaging materials used affect the seeds. The results showed the pathogen that affect stored *G. kola* seed and they are *Penicillium sp.*, *Aspergillus sp.* and *Diplodia sp.*, irrespective of the processing method used. These pathogens

leads to quick deterioration and decrease in nutritive value of the seeds. Some pathogens invade the seeds mainly through harvesting in line with (14), (11) as well as (3).

## 5. Conclusion

The investigation of different processing of *Garcinia kola* revealed that there should be awareness and encouragement of the dealer or farmers in gender participation and to embark on simple and easily handled processing through relatively simple and available method, to reduce injuries on the seeds, add value and improve quality of the processed seeds. Farmer/marketers of bitter kola should adopt use of good packaging materials, storage and other management, which will improve the shelf life of *Garcinia kola* seeds and ensure moisture retention and long preservation of seeds. Phytochemical adds nutritional and medicinal value to the seed and pulp and make them a potential source of nutritionally valuable nutrients and industrial raw materials.

Pods processed when they are kept outside on the ground and those soaked in water gave the best quality produce, while seeds packaged with dry plantain and cocoyam leaves produce well and retained moisture seeds of high quality, better shelf life and low associated microorganisms.

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