



*Full Length Research Paper*

# Evaluation of the effect of storage time and temperature on some physicochemical properties of juice and jam developed from two varieties of monkey kola (*Cola parchycarpa*, *Cola lepidota*)

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## ABSTRACT

This study was aimed at evaluating the effect of storage time and temperature on some physicochemical properties of juice and jam developed from two varieties of monkey kola (*Cola parchycarpa*, *Cola lepidota*). Two varieties of monkey kola (white and yellow) were purchased from Umuahia Main Market Abia State Nigeria from five randomly selected vendors and pooled to obtain the samples for the jam and juice production. The pH, total solid, soluble solid, titratable acidity, and total plate counts varied with storage time and temperature; the parameters studied were more stable in samples stored at refrigeration temperature (12°C) than those stored at ambient temperature (29-32°C). There was no significant change in specific gravity throughout storage period. Under ambient storage at week 4 *C.parchycarpa* jam had the least total plate count (42.5Cfu/g). Under refrigeration (12°C) *Cola lepidota* jam had the least (22.5Cfu/g) plate. *C.parchycarpa* juice was more stable than *Cola lepidota* juice at both ambient and refrigeration temperatures. From the result of this study, it can be concluded that the shelf-life of the products (jam and juice) can be extended by storing them in the refrigerator. Further investigation on how to keep the products longer is however recommended.

**Keywords:** monkey kola, stability, physicochemical, microbial load, juice, jams

## INTRODUCTION

Fruits are an important component of a healthy diet; however, they are highly perishable and as a result large quantities are lost post harvest. Improper handling, packaging, storage and poor post harvest management cause producers and traders in Pakistan 20-30% loss of this important commodity (Tahir *et al.*, 2002). In Nigeria, 40% of food losses occur at post-harvest and processing levels of the food chain (CTA, 2012). Processing plays important role in the conservation and better utilization of fruits and vegetables; it also ensures fair returns to

growers to improve their economic condition which in turn help to mitigate the problem of under-employment during off-seasons in the agricultural sectors (Vidhya and Narain, 2010). Monkey kola is a fruit of the family of *sterculiaceae* and belongs to a group called drupes (Pamplona-Roger, 2008). It is made up of three varieties: red (*Cola latertia*), yellow (*Cola parchycarpa*) and white (*Cola lepidota*) (Singh *et al.*, .2010). The pod of the yellow variety is roundish, while the white variety has more cylindrical shape. Monkey kola is identified by



**Monkey Kola (Yellow variety)**



**Monkey Kola (White variety)**

**Figure 1.** Pictorial image of the *Cola parchycarpa* (yellow) and *Cola lepidota* (white) varieties.

various local names in Southern Nigeria (“achicha” or “ohiricha” in Igbo and “ndiyah” in Efik). It is used as famine food in some parts of Africa. Monkey kola is rich in micronutrients (Ene-Obong *et al.*, 2014) and also has some health benefits (Singh *et al.*, 2010). The seed of monkey kola is not edible, but the waxy pulp is relished by people due to its sugary taste. The fruit is cultivated throughout the tropical regions of the world; it is commonly found in Southern Nigeria between the months of June to November (Ogbu *et al.*, 2007). In Nigeria monkey kola is mostly consumed fresh and like most fruits and vegetables it has a very short life span probably due to its high moisture content. To conserve it throughout the year monkey kola can be processed into products like juice and jam (Umeh and Nwadialu, 2010; Okudu and Ene-Obong, 2015). Quality parameters of fruit products, such as color, acidity, soluble solids, texture, pH, total acidity among others are usually affected by processing and storage (Wicklund *et al.*, 2005; Kviliene *et al.*, 2006). Storage temperature is the prime limiting factor for shelf life of most of products developed from fruits. Studies have been done on the development, pasteurization, nutrition, antioxidant content and activities of monkey kola jam and juice (Ene-Obong, 2015; Okudu *et al.*, 2015); however, there is no report on the effect of storage time and temperature on the physicochemical and microbiological properties of jam and juice produced from monkey kola. This work is therefore designed to investigate the storage stability of monkey kola jam and

juice at ambient (29-32°C) and refrigeration temperature (12°C) for a period of four weeks.

## MATERIALS AND METHODS

### Source of materials/ selection of fruits

Two varieties of monkey kola (white and yellow) were purchased from Umuahia Main Market Abia State Nigeria from five randomly selected vendors and pooled to obtain the samples for the jam and juice production. Mature and undamaged fruits were selected for the production of jam. Sorting was done by hand and any fruit that was moldy was removed. Grading of fruits was done based on firmness, size, maturity, colour, shape and freedom from foreign matters, insect damage or mechanical injury. The fruits were washed using potable water. The fruits were open longitudinally with a sharp kitchen knife to remove the seeds. The pulp was placed in water containing lemon juice (250ml lemon juice per liter of water) to stop them from browning.

### Preparation of jam

A modified method as described by Adepoju *et al.* (2010) was used to prepare the jam. Grating was done manually using kitchen grater. Kenwood kitchen blender



**Figure 2.** Pictorial image of the *Cola parchycarpa* (yellow) and *Cola lepidota* (white) products (juice and jam).

(Model KMC 500) was used to blend and homogenize the pulp. To 500g of the pulp were added 500g of sugar and 250ml of water. Twenty (20) ml of lemon juice and a pinch of salt were also added to enhance gel formation, improve colour and flavor of the jam. The mixture was left at room temperature for 45 minutes and then cooked slowly with occasional stirring for twenty (20) minutes. The cooked jam was poured into a sterilized bottle and allowed to cool at room temperature (29-32°C).

### Preparation of juice

Juice preparation as described by 'the wonder of carrot juice (The wander of carrot juice. 2013) was adopted for the preparation of juice. Six hundred (600) g of monkey kola (pulp) was cut into sizes of about ½ cm and placed in an electric blender; one cupful of the pulp was placed in blender at a time until the blender was ¾ ways filled. Twenty milliliter of water was added to the monkey kola in the blender for each blend. A total of 100 ml of water was

used for blending. The monkey kola was blended into a smooth pulp. The pulp was removed and poured into a large mixing bowl. Two hundred and fifty (250) ml of water was added to the pulp. A clean muslin cloth was used to filter the pulp. The monkey kola juice was drained into another container through a clean muslin cloth so as to stop any unblended pulp from getting into the final product. Twenty five grams of sugar was added. The juices were pasteurized at 70°C for 20 minutes.

### Shelf-life study

Aqueous solution from the jam was prepared as described by Vidhya and Narain (2010), by weighing about 25g of the sample and dissolving it in 200ml of potable water. The aqueous solution was kept in a boiling water bath for 1hour. The sample was allowed to cool and diluted to 250ml with distilled water. The sample was filtered using a muslin cloth. Physicochemical test was carried out on the filtrate. The products (jam and juice)

**Table 1.** The effect of storage temperature and time on the pH of monkey kola products (juice and jam)

Storage Time	CPJm 29-32°C	CPJm 12°C	CLJm 29-32°C	CLJm 12°C	CPJu 29-32°C	CPJu 12°C	CLJu 29-32°C	CLJu 12°C
Week 0	4.5± 0.1 <sup>a</sup>	4.5±0.1 <sup>a</sup>	4.5± 0.1 <sup>a</sup>	4.5±0.7 <sup>a</sup>	4.2± 0.7 <sup>a</sup>	4.2 ±0.7 <sup>a</sup>	3.9± 0.7 <sup>a</sup>	3.9± 0.7 <sup>a</sup>
Week 1	3.8± 0.1 <sup>b</sup>	4.5±0.1 <sup>a</sup>	3.8 ±0.1 <sup>b</sup>	4.4 ±0.7 <sup>a</sup>	4.2 ±0.1 <sup>a</sup>	4.2 ±0.1 <sup>a</sup>	3.9 ±0.7 <sup>a</sup>	3.9 ±0.1 <sup>a</sup>
Week 2	3.4 ±0.1 <sup>c</sup>	4.4 ±0.1 <sup>a</sup>	2.9 ±0.0 <sup>c</sup>	4.4 ±0.7 <sup>a</sup>	3.9 ±0.1 <sup>ab</sup>	4.2 ±0.1 <sup>a</sup>	2.9 ±0.2 <sup>b</sup>	3.9 ±0.7 <sup>a</sup>
Week 3	3.0 ±0.4 <sup>d</sup>	4.2±0.2 <sup>a</sup>	2.7± 0.3 <sup>c</sup>	4.1 ±0.1 <sup>b</sup>	3.2 ±0.4 <sup>d</sup>	3.7±0.7 <sup>b</sup>	2.8 ±0.3 <sup>b</sup>	3.8 ±0.1 <sup>b</sup>
Week 4	2.3 ±0.1 <sup>e</sup>	3.2±0.1 <sup>b</sup>	2.3± 0.2 <sup>cd</sup>	3.8±0.7 <sup>c</sup>	3.0 ±0.1 <sup>b</sup>	3.2± 0.2 <sup>c</sup>	2.4 ±0.4 <sup>c</sup>	3.6±0.1 <sup>c</sup>

Means with different superscripts along the same row are statistically different from each other ( $P < 0.05$ ). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature - 29 - 32°C; Refrigeration temperature -12°C.

were pasteurized at 60°C for 15 minutes in a water bath. Each of the products was divided into two equal parts using sterile containers. One part was stored in the refrigerator in sterile tight covered sample bottles while the second portions were stored at room temperature (30±2°C). Storage was done for a period of four (4) weeks in order to determine the effect of storage time and temperature on the qualities (pH, specific gravity, soluble solids, and total solid, titratable acidity and microbial load) of the products.

### pH Determination

The pH was measured using pH meter (Jenway, 3310). Ten (10) milliliters of each of the sample was measured into 100ml beaker. The electrode of the pH meter was placed inside the sample and the pH was read directly from the screen of the meter when the pointer became steady.

### Determination of Soluble Solid, Total Solid, Specific gravity and Titratable acidity

The method of oven drying as described by AOAC (2006) was used to determine the soluble solids of the products. The total solid was determined by oven method (AOAC 2006). The pyconometer method (AOAC, 2006) was used to test for specific gravity. The acidity of the sample was determined using AOAC (2006) method.

### Determination of microbial load

The microbial load (bacteria and mould) from products (juice and jam) was determined by the total plate count method described by the International Commission of Microbiological Specification of Food (ICMSF, 1978). One milliliter of each of the product was measured separately

into two test tubes containing 9ml of distilled water to make it up to 10ml. From 1 x 10<sup>-1</sup> dilution, 1 ml from each test tube was measured out and diluted to 10ml in separate test tubes to form another fold of dilution 10<sup>-2</sup>. Ten (10) fold serial dilutions of the samples were made. Eight (8) grams of agar powder was weighed out and dispersed in 250ml distilled water in a conical flask. The mixture was sterilized by autoclaving at 126°C for 15 minutes. The prepared medium was stored at room temperature. Each plate was inoculated with 0.5ml of the products sample from each serial dilution. The inoculum was carefully spread evenly over the entire plate and incubated at 37°C for 48 hours. (Uniscop SM 9023). After 24-hour incubation period, the number of colonies were counted using colony counter and the colonies were multiplied by the dilution factor. The results were recorded as colony forming units per ml (Cfu ml<sup>-1</sup>).

### Statistical Analysis

All determinations were done in duplicates. The data generated were entered into the computer and analyzed using Statistical Package for Social Sciences (SPSS version 16.0) Means and standard deviation were calculated for values obtained from the analysis. Analysis of variance (ANOVA) was used to compare the values obtained. Level of significance was accepted at  $p < 0.05$ .

## RESULTS AND DISCUSSION

### The effect of storage temperature and time on the pH of monkey kola products (juice and jam).

Table 1 shows the effect of storage temperature and time on the pH of jam and juice prepared from monkey kola. The pH of *C.parchycarpa* jam stored at room temperature (29-32°C) were stable for few days (less than a week)

**Table 2.** The effect of storage temperature and time on the specific gravity of Monkey kola products (juice and jam).

Storage Time	CPJm 29-32°C	CPJm 12°C	CLJm 29-32°C	CLJm 12°C	CPJu 29-32°C	CPJu 12°C	CLJu 29-32°C	CLJu 12°C
Wk 0	1.02±0.0	0.02±0.0	1.01±0.1	1.0±0.07	1.02±0.0	1.02±0.0	1.01±0.1	1.01±0.1
Wk 1	1.02±0.1	1.02±0.0	1.02±0.1	1.02±0.0	1.02±0.1	1.02±0.0	1.02±0.1	1.02±0.1
Wk 2	1.03±0.0	1.02±0.1	1.03±0.0	1.02±0.0	1.03±0.0	1.02±0.1	1.03±0.0	1.02±0.0
Wk 3	1.03±0.1	1.02±0.1	1.03±0.1	1.02±0.1	1.03±0.1	1.02±0.1	1.03±0.1	1.02±0.1
Wk 4	1.04±0.1	1.03±0.0	1.04±0.1	1.03±0.1	1.04±0.1	1.03±0.0	1.04±0.1	1.03±0.0

Means with different superscripts along the same row are statistically different from each other ( $P < 0.05$ ). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

while there was no significant decrease ( $p > 0.05$ ) in pH of the sample stored at refrigeration temperature (12°C) until the 4<sup>th</sup> week of storage when the pH decreased to 3.2. This indicates that storage of *C.parchycarpa* under refrigeration temperature reduced pH changes suggesting better product stability. The pH changes in jam from *C.lepidota* followed a similar trend when stored at ambient temperature (29-32°C). pH of *C.lepidota* jam stored at refrigeration temperature (12°C) was more stable than that of *C.parchycarpa* jam stored at the same temperature. pH of *C.parchycarpa* juice stored at ambient temperature (29-32°C) was stable for one week while the one stored in refrigeration temperature (12°C) was stable for two weeks. Juice from *C.parchycarpa* stored at ambient temperature showed a significant decrease in pH ( $p < 0.05$ ) after 2 weeks storage period. The pH values decreased from 4.2 to 3.0. For juice samples stored at refrigeration significant decreases in pH were observed by the 3<sup>rd</sup> and 4<sup>th</sup> weeks of storage. *C. lepidota* juice stored at 29-32°C showed significant pH reduction after the 2<sup>nd</sup> week of storage pH values ranged from pH 4.2 for fresh samples to pH 2.4 after 4 weeks of storage. There were no significant changes in the pH of juices stored at refrigeration temperature until after 3 weeks of storage. The drop in pH signifies deterioration in quality of the product. The pH was higher at week 0 will hinder the proliferation of pathogenic and spoilage microorganisms in juice. The drop in pH in the samples was more pronounced at room temperature than storage under refrigeration. The results generally show that the higher the pH, the lower the acidity of the juice. This indicated that more acids were produced at higher temperature (28°C) than at lower temperature (12°C) during storage. This observation may also be due to a greater rate of carbohydrate utilization in the sample stored at room temperature by microorganism leading to increased acidity (Fasajiro *et al.*, 2005; Ashaye *et al.*, 2006). Decrease in pH was also reported by Safdar *et al.* (2012) on jam prepared from different mango varieties.

However, the finding in this study was not in line with the report of Vidhya and Nadhya (2010) where they found no decrease in pH of *Limonia acidissima* fruit jam stored for 90 days. Decrease in pH of food product is said to be proportional to increase in acidity (Hussain *et al.*, 2008; Safdar *et al.*, 2012). The hydrogen ions generated from the acids produced by microorganisms are responsible for the decrease in pH values. The difference in pH values was observed to be consistent with titratable acidity. Saka *et al.* (2007) reported a similar finding in a work they carried out on some indigenous fruits.

#### The effect of storage temperature and time on the specific gravity (SP) of monkey kola products (juice and jam).

Table 2 shows the effects of storage temperature and time on specific gravity of jam and juices from two varieties of monkey kola stored at different temperatures. There were no significant differences ( $p > 0.05$ ) in specific gravity of the jam and juice samples stored for the period of 4 weeks. The results indicated minimum and insignificant changes in the overall weight of the products within the storage period. Significant changes in soluble solids are an indication that probably microorganisms are using up nutrients in the juice for their growth or multiplication; that does not however translate into significant changes in weight of the juice. At week 0 the specific gravity of the juices (1.0- 1.02) was similar to 1.02 -1.03 reported for cow's milk (Ihekoronye and Ngoddy, 1985). A beverage with such specific gravity would be smooth when drinking (Ihekoronye and Ngoddy, 1985).

#### The effect of storage temperature and time on the total solids (TS) of monkey kola products (jam and juice) (%).

The effect of storage temperature and time on the total

**Table 3.** The effect of storage temperature and time on the total solids (TS) of monkey kola products (jam and juice) (%).

Storage Time	CPJm 29-32°C	CPJm 12°C	CLJm 29-32°C	CLJm 12°C	CPJu 29-32°C	CPJu 12°C	CLJu 29-32°C	CLJu 12°C
Wk 0	10.2±0.1 <sup>a</sup>	10.2±0.1 <sup>a</sup>	11.9±0.1 <sup>a</sup>	11.9±0.1 <sup>a</sup>	9.7±0.7 <sup>a</sup>	9.7±0.7 <sup>a</sup>	9.4±0.1 <sup>a</sup>	9.4±0.1 <sup>a</sup>
Wk 1	9.2±0.2 <sup>b</sup>	10.6±0.2 <sup>a</sup>	10.6±0.1 <sup>a</sup>	11.8±0.1 <sup>a</sup>	9.7±0.7 <sup>a</sup>	9.7±0.7 <sup>a</sup>	9.4±0.1 <sup>a</sup>	9.4±0.7 <sup>a</sup>
Wk 2	7.2±0.2 <sup>c</sup>	10.1±0.1 <sup>a</sup>	8.8±0.1 <sup>b</sup>	11.5±0.1 <sup>a</sup>	8.6±0.2 <sup>b</sup>	9.7±0.7 <sup>a</sup>	8.8±0.1 <sup>b</sup>	9.4±0.7 <sup>a</sup>
Wk 3	5.4±0.1 <sup>d</sup>	9.6±0.2 <sup>ab</sup>	8.4±0.2 <sup>b</sup>	10.6±0.2 <sup>b</sup>	6.6±0.2 <sup>c</sup>	9.6±0.1 <sup>a</sup>	6.9±0.1 <sup>c</sup>	9.3±0.1 <sup>a</sup>
Wk 4	4.7±0.1 <sup>d</sup>	8.6±0.1 <sup>b</sup>	8.6±0.2 <sup>c</sup>	6.9±0.1 <sup>c</sup>	4.1±0.0 <sup>d</sup>	9.5±0.3 <sup>a</sup>	6.7±0.2 <sup>c</sup>	9.3±0.1 <sup>a</sup>

Means with different superscripts along the same row are statistically different from each other ( $P < 0.05$ ). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

**Table 4.** The effect of storage temperature and time on the soluble solids (SS) of monkey kola products (jam and juice) (%).

Storage Time	CPJm 29-32°C	CPJm 12°C	CLJm 29-32°C	CLJm 12°C	CPJu 29-32°C	CPJu 12°C	CLJu 29-32°C	CLJu 12°C
Wk 0	7.5±0.1 <sup>a</sup>	7.5±0.2 <sup>a</sup>	7.9±0.1 <sup>a</sup>	7.9±0.1 <sup>a</sup>	6.1±0.2 <sup>a</sup>	6.1±0.2 <sup>a</sup>	6.5±0.7 <sup>a</sup>	6.5±0.7 <sup>a</sup>
Wk 1	6.3±0.1 <sup>b</sup>	7.4±0.1 <sup>a</sup>	5.5±0.1 <sup>b</sup>	7.7±0.1 <sup>a</sup>	6.1±0.1 <sup>a</sup>	6.1±0.1 <sup>a</sup>	6.5±0.7 <sup>a</sup>	6.5±0.7 <sup>a</sup>
Wk 2	5.6±0.2 <sup>bc</sup>	7.3±0.1 <sup>a</sup>	4.7±0.1 <sup>b</sup>	7.3±0.1 <sup>a</sup>	5.8±0.2 <sup>a</sup>	6.1±0.7 <sup>a</sup>	5.1±0.8 <sup>b</sup>	6.5±0.7 <sup>a</sup>
Wk 3	4.6±0.1 <sup>c</sup>	7.1±0.1 <sup>a</sup>	4.3±0.1 <sup>b</sup>	7.2±0.1 <sup>a</sup>	4.9±0.2 <sup>b</sup>	6.1±0.4 <sup>a</sup>	4.1±0.1 <sup>c</sup>	6.5±0.7 <sup>a</sup>
Wk 4	3.6±0.1 <sup>d</sup>	6.7±0.1 <sup>ab</sup>	3.8±0.1 <sup>bc</sup>	6.6±0.2 <sup>b</sup>	3.4±0.2 <sup>c</sup>	5.5±0.2 <sup>b</sup>	3.3±0.2 <sup>d</sup>	5.3±0.2 <sup>b</sup>

Means with different superscripts along the same row are statistically different from each other ( $P < 0.05$ ). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

solids of monkey kola products stored for 4 weeks is shown on Table 3. The result shows that the *C.parchycarpa* jam stored under refrigeration (12°C) was stable for two weeks while the sample stored at ambient temperature had steady total soluble solid for less than a week. Total solids decreased as storage period increase in jam from *C.parchycarpa*, at 29-32°C. Values decreased from 10.2% to 4.7% TS. However, there was no significant difference ( $p > 0.05$ ) in the TS values of sample stored for 3 and 4 weeks. The changes in total solid content were lower for samples stored at refrigeration temperature (12°C). Values decreased from 11.2% TS in the fresh sample to 8.6% after 4 weeks of storage at 12°C. TS values for weeks 3 and 4 were significantly lower than other values. For *C.lepidota* jam stored at 29-32°C, TS values decreased significantly ( $p < 0.05$ ) after the first week of storage. Further decrease ( $p < 0.05$ ) was observed after the 3<sup>rd</sup> week of storage. For *C.lepidota* jam stored at 12°C, there was no statistical decrease in TS until the 3<sup>rd</sup> week of storage. Further significant decrease ( $p < 0.05$ ) was observed by the 4<sup>th</sup> week of storage. The stability of total solids in *C.lepidota* jam stored at 12°C was similar to that of *C.parchycarpa* jam stored under refrigeration (12°C) but the TS of *C.lepidota* jam stored at 29-32°C was more steady compared to that

of *C.parchycarpa* stored at 29-32°C. These differences could be attributable to varietal difference. *C.parchycarpa* juice stored at 29-32°C showed a sharp decrease in TS as storage period increased (9.7 to 4.1%). When stored at 12°C, there were no significant changes in TS ( $p > 0.05$ ) (9.7-9.5). A similar trend was observed for *C.lepidota* juice stored at 29 -32°C and *C.lepidota* juice stored at 12°C. In this, it is likely that microorganisms in the products feed on the nutrients thereby reducing the total solids and the soluble solids to produce energy for their life activities; organic acids were also produced and are responsible for lowering the  $p^H$ .

#### The effect of storage temperature and time on the soluble solid (SS) of monkey kola products (juice and jam) (%)

Changes in soluble solids (SS) of jam and juice from monkey kola are shown in Table 4. Soluble solids (SS) of *C.parchycarpa* jam stored at 29-32°C decreased significantly (from 7.5 to 3.6%) as the period of storage increased. The same trend was also observed in *C.lepidota* jam (except that decrease in SS of *C.parchycarpa* jam (3.9%) was higher than decrease in

**Table 5.** The effect of storage temperature and time on the titratable acidity of monkey kola products (jam and juice) (%).

Storage Time	CPJm	CPJm	CLJm	CLJm	CPJu	CPJu	CLJu	CLJu
	29-32°C	12°C	29-32°C	12°C	29-32°C	12°C	29-32°C	12°C
Wk 0	0.1±0.7 <sup>d</sup>	0.1±0.7 <sup>b</sup>	0.1±0.1 <sup>c</sup>	0.1±0.1 <sup>b</sup>	0.2±0.0 <sup>c</sup>	0.2±0.0 <sup>c</sup>	0.2±0.0 <sup>d</sup>	0.2±0.0 <sup>c</sup>
Wk 1	0.1±0.7 <sup>d</sup>	0.1±0.0 <sup>b</sup>	0.1±0.7 <sup>c</sup>	0.1±0.0 <sup>b</sup>	0.2±0.1 <sup>c</sup>	0.2±0.0 <sup>c</sup>	0.2±0.1 <sup>d</sup>	0.2±0.7 <sup>c</sup>
Wk 2	0.3±0.1 <sup>c</sup>	0.1±0.7 <sup>b</sup>	0.2±0.7 <sup>c</sup>	0.1±0.7 <sup>b</sup>	0.3±0.1 <sup>c</sup>	0.2±0.7 <sup>c</sup>	0.4±0.2 <sup>c</sup>	0.2±0.0 <sup>c</sup>
Wk 3	0.3±0.2 <sup>b</sup>	0.1±0.7 <sup>b</sup>	0.3±0.2 <sup>b</sup>	0.1±0.1 <sup>b</sup>	0.6±0.7 <sup>b</sup>	0.3±0.2 <sup>b</sup>	0.7±0.1 <sup>b</sup>	0.3±0.1 <sup>b</sup>
Wk 4	0.5±0.7 <sup>a</sup>	0.2±0.1 <sup>a</sup>	0.4±1.4 <sup>a</sup>	0.3±0.7 <sup>a</sup>	0.7±0.1 <sup>a</sup>	0.4±0.2 <sup>a</sup>	0.8±0.4 <sup>a</sup>	0.4±0.1 <sup>a</sup>

Means with different superscripts along the same row are statistically different from each other (P<0.05). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

SS of *C.lepidota* jam (2.7%). There was no significant decrease (p>0.05) in SS of jam stored at 12°C until the 4<sup>th</sup> week of storage. *C.parchycarpa* juice stored at 29-32°C showed a significant decrease in SS by the 3<sup>rd</sup> week of storage. *C.lepidota* juice stored at the same temperature also showed a significant difference in SS (P<0.05) after 2 weeks of storage. *C.parchycarpa* juice and *C.lepidota* juice at 12°C were more stable (showing a significant decrease in SS after 3 weeks of storage). The decrease SS was not in line with the finding of Rababah *et al.* (2011), who reported increase SS of strawberry jam and the reason for the differences may be because they added citric acid to their jam which must have inhibited microbial growth in the product. Decrease in soluble solids during storage in this study might be due to acid hydrolysis of poly saccharides especially gum and pectin (Luh and Woodroof, 1975).

#### The effect of storage temperature and time on the titratable acidity of monkey kola products (juice and jam) (%).

Titratable acidity changes in jam and juice samples from monkey kola are shown in Table 5. In all cases titratable acidity (TTA) increased as storage period increased. For *C.parchycarpa* jam stored at 29-32°C TTA increased from 0.11 to 0.55%. For *C.lepidota* jam stored at the same temperature TTA increased from 0.13 to 0.44%. This indicates that increase in TTA was lower for *C.lepidota* jam than for *C.parchycarpa* jam. Storage at 12°C (refrigeration temperature) led to more gradual increase in TTA, both for *C.parchycarpa* and for *C.lepidota* jams. Titratable acidity (%) of juice from *C.parchycarpa* stored at 29-32°C increased from 0.21 to 0.75 (%). TTA values for *C.parchycarpa* juice were significantly different

(p<0.05) after 2 and 3 weeks of storage at 29-32°C. Changes in values for juice from *C.lepidota* followed the same pattern. At 12°C, TTA values increased from 0.12 to 0.43 (%) for *C.parchycarpa* juice and from 0.23 to 0.39 (%) for *C.lepidota* juice. In both cases, significant increases were observed by the 3<sup>rd</sup> and 4<sup>th</sup> weeks of storage. The increase in titratable acidity was more pronounced in the samples stored at room temperature (29-32°C) than in those stored in the fridge (12°C). The increase in acidity might be ascribed to rise in the concentration of weakly ionized acids and their salts during storage (Safdar *et al.*, 2012). Increase in acidity might also be due to formation of acids by degradation of polysaccharides and oxidation of reducing sugars or by breaking of pectin substances and uronic acid (Iqbal *et al.*, 2001). The increase in titratable acidity as observed under different storage temperature in this study was in line with similar work carried out by Ashaye and Adeleka (2009) on Roselle jam, on jam prepared from different mango varieties (Safdar, *et al.*, 2012) and also on wood apple (*Limonia acidissima*) fruits (Vidhya and Narain, 2010).

#### The effect of storage temperature and time on the total plate count of jam.

The effect of storage temperature and time on the total plate count (TPC) of jam stored for 4 weeks is shown on Table 6. The total plate count of *C.parchycarpa* jam stored at room temperature increased from 2.0 to 42.4 x10<sup>4</sup> (Cfu/g). The total plate count of *C.lepidota* stored at the same temperature also increased from 1.4 to 47 x 10<sup>4</sup> (Cfu/g). The same pattern of growth was observed in the samples stored in the refrigerator but the multiplication was however lower than those of the

**Table 6.** The effect of storage temperature and time on microbiological growth (TPC cfu/g) in jam

	Total Plate count TPC (cfu/g)(10 <sup>4</sup> )			
	T <sub>1</sub> (29-32°C) CPJm	T <sub>2</sub> (12°C)	T <sub>1</sub> (29-32°C) CLJm	T <sub>2</sub> (12°C)
Wk 0	2.0±0.1 <sup>b</sup>	2.0±0.1 <sup>b</sup>	1.4±0.2 <sup>b</sup>	1.4±0.2 <sup>b</sup>
Wk 1	3.5±0.3 <sup>b</sup>	2.4±0.1 <sup>b</sup>	5.5±0.1 <sup>b</sup>	3.7±0.7 <sup>b</sup>
Wk 2	6.1±0.1 <sup>b</sup>	3.7±0.7 <sup>b</sup>	6.7±0.7 <sup>b</sup>	5.1±0.2 <sup>b</sup>
Wk 3	35±0.1 <sup>a</sup>	25.5±0.7 <sup>a</sup>	42±0.1 <sup>a</sup>	18.5±0.2 <sup>a</sup>
Wk 4	42.5±0.2 <sup>a</sup>	30±0.3 <sup>a</sup>	47±0.1 <sup>a</sup>	22.5±0.7 <sup>a</sup>

Means with different superscripts along the same row are statistically different from each other (P<0.05). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

**Table 7.** The effect of temperature and time on the microbial growth TPC (cfu/g)(10<sup>4</sup>) in juice.

	CPJu		CLJu	
	T <sub>1</sub> (29-32°C)	T <sub>2</sub> (12°C)	T <sub>1</sub> (29-32°C)	T <sub>2</sub> (12°C)
Wk 0	2.5± 0.7 <sup>b</sup>	2.5± 0.7 <sup>b</sup>	3.8±0.2 <sup>b</sup>	3.8±0.2 <sup>b</sup>
Wk 1	5.0± 0.3 <sup>b</sup>	3.6 ±0.2 <sup>b</sup>	5.8±0.1 <sup>b</sup>	4.3±0.1 <sup>b</sup>
Wk 2	6.4 ±0.1 <sup>b</sup>	3.9 ±0.2 <sup>b</sup>	7.7±0.3 <sup>b</sup>	5.1 ±0.3 <sup>b</sup>
Wk 3	46 ±1.4 <sup>a</sup>	29 ±1.4 <sup>a</sup>	51 ±0.7 <sup>a</sup>	42 ±0.7 <sup>a</sup>
Wk 4	51.5± 2.1 <sup>a</sup>	34 ±2.1 <sup>a</sup>	56±2.1 <sup>a</sup>	49±2.1 <sup>a</sup>

Means with different superscripts along the same row are statistically different from each other (P<0.05). CPJu - *C.parchycarpa* juice; CLJu - *C.lepidota* juice; CPUJm - *C.parchycarpa* jam; CLUJm - *C.lepidota* jam; Room Temperature -29 - 32°C; Refrigeration temperature -12°C.

samples stored at room temperature. This implies that low temperature slows down microbial multiplication. In all the samples the TPC for the first two weeks were not significantly (p<0.05) different from each other but differed significantly from the TPC of weeks 4 to 5. This implies that microorganisms increase with increase in storage time. The high TPC seen in *C. lepidota* jam stored at room temperature is attributable to its total sugar content; the sugar content will increase (not decrease) microbial growth because the sugar is a nutrient which microbes will use for their metabolic processes (Hoover, 1997). *C. lepidota* jam started with a low plate count compared to *C.parchycarpa* jam. The total plate count for *C.parchycarpa* jam stored in the refrigerator varied between 2.0 to 30 Cfμ/g, while that *C.lepidoda* jam varied between 1.4 to 22.5 Cfμ/g. This result implies that *C.lepidoda* jam stores better than that of *C.parchycarpa* at cold temperature. The result however showed that the jams can still be consumed even after 4 weeks of storage because the TPC was still below 10<sup>6</sup>cfμ/g (ICMSR, 1994).

### The effect of storage temperature and time on the total plate count (cfu/g) in juice.

The effect of storage temperature and time on the total plate count (TPC) (cfu/g) of the juice stored for 4 weeks is shown on Table 7. The TPC increase as storage period increased in juice from *C.parchycarpa*, at 29 – 32°C. The total count increased from 2.5 to 51.5(cfμ/g). There was no significant (p<0.05) difference in the TPC values of the sample stored for 1 and 2 weeks. For samples stored in the refrigerator, insignificant growth was also recorded for the first 2 weeks. Rapid growth was observed by the 3<sup>rd</sup> and 4<sup>th</sup> weeks. The rapid decline in microbial count indicates that the nutrient was used up and microbes were no longer growing. Rather they were in stationary or death phase. Growth of microorganism has five staged; lag phase, log phase, exponential growth phase, stationary phase and death phase. Microbial growth, which is an indication of increased microbial count, only takes place during the log phase and the exponential growth phase. The TPC of *C.lepidota* juice stored at



room temperature for 4 weeks ranged between 3.8 to 56 (cfu/g) while the one stored in the refrigerator ranged between 3.8 to 49 (cfu/g) indicating that cold temperature inhibits microbial multiplication in food products. Microbial contaminants were found in all the samples analysed; bacteria found on fruit surfaces comprise the most frequent spoilers of fruit juice because they exist on the surface of plant and fruits growing at the expense of secreted plant materials (Frazier and Westhoff, 1998). However, data regarding total plate count of the samples within the study period were well within permissible limits (ICMSR, 1994). The low count could be attributed to pasteurization and proper handling. The major contaminants isolated were *Bacillus subtilis*, *Clostridium butyrium*, and *Sacharomyces* spp. The presence of these organisms in the products could be due to the low pH of the products (Tournas *et al.*, 2005). The presence of these organisms though in low amount need to be controlled to prevent spoilage and food borne illness (Mudgil *et al.*, 2004; Oranusi *et al.*, 2004; 2007).

## CONCLUSION

The results of this study showed that the shelf-life of the products (jam and juice) produced from monkey kola can be extended by storing them in the refrigerator. Further investigation on how to keep the products longer is however recommended.

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