

## **Original Research Article**

### **EFFECT OF SOME PROCESSING AND STORAGE METHODS ON THE QUALITY OF OKRA (*Abelmoschus esculentus*)**

#### **ABSTRACT**

Three experiments, comprising packaging of fresh Okra fruits for storage using perforated and imperforated polypropylene and polyethylene bags, dipping of fresh okra fruits in hot water before packaging to store and drying of sliced Okra fruits were carried out in the laboratory at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana to determine the effects of different packaging and storage methods on quality and shelf life of okra fruits. The Completely Randomized Design (CDR) with 2x 2 x 2 factorial was employed in this research where the treatments were assigned completely at random, so that each experimental unit has the same chance of receiving a treatment. There were ten treatments for both experiments 1 and 2 and twelve for experiment 3. Each treatment was replicated three times. The results from experiment one showed that fresh okra fruits packed in both polypropylene and polyethylene bags and store at 7- 9 °C can stay up to 24 days with no significant ( $p \leq 0.05$ ) weight loss. However, okra fruits packed in perforated polypropylene and polyethylene bags gave a higher salvage of 82.1% compared to 77% from those packed in the imperforated bags of the two packaging materials. The results of the second experiment showed a very fast rate of deterioration of fruits, with no fruit being salvaged at the end of the storage period. The third experiment involving slicing and drying of okra fruits in a solar cabinet dryer showed that okra fruits dried for 24 hours lost comparatively less weight than those dried for 48 hours. From the three experiments it was concluded that packaging of fresh okra fruits before storage enables the fruit to keep longer and remained in the useable state than unpackaged fruits for storage. On the choice of

packaging material, one should prefer polypropylene to polyethylene for better results. Again, perforation of the chosen packaging material had advantage over the imperforated ones.

**KEYWORDS:** Okra, storage methods, processing methods, okra fruit quality, packaging material

## 1.0 INTRODUCTION

In Ghana Okra is among the non-traditional export crops of importance, contributing 0.02% of Gross Domestic Product (GEPC, 2002). Annual production of Okra in Ghana is estimated between 1,548 to 4,507 metric tons (SRID, MOFA, 2007).

Despite all these importance, the crop, like all other fresh vegetable has a problem of short shelf life. The fresh fruits remain in usable quality for only 8 to 10 days if held at 2-13 °C at 90% relative humidity. Those held at 0-10 °C lasted for only 4 to 6 days and deteriorated rapidly on exposure to higher temperature (20-26 °C) (Yamaguchi, 1983).

Large quantities of Okra fruits produced during the main production season are usually left to deteriorate, as they cannot be kept longer. Producers are forced under the circumstances to give their commodities out at very low “take-away” prices. In certain situations, market women have no alternative than to throw away Okra fruits in the market to carry their empty baskets or sacks home. This is to avoid paying extra cost of transporting those fruits they could not sell and cannot store till the next market day (Personal observation). Traditionally, Okra fruits have been processed by drying to extend the shelf life well beyond the few weeks when they are in season (Kordylas, 1991). However, this traditional method has problems associated with it including lack of pre-treatment, non-uniformity of slice thickness (resulting in uneven drying), direct exposure to dirt, insects and other pests. Thus, affecting the

nutritional and sensory qualities of the final product (Tindall, 1983, Kordylas, 1991). The final product from drying usually has a brown or dark- brown colour which is not appealing to the consumer. Both fresh and dried Okra, like other vegetables, for local retailing are usually packed in baskets resulting in over exposure of produce to the weather. These practices lead to quick deterioration as well as contamination of produce (Adegoreye *et al.*, 1990).

At the production level little is done about fresh storage of produce. Storage of fresh fruits and vegetables prolongs their usefulness, checks market gluts, and provides wider selection of fruits and vegetables throughout the year (FAO, 1988). This helps orderly marketing and may increase the financial gain to the producer. However, farmers do not have adequate storage facilities to reduce losses. This study is intended to add value to the production of okra by exploring acceptable methods of packaging and storing freshly harvested okra to extend its shelf life. In view of the problems associated with storability of fresh Okra fruits and the quality of dried fruits, the study was aimed at evaluation and selection of processing and packaging methods for fresh Okra fruits to enhance longer shelf life without marked changes in external and internal qualities.

## **2.0 MATERIALS AND METHODS**

Three experiments, comprising; (i) packaging of fresh Okra fruits for storage, (ii) dipping of fresh okra fruits in hot water before packaging to store and (iii) drying of sliced Okra fruits, were set up to study their effects on the storage life and quality of the produce. The experiment involved a fieldwork to produce Okra fruits which were later used after harvest in the laboratory for the storage of okra fruits.

## **2.1 EXPERIMENTAL SITE AND LOCATIONS**

The field and laboratory experiments were carried out at the Department of Horticulture, Faculty of Agriculture at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The field experimental site falls within the forest area of Ashanti Region of Ghana. The area has a bimodal rainfall regime, with the major rainfall season between March and July and a minor season between September and November.

The laboratory rooms at the Department of Horticulture, Faculty of Agriculture at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. were used for handling and storage of okra fruits at ambient temperatures whilst a refrigerator in the laboratory was also used as one of the storage methods. Hot water bath at the Pathology laboratory of Crop Science Department of the Faculty of Agriculture was use for the hot water treatment of fruits. Drying of fruits was done by the use of a solar cabinet dryer located at the old site of Forestry Research Institute of Ghana on Kwame Nkrumah University of Science and Technology compound. Proximate analyses of materials (samples) for nutrient content were carried-out in the Bio-chemistry laboratory of Crop Research Institute at Fumesua near Kumasi.

## **2.2 EXPERIMENTAL DESIGN AND TREATMENTS**

### **2.2.1 Experimental design**

The Completely Randomized Design (CDR) with 2x 2 x 2 factorial was employed in this research where the treatments were assigned completely at random, so that each experimental unit has the same chance of receiving a treatment to avoid any experimental error.

### 2.2.2 Treatments

There were ten treatments for experiment 1 and 2 and twelve for experiment 3. Each treatment was replicated three times.

Treatments for experiment 1:

M<sub>1</sub>P<sub>1</sub>F.....four days after fruit set, polypropylene, perforated.

M<sub>1</sub>P<sub>1</sub>N..... four days after fruit set, polypropylene, not perforated.

M<sub>1</sub>P<sub>2</sub>F..... four days after fruit set, polyethylene perforated.

M<sub>1</sub>P<sub>2</sub>N..... four days after fruit set, polyethylene not perforated.

M<sub>2</sub>P<sub>1</sub>F..... six days after fruit set, polypropylene perforated.

M<sub>2</sub>P<sub>1</sub>N..... six days after fruit set, polypropylene not perforated

M<sub>2</sub>P<sub>2</sub>F..... six days after fruit set polyethylene perforated.

M<sub>2</sub>P<sub>2</sub>N... six days after fruit set polyethylene not perforated

CM<sub>1</sub>.....control for four days after fruit set.

CM<sub>2</sub>..... control for six days after fruit set.

#### Treatments for experiment 2:

M<sub>1</sub> 50 °C P<sub>1</sub>.....fruits harvested 4 days after setting heated at 50 °C and packed in polypropylene

M<sub>1</sub> 50 °C P<sub>2</sub>.....fruits harvested 4 days after setting heated at 50 °C and packed in polyethylene.

M<sub>1</sub> 75 °C P<sub>1</sub>... fruits harvested 4 days after setting heated at 75 °C and packed in polypropylene.

M<sub>1</sub> 75 °C P<sub>2</sub>... fruits harvested 4 days after setting heated at 75 °C and packed in polyethylene.

M<sub>2</sub> 50 °C P<sub>1</sub>.....fruits harvested 6 days after setting heated at 50 °C and packed in polypropylene

M<sub>2</sub> 50 °C P<sub>2</sub>.....fruits harvested 6 days after setting heated at 50 °C and packed in polyethylene.

M<sub>2</sub> 75 °C P<sub>1</sub>.....fruits harvested 6 days after setting heated at 75 °C and packed in polypropylene .

M<sub>2</sub>75 °CP<sub>2</sub>..... fruits harvested 6 days after setting heated at 75 °C and packed in polyethylene

CM<sub>1</sub> ..... Control of fruits harvested 4 days after setting, unpackaged

CM<sub>2</sub>..... Control of fruits harvested 6 days after setting, unpackaged

### **Treatments for experiment 3**

M<sub>1</sub> 0.5 D<sub>1</sub>..... Fruits harvested 4 days after setting, sliced 0.5 cm thick, dried for 24 hours

M<sub>1</sub> 0.5 D<sub>2</sub>..... Fruits harvested 4 days after setting, sliced 0.5 cm thick, dried for 48 hours.

M<sub>2</sub> 0.5 D<sub>1</sub>..... Fruits harvested 6 days after setting, sliced.0.5 cm thick, dried for 24 hours.

M<sub>2</sub> 0.5 D<sub>2</sub>..... Fruits harvested 6 days after setting, sliced 0.5 cm thick, dried for 48 hours.

M<sub>1</sub> 1.0 D<sub>1</sub>..... Fruits harvested 4 days after setting, sliced 1.0 cm thick, dried for 24 hours

M<sub>1</sub> 1.0 D<sub>2</sub>..... Fruits harvested 4 days after setting, sliced 1.0 cm thick, dried for 48 hours.

M<sub>2</sub> 1.0 D<sub>1</sub>..... Fruits harvested 6 days after setting, sliced 1.0 cm thick, dried for 24 hours.

M<sub>2</sub> 1.0 D<sub>2</sub>..... Fruits harvested 6 days after setting, sliced 1.0 cm thick, dried for 48 hours.

M<sub>1</sub> 1.5 D<sub>1</sub>..... Fruits harvested 4 days after setting, sliced 1.5 cm thick, dried for 24 hours

M<sub>1</sub> 1.5 D<sub>2</sub>..... Fruits harvested 4 days after setting, sliced 1.5cm thick, dried for 48hours.

M<sub>2</sub> 1.5 D<sub>1</sub>..... Fruits harvested 6 days after setting, sliced 1.5 cm thick, dried for 24 hours.

M<sub>2</sub> 1.5 D<sub>2</sub>..... Fruits harvested 6 days after setting, sliced 1.5 cm thick, dried for 48 hours.

### **2.3 Land Preparation and field Layout**

The land for the field experiment was ploughed by a tractor with a disc plough and was harrowed after two days. A portion of plot measuring 14 m x 40 m was demarcated for planting. The experimental field was divided into 3 blocks each measuring 4 meters and separated by a path of 1 meter wide. Each block was then divided into smaller plots of 4 m x 4 m and separated by paths of 0.5 m from each other giving a total of 27 plots (9 plots per block).

The same layout was used for three successive cropping, October 2017 to February 2018, April to July 2018 and October 2019 to February 2020 respectively. The second, third and fourth crops were grown on plots different from where the first one was planted.

### **2.4 Data collection and Analysis**

#### **2.5 Selection of okra fruits for harvesting**

Twenty plants were randomly selected from each experimental plot. The first fruits were harvested at 56 days from the day of sowing; this was 4 days after fruit set. The second harvest was done on the 58th day after seed sowing, which was 6 days after fruit set. Fruits

were harvested at these two stages of maturity (4 and 6 days after setting) for the three experiments of fresh storage, hot water treatment and solar drying.

## **2.6 Cooling after harvest**

Okra fruits, harvested from the field, were washed with tap water, to clean the fruits, and then mopped with cotton cloth, to remove water particles from the surface. The fruits thus cleaned were spread on a flat bench for cooling overnight.

## **2.7 Packaging and storage of fresh okra fruits for experiment one**

After cooling overnight, two hundred fruits from each maturity were selected for packaging and storage in a refrigerator. Okra fruits of 4 to 6 cm length and 1 to 1.5 cm in diameter were selected using a metric plastic ruler and calipers to measure length and diameter respectively. All rated fruits were then packed into two types of bags: Polypropylene (as packaging material one: P<sub>1</sub>) and polyethylene (as packaging material two: P<sub>2</sub>) measuring 12 x 14 cm with each package containing 10 fruits. Some of the bags were perforated with a pin of 1mm diameter making two holes at each side of the bag whilst the rest were not perforated. Twenty fruits were put into two plastic plates as the controls. All the packages were sealed using an electrical hand-operated rubber sealing machine. After sealing each package was weighed and the weight recorded as initial weight before storage and then labeled.

## **2.8 Hot – water treatment of okra fruits and storage for experiment two**

Harvested okra fruits from the two maturity stages were dipped in hot water. Selected fruits were put into plastic baskets with looped handles fixed to the sides of the basket. Hot-water – bath (Gallenkamp, England) with electric heating coils was filled with tap water up to 5cm

below the brim. A long stem thermometer was inserted through a side jacket into the water. The water was heated to 50 °C and a basket of Okra fruits dipped into it and covered for 3 minutes whilst the electricity power was switched off. The water was again heated to 75 °C and another set of fruits were dipped in for 3 minutes.

The heated temperatures for okra fruits harvested at different days were:

M<sub>1</sub> 50°C.....fruits harvested 4 days after setting, heated at 50 °C.

M<sub>1</sub> 75°C..... fruits harvested 4 days after setting, heated of 75 °C

M<sub>2</sub> 50°C..... fruits harvested 6 days after setting, heated at 50 °C.

M<sub>2</sub> 75°C..... fruits harvested 6 days after setting, heated at 75 °C.

The heated okra fruits samples were allowed to cool off under room temperature. Samples after cooling were then packed into polypropylene (P<sub>1</sub>) and polyethylene (P<sub>2</sub>) bags and weighed before putting them into a refrigerator. Packaging increased the sample size to eight, with 2 controls.

### **2.9 Solar drying of okra fruits for experiment three**

Fresh Fruits selected and harvested at 2 stages of maturity (4 and 6 days after setting) were washed and allowed to cool off at room temperature. The fruits were then sliced into thickness sizes of 0.5 cm 1.0 cm and 1.5 cm using an adjustable pair of knife cutter designed by the Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The sliced fruits were then weighed and the weights recorded as initial weight (weight before drying) and graded for colour using the colour chart by Kornerup and Wanscher (1981). The sliced okra fruits were dried by using a solar cabinet dryer for 24 and 48 hours.

### **2.10 Viscosity**

Viscosity, an indicative measure of the sliminess of Okras' mucilage was tested for fresh fruit samples before packaging and storage. During the storage period samples were tested for their viscosity at 8, 16 and 24 days.

Twenty grammes (20gm) of sample were weighed by a triple beam balance (Ohaus, U.S.A) into an electronic blender (Monlinex optiblend 2000-France) and 100ml of water added. The blender was then connected to an electrical power source and switched on and run for two minutes. The blended sample was poured into a funnel lined with 0.5mm sieve supported over a beaker into which the slimy mucilage was collected. Viscosity is then determined by using "Redwood no.1" viscometer (England), which has a cup with a capillary tube of 1.6mm bore and 10mm length fitted to the base. A discharge valve fitted in the cup controlled the flow of fluid through the capillary. The cup was surrounded by a water jacket having a thermometer inserted through the side.

The mucilage was poured into the cup and allowed to reach the same temperature (30°C) with the surrounding water before the discharge valve was opened for the fluid to flow through the capillary into a collector marked at 50ml under it. The time taken to discharge 50ml of fluid into the collector beneath was noted using an electronic stop-watch.

Viscosity was quoted as:  $N_{\text{seconds}} \text{ Redwood@T}^{\circ}\text{C}$

$V = N_{\text{seconds}} \text{ Redwood@T}^{\circ}\text{C}$ .

The more viscous the fluid was the longer the discharge time.

## **2.11 DATA ANALYSIS**

Statistical Software (SPSS) package was applied as 2x 2 x 2 factorial in a completely randomized Design (CRD) to test for the interactive effect of packaging material, perforation and stage of maturity on quality of the okra fruits.

### **3.0 RESULTS**

#### **3.1 EXPERIMENT ONE**

##### **3.1.1 Weight of fresh okra fruits stored in polypropylene and polyethylene bags at 7 to 9 °C**

**Table 1: Mean weight of fresh fruits stored in polypropylene and polyethylene bags at 7 to 9°C**

Treatment	Initial Weight(g)	Weight after 8days(g)	Weight after 16days(g)	Weight after 24days(g)	Total weight Loss(g)	Mean weight Loss(g)
M <sub>1</sub> P <sub>1</sub> F	89.50	86.48	86.40	85.36	10.26	3.42
M <sub>1</sub> P <sub>1</sub> N	87.80	85.50	84.80	84.40	8.70	2.90
M <sub>1</sub> P <sub>2</sub> F	90.50	88.36	87.30	87.00	8.84	2.95
M <sub>1</sub> P <sub>2</sub> N	91.60	89.60	88.50	88.45	8.25	2.75
M <sub>2</sub> P <sub>1</sub> F	98.70	97.50	96.40	95.35	6.85	2.28
M <sub>2</sub> P <sub>1</sub> N	95.10	93.97	92.95	92.70	5.65	1.89
M <sub>2</sub> P <sub>2</sub> F	92.40	90.40	90.36	90.00	6.44	2.15
M <sub>2</sub> P <sub>2</sub> N	90.80	89.76	88.50	88.35	5.79	1.93
CM <sub>1</sub>	87.40	67.25	57.30	52.36	85.29	28.43*
CM <sub>2</sub>	98.30	73.30	72.50	63.30	85.80	28.60*

Mean for the parameters: M<sub>1</sub>=3.00g, M<sub>2</sub>= 2.06g, P<sub>1</sub>= 2.78g, P<sub>2</sub>= 2.44g, F =2.85g and N=2.38g.

*Note:*

M<sub>1</sub>P<sub>1</sub>F..... four days after fruit set, polypropylene bag perforated.

M<sub>1</sub>P<sub>1</sub>N..... four days after fruit set, polypropylene bag not perforated.

M<sub>1</sub>P<sub>2</sub>F..... four days after fruit set, polyethylene bag perforated.

M<sub>1</sub>P<sub>2</sub>N..... four days after fruit set, polyethylene bag not perforated.

M<sub>2</sub>P<sub>1</sub>F..... six days after fruit set, polypropylene bag perforated.

M<sub>2</sub>P<sub>1</sub>N..... six days after fruit set, polypropylene bag not perforated

M<sub>2</sub>P<sub>2</sub>F..... six days after fruit set, polyethylene bag perforated.

M<sub>2</sub>P<sub>2</sub>N... six days after fruit set, polyethylene bag not perforated

CM<sub>1</sub>.....control for four days after fruit set.

CM<sub>2</sub>..... control for six days after fruit set.

Mean for the parameters: M<sub>1</sub>=3.00g, M<sub>2</sub>= 2.06g, P<sub>1</sub>= 2.78g, P<sub>2</sub>= 2.44g, F =2.85g and N=2.38g.

Fresh Okra fruits packed in polypropylene and polyethylene bags were weighed and

put into a refrigerator at temperature of 7-9°C. The weight of the samples were checked at time intervals of 8, 16 and 24 days during the storage period.

Changes in weight (weight loss) that were observed was used to determine how the under listed parameters had influenced the shelf life of the Okra fruits during storage as compared to the unpacked samples (controls):

- (a) Stage of maturity,
- (b) Type of packaging material,
- (c) Perforation and imperforation of packaging material.

Total weight loss was the cumulative values observed at 8, 16 and 24 days of storage.

#### **(a) First stage of maturity (4 days after fruit set).**

The results (Table 1) indicated that Okra fruits that were harvested at 4 days after setting and packed in perforated polypropylene bags lost 3.02g of weight from an initial weight of 89.50g after eight days of storage. Up to the 16<sup>th</sup> day they lost 3.10g of weight and further lost 4.14g by the 24<sup>th</sup> day of storage. Thus, at the end of 24 days of storage the total weight lost recorded was 10.26g, giving a mean weight loss of 3.42g for each 8 day period.

Okra fruits from the same maturity stage packed in unperforated polypropylene bags lost 2.30, 3.00 and 3.40g of weight after the 8<sup>th</sup>, 16 and 24<sup>th</sup> day of storage respectively from an initial weight of 87.80g. The total weight lost in this case was 8.70g and a mean of 2.90g for each 8 day period.

Okra fruits harvested at 4 days after setting and packed in perforated polyethylene bags lost 2.14g weight after 8 days of storage. They further lost 3.20 and 3.50g by the 16<sup>th</sup> and 24<sup>th</sup> days of storage respectively from an initial weight of 90.50g. The total weight lost was 8.84g giving a mean of 2.95g for each 8 day period. Those packed in unperforated polyethylene bags lost 2.00, 3.10 and 3.15g after the 8<sup>th</sup>, 16<sup>th</sup> and 24<sup>th</sup> day of storage respectively.

These gave a total weight loss of 8.25g from an initial weight of 91.60g. The mean weight lost was 2.75g for each 8 day period. The control (unpacked) samples lost 20.15g after 8 days of storage and subsequently lost 30.10 and 35.04g after the 8<sup>th</sup> and 24<sup>th</sup> day of storage respectively. The total weight lost recorded was 85.29g from an initial weight of 87.40g giving a mean loss of 28.43g for each 8 day period.

#### **(b) Second stage of maturity (6 days after fruit set).**

Okra fruits harvested at 6 days after setting and packed in perforated polypropylene bags lost 1.20g of their weight after 8 days of storage. Further losses of 2.30 and 3.35g were

recorded for the 16<sup>th</sup> and 24<sup>th</sup> days respectively. Total weight lost was 6.85g from an initial weight of 89.7g, giving a mean of 2.28g. Those samples packed in unperforated polypropylene bags recorded weight losses of 1.13, 2.15 and 2.40g after 8, 16 and 24 days of storage respectively. The total weight lost was 5.68g from an initial weight of 95.1g giving a mean of 1.89g for each 8 day period. Samples packed in perforated polyethylene bags lost 2.00g of their weight after 8 days of storage and further lost 2.04 and 2.40g after the 16 and 24 days of storage respectively. Total weight lost recorded was 6.44g out of the initial weight of 92.4g and a mean of 2.15g for every 8 days of storage. Those packed in unperforated polyethylene bags lost 1.04, 2.30 and 2.45g of their weight after 8, 16 and 24 days of storage respectively. The total weight lost by these samples was 5.79g from the initial weight of 90.8g giving a mean of 1.93g loss every eight days. The control (unpacked) samples of fruits harvested 6 days after setting lost 25.00g of their weight after 8 days of storage. They further weight lost 25.80 and 35.00g after the 8<sup>th</sup> and 24<sup>th</sup> days of storage respectively. Total weight lost was 85.80g from an initial of 98.30g. On the average a lost of 28.60g was recorded for every eight days of storage.

### 3.1.2 VISCOSITY

The highest mean viscosity (3:81 seconds<sub>Redwood</sub>) was recorded for Okra fruit samples harvested at 4 days after fruit set and packed in unperforated polypropylene bags (M<sub>1</sub>P<sub>1</sub>N). These samples lost 58.9% of their viscosity after 24 days of storage from the initial viscosity of 9:33 seconds<sub>Redwood</sub>. The second highest mean viscosity of 3:59 seconds<sub>Redwood</sub> was recorded for samples from the same stage of maturity and packed in unperforated polyethylene bags. These samples lost 61.5% viscosity compared to the initial value.

Figure 1 shows the relation between storage time and viscosity of the fresh Okra fruits observed for 16 days of storage. For the first two days of storage viscosity of the fruits was 10 seconds<sub>Redwood</sub>. There was a steady decrease in viscosity as storage period increases such that by the 14<sup>th</sup> day of storage the value fell from 10 to 3.1 seconds<sub>Redwood</sub>.

**Table 2: Viscosity of fresh Okra fruits stored at 7-9 °C**

Treatment	8days of storage	16 days of storage	24days of storage	Mean
M <sub>1</sub> P <sub>1</sub> F	4:13	3:28	2:51	3:31
M <sub>1</sub> P <sub>1</sub> N	5:10	4:13	2:25	3:83
M <sub>1</sub> P <sub>2</sub> F	4:42	3:39	2:51	3:44
M <sub>1</sub> P <sub>2</sub> N	4:34	3:41	3:01	3:59
M <sub>2</sub> P <sub>1</sub> F	4:12	3:18	2:25	3:18
M <sub>2</sub> P <sub>1</sub> N	3:49	2:37	2:51	2:79
M <sub>2</sub> P <sub>2</sub> F	4:01	3:13	2:54	3:23
M <sub>2</sub> P <sub>2</sub> N	4:16	3:25	2:42	3:28
CM <sub>1</sub>	3:09	2:15	0:40	2:82
CM <sub>2</sub>	3:00	2:10	0:37	1:82

Initial Viscosity: M<sub>1</sub>=9.33, M<sub>2</sub>=8.52

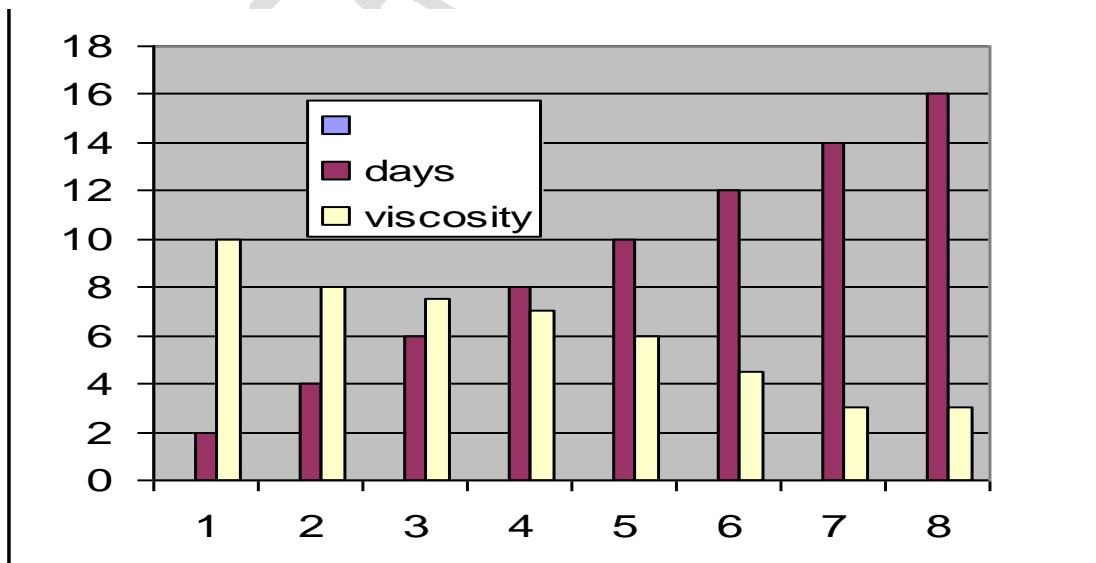


Figure 1: **Relation between viscosity and storage time.**

### 3.1.3 Fresh okra fruits nutrient content

Table 3. Mean Nutrient content of fresh Okra fruits stored at 7-9°C.

NB: Means with the same letter(s) are not significantly different: Duncan's multiple test range

Treatment	Calcium g/100g	Phosphorus g/100g	Iron g/100g	Ash. g/100g	Fats g/100g	Fiber g/100g	Protein % %	Carbohydrate g/100g	Ascorbic acid g/100g
M <sub>1</sub> P <sub>1</sub> F	17.0a	0.77a	0.07a	1.25a	0.13a	0.02a	2.49a	6.45b	17.0b
M <sub>1</sub> P <sub>1</sub> N	19.3a	0.79a	0.05a	1.28a	0.13a	0.02a	2.14a	7.99a	16.0b
M <sub>1</sub> P <sub>2</sub> F	19.3a	0.78a	0.07a	1.19a	0.14a	0.01b	2.44a	6.76ba	17.0b
M <sub>1</sub> P <sub>2</sub> N	17.3a	0.81a	0.07a	1.28a	0.17a	0.01b	2.32a	6.66b	15.9b
M <sub>2</sub> P <sub>1</sub> F	20.0a	0.80a	0.07a	1.25a	0.13a	0.01b	2.37a	6.79ba	15.0b
M <sub>2</sub> P <sub>1</sub> N	19.0a	0.81a	0.06a	1.30a	0.14a	0.01b	2.14a	7.11ba	14.8b
M <sub>2</sub> P <sub>2</sub> F	21.0a	0.80a	0.07a	1.30a	0.16a	0.01b	2.21a	6.69ba	15.7b
M <sub>2</sub> P <sub>2</sub> N	20.0a	0.79a	0.07a	1.28a	0.13a	0.02a	2.18a	7.34ba	14.8b
CM <sub>1</sub>	18.7a	0.80a	0.07a	1.23a	0.14a	0.02a	2.51a	7.02ba	4.4a
CM <sub>2</sub>	19.3a	0.83a	0.07 a	1.37a	0.14a	0.01b	2.17a	6.99ba	4.2a

#### (1) CALCIUM:

Mean calcium content of fresh Okra fruits harvested at 4days after fruit set was 20.50g/100g and that for fruits harvested at 6days after fruit set was 21.00g/100g before packaging and storage. After the storage period of 24days the control sample (unpacked) of fruits harvested 4days after setting have their mean calcium content reduced to 18.7g/100g and 19.3g/100g for the control (unpacked) sample of fruits harvested 6 days after setting. The mean calcium content of Okra fruits from the two maturity stages packed in Polypropylene and Polyethylene bags ranged between 17.00 and 21.00g /100g after 24 days of storage.

#### (2) PHOSPHORUS.

The mean phosphorus content for fresh Okra fruits harvested at 4days after fruit set was 0.83g/100g and 0.81g/100g for those fruits harvested at 6days after setting before they were

packaged for storage. After the storage period of 24days the mean Phosphorus content for the controls (unpacked samples) was 0.80g/100g for fruits harvested 4days after setting and 0.83g/100g for those harvested 6days after setting. For the packed samples, the highest mean Phosphorus content, after 24days of storage was 0.81g/100g and the lowest 0.77g/100g.

### **(3) IRON**

The mean Iron content of fresh Okra fruits from both stages of maturity was 0.07g/100g before packaging and storage. Fruits harvested at 4days and 6days after setting and packed in perforated and unperforated Polypropylene bags recorded mean values of 0.05g and 0.06g/100g Iron respectively after 24 days of storage. All the other treatments, including the controls had values of 0.07g/100g.

### **(4) ASH**

The mean Ash content for the fresh Okra fruits, from both stages of maturity was 1.38g/100g before packaging and storage. After 24 days of storage the controls (unpacked) sample recorded means of 1.23g/100g for fruits harvested at 4days after fruit set and 1.37g/100g for those fruits harvested at 6days after setting. The mean Ash content of all the other treatments ranges between a lowest value of 1.19g/100g and a highest of 1.30g/100g which were statistically not different from each other as well as the controls

### **(5) FATS.**

The mean Fat content for fresh Okra fruits ranges between a highest 0.17g/100g and a lowest of 0.13g/100g before and after storage period of 24days respectively. The controls from both stages of maturity recorded a mean value of 0.14g/100g which is not significantly different from values recorded for the other treatments packed in perforated and unperforated bags of Polypropylene and Polyethylene material ranging between 0.13 and 0.17g/100g.

### **(6) FIBER**

The mean Fiber content recorded for the fresh Okra fruits from both stages of maturity was 0.02g/100g before packaging and storage. After 24days of storage the control (unpacked) for samples harvested at 4days after fruit set and the same samples packed in perforated and unperforated Polypropylene bags recorded a mean Fiber content of 0.02g/100g. The same mean (0.02g/100g) was recorded for materials harvested at 6days after fruit set and packed in unperforated Polyethylene bags.

## **(7) PROTEIN**

Mean Protein content, before packaging and storage, for fresh Okra fruits harvested 4days after fruit set was 2.51% and 2.40% for fruits harvested at 6days after fruit set. After 24days of storage the controls (unpacked) samples of Okra fruits harvested at 4 and 6days after setting recorded mean values of 2.51 and 2.17% respectively which were not significantly different. The highest mean Protein content recorded was 2.49% for Okra fruits samples harvested at 4days after setting and packed in perforated Polypropylene bags. Okra fruits samples from the two stages of maturity packed in unperforated Polypropylene gave the lowest mean Protein content of 2.14%. The means for the rest of the treatments, in percentages, were 2.18, 2.21, 2.32, 2.37 and 2.44.

## **(8) CARBOHYDRATE**

Carbohydrate content of fresh Okra fruits harvested at 4 and 6days after fruit set were 8.61 and 8.82% respectively, before packaging and storage. After 24days of storage at 7-9o C, samples harvested at 4days after fruit set and packed in unperforated Polypropylene bags registered the highest mean carbohydrate content of 7.99%. The lowest mean carbohydrate content of 6.45% was registered for samples from the same fruits harvested at 4days after setting and packed in perforated Polypropylene bags. Another lower mean of 6.66% was registered for samples harvested 4days after setting and packed in unperforated Polyethylene bags. The rest of the treatments, including the controls, registered percentage mean carbohydrate contents of 6.69, 6.76, 6.79, 6.99, 7.02, 7.11 and 7.34 which were not significantly different from each other.

## **(9) ASCORBIC ACID.**

The mean Vitamin C (ascorbic acid) content for the fresh Okra fruits harvested at 4days after fruit set was 24.4g/100g and that of fruits harvested at 6days after fruit set was 24.2g/100g before packaging and storage. After the storage period of 24 days fruits harvested at 4days after setting and packed in perforated and unperforated Polypropylene bags recorded 17.0 and 16.0g/100g mean Vitamin C content respectively. The same samples packed in perforated and unperforated Polyethylene bags recorded 17.0 and 15.9g/100g of Vitamin C respectively. After the same period of storage Okra fruits harvested at 6days after setting and packed in perforated and unperforated Polypropylene bags recorded mean Vitamin C contents of 15.0 and 14.8g/100g respectively. Those samples packed in perforated and unperforated Polyethylene bags recorded 15.7 and 14.8g/100g mean Vitamin C content respectively. The controls (unpacked) recorded 4.4 and 4.2g/100g respectively for samples harvested at 4 and 6days after fruit set.

## 3.2 EXPERIMENT TWO

### 3.2.1 Weight Loss of Okra fruits dipped in hot water at 50 and 75 oC

Observations on weight changes of Okra fruits during the storage period, after dipping them in hot water at 50 and 70 °C, indicated a more stable weight for all the samples except the controls as shown in Table 4.

Table 4: Mean weight of Okra fruits dipped in hot water at 50 and 75°C

Treatments	Initial mean weight (g)	Mean weight after 8 days (g)	Mean weight after 16 days (g)	Mean weight after 24 days (g)
M <sub>1</sub> 50 <sup>o</sup> CP <sub>1</sub>	44.15	44.05	43.55	43.15
M <sub>1</sub> 50 <sup>o</sup> CP <sub>2</sub>	43.50	43.50	43.50	43.30
M <sub>1</sub> 75 <sup>o</sup> CP <sub>1</sub>	50.70	50.70	50.50	50.40
M <sub>1</sub> 75 <sup>o</sup> CP <sub>2</sub>	52.60	52.40	52.10	52.10

M <sub>2</sub> 50 <sup>o</sup> CP <sub>1</sub>	64.84	64.80	64.70	64.70
M <sub>2</sub> 50 <sup>o</sup> CP <sub>2</sub>	66.20	66.10	66.00	65.90
M <sub>2</sub> 75 <sup>o</sup> CP <sub>1</sub>	78.90	78.70	78.10	78.10
M <sub>2</sub> 75 <sup>o</sup> CP <sub>2</sub>	68.90	68.90	68.70	68.50
CM <sub>1</sub>	57.40	38.10	22.00	11.40
CM <sub>2</sub>	60.70	41.30	26.10	12.70

### 3.2.2 VISCOSITY

Table 5 shows the changes in viscosity observed in Okra fruits dipped in hot water at 50 and 75 °C, packed in Polypropylene and Polyethylene bags and stored at 7-9 °C over a period of 24 days. Okra fruit samples harvested at 4 days after setting lost 53-55% of their viscosity after 8 days of storage whilst those harvested at 6 days after setting lost 51-60% of their viscosity during the same period. The control for samples harvested at 4 and 6 days after setting lost 66 and 65% of their viscosity respectively after the 8 days of storage.

Table 5: Viscosity of Okra fruits dipped in hot water at 50 and 75<sup>o</sup>C, stored for 24 days at 7-9 °C

Treatment	Viscosity after 8days of storage	Viscosity after 16days storage	Viscosity after 24days storage	Mean Viscosity
M <sub>1</sub> 50°C P <sub>1</sub>	4:20	2:15	-	3.18
M <sub>1</sub> 50°C P <sub>2</sub>	4:15	2:10	-	3.13
M <sub>1</sub> 75°C P <sub>1</sub>	4:22	2:12	-	3.17
M <sub>1</sub> 75°C P <sub>2</sub>	4:34	2:30	-	3.32
M <sub>2</sub> 50°C P <sub>1</sub>	4:15	2:15	-	3.15
M <sub>2</sub> 50°C P <sub>2</sub>	3:40	1:35	-	2.38
M <sub>2</sub> 75°C P <sub>1</sub>	4:10	1:15	-	2.63
M <sub>2</sub> 75°C P <sub>2</sub>	4:15	1:25	-	2.70
CM <sub>1</sub>	3:09	2:15	-	2.62
CM <sub>2</sub>	3:00	2:10	-	2.55

Initial mean viscosity: M<sub>1</sub>=9:33, M<sub>2</sub>=8:52

### 3.3 EXPERIMENT THREE

#### 3.3.1 WEIGHT LOSS IN SLICED OKRA FRUITS AFTER DRYING

Table 6 shows the loss in weight for the sliced Okra fruits after drying for 24 and 48 hours. The highest percent weight loss of 90.7 was recorded for Okra a fruit samples harvested at 4 days after fruit set, sliced 1.5 cm thick and dried for 48 hours.

The lowest percentage weight loss of 86.1% was recorded for two treatments from samples harvested at 4 and 6 days after fruit set which were both sliced 0.5 cm thick and dried for 24 hours.

Table 6: Weight loss in sliced okra fruits after drying

Treatment	WBDg.	WAD g.	Weight loss (WBD-	% Weight loss
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	WAD)g.			
M <sub>1</sub> 0.5 D <sub>1</sub>	949.3	131.8	817.5	86.1
M <sub>1</sub> 1.0 D <sub>1</sub>	1298.1	163.3	1134.8	87.4
M <sub>1</sub> 1.5 D <sub>1</sub>	1064.1	131.7	932.4	87.6
M <sub>1</sub> 0.5 D <sub>2</sub>	255	26.8	229	89.5
M <sub>1</sub> 1.0 D <sub>2</sub>	392.4	38.3	354.1	90.2
M <sub>1</sub> 1.5 D <sub>2</sub>	363.2	329.5	33.7	90.7
M <sub>2</sub> 0.5 D <sub>1</sub>	949.3	131.8	817.5	86.1
M <sub>2</sub> 1.0 D <sub>1</sub>	1298.1	163.3	1134.8	87.4
M <sub>2</sub> 1.5 D <sub>1</sub>	1064.1	131.7	932.4	87.6
M <sub>2</sub> 0.5 D <sub>2</sub>	205.7	21.7	184	89.8
M <sub>2</sub> 1.0 D <sub>2</sub>	363.6	37.2	326.4	89.8
M <sub>2</sub> 1.5 D <sub>2</sub>	385.2	37.2	348	90.3

NB: WBD = Weight Before Drying, WAD = Weight After Drying.

### 3.3.2 VISCOSITY OF SLICED OKRA FRUITS AFTER DRYING

Viscosity of fresh Okra fruits harvested at 4 and 6 days after setting was 9:33 and 8:57 seconds<sub>Redwood</sub> respectively (Table 7). After slicing and drying for 24 hours, samples from materials harvested at 4 days after setting gave a lower viscosity of 8:01seconds<sub>Redwood</sub> for fruits sliced 0.5cm thick. The highest viscosity of 8:20 seconds<sub>Redwood</sub> was recorded for samples sliced 1.0 cm thick. The loss in viscosity, from the initial fresh values, registered after 24 hours of drying were 14.15 and 12.11%, for the lower and the highest values respectively. After 90 days of storage, the loss in viscosity from the initial fresh stage was 31.20% for the lower value and 30.87% for the highest.

Table 7: Viscosity of sliced and dried Okra fruits stored for 90 days.

Treatment	Before storage	30 Days	60 Days	90 Days
M <sub>1</sub> 0.5 D <sub>1</sub>	8.01	7.16	7.05	6.42
M <sub>1</sub> 1.0 D <sub>1</sub>	8.20	7.29	7.17	6.45
M <sub>1</sub> 1.5 D <sub>1</sub>	8.13	8.04	7.34	7.21
M <sub>1</sub> 0.5 D <sub>2</sub>	8.11	8.01	7.37	7.19
M <sub>1</sub> 1.0 D <sub>2</sub>	8.21	8.01	7.29	7.08
M <sub>1</sub> 1.5 D <sub>2</sub>	8.14	8.01	8.08	7.42
M <sub>2</sub> 0.5 D <sub>1</sub>	7.31	7.01	6.48	6.08
M <sub>2</sub> 1.0 D <sub>1</sub>	7.42	7.27	7.04	6.32
M <sub>2</sub> 1.5 D <sub>1</sub>	7.55	7.34	7.11	6.41
M <sub>2</sub> 0.5 D <sub>2</sub>	7.45	7.37	7.31	7.29
M <sub>2</sub> 1.0 D <sub>2</sub>	7.35	7. 11	6.40	6.30
M <sub>2</sub> 1.5 D <sub>2</sub>	7.38	7.26	6.52	6.44

NB: Viscosity of fresh Okra fruit on the day of harvest for M<sub>1</sub>= 9:33 and M<sub>2</sub>= 8:57

### 3.3.3 NUTRIENT CONTENT OF DRY OKRA FRUITS

The highest mean protein content of 2.70% was recorded for okra fruits harvested at 4 days after fruit set sliced 0.5 cm and thick and dried for 24 hours (Table 8). Okra fruits harvested at 4 days after fruit set sliced 1.5 cm thick and dried for 24 hours gave the next highest percent protein content of 2.68 (Table 8). These two were not significantly different from each other ( $P < 0.05$ ). The control (fresh okra fruits) harvest at 6 days after fruit set was not significantly different from fruits harvested at 4 days after fruit set sliced 1.5 cm thick and dried for 48 hours and those harvested at 6 days after fruit set, sliced 1.0 cm thick and dried for 24 and 48 hours respectively. Observed difference among treatments indicated that slice

thickness, drying time and stage of maturity have not significantly affected the protein content of okra fruit. Table 8:

Table 8: Mean nutrient content of dry okra fruits

Treatment	PROTEIN%	FATS g/100g	ASH g/100g	FIBER g/100g	CARBO. %	VITC. g/100g
M <sub>1</sub> 0.5D <sub>1</sub>	2.68 a	0.10 b	1.25 bc	1.22 ba	7.01 a	11.4b
M <sub>1</sub> 1.0D <sub>1</sub>	2.52 ba	0.11 b	1.07 bd	1.13 ba	6.95 ba	11.6b
M <sub>1</sub> 1.5D <sub>1</sub>	2.70 a	0.11 b	1.27 bc	1.31 a	6.88 ba	11.3b
M <sub>1</sub> 0.5D <sub>2</sub>	2.28 bd	0.09 b	1.14 bc	0.92 c	6.20 ba	9.6c
M <sub>1</sub> 1.0D <sub>2</sub>	2.20 cd	0.09 b	0.94 b	1.02 bc	6.25 ba	9.9c
M <sub>1</sub> 1.5D <sub>2</sub>	2.09 cd	0.09 b	0.91 b	1.03 bc	5.64 b	9.7c
M <sub>2</sub> 0.5D <sub>1</sub>	1.93 c	0.09 b	0.91 b	0.95 c	6.48 ba	11.2b
M <sub>2</sub> 1.0 D <sub>1</sub>	2.19 cd	0.09 b	1.08 bd	1.04 bc	6.27 ba	10.9b
M <sub>2</sub> 1.5D <sub>1</sub>	2.32 bd	0.39 a	1.02 bd	1.11 ba	6.26 ba	10.7b
M <sub>2</sub> 0.5 D <sub>2</sub>	2.29 bd	0.09 b	0.97 b	0.99 c	6.40 ba	9.8c
M <sub>2</sub> 1.0 D <sub>2</sub>	2.12 cd	0.09 b	0.92 b	0.91 c	5.94 b	9.5c
M <sub>2</sub> 1.5 D <sub>2</sub>	2.29 bd	0.10 b	1.05 bd	0.98 c	6.85 ba	9.3c
CM <sub>1</sub>	2.57 ba	0.11 b	1.45 a	0.02 d	7.10 a	24.4a
CM <sub>2</sub>	2.09 cd	0.15 b	1.33 a	0.01 d	7.00 a	24.2a

Duncan's multiple range tests

Means with the same letter are not significantly different.

## **4.0 DISCUSSION**

### **4.1 EXPERIMENT ONE**

#### **4.1.1 Weight of fresh okra fruits stored in polypropylene and polyethylene bags at 7 to 9 °C**

The two controls were significantly different from all the other treatments ( $p < 0.01$ ). However, there was no significant difference between them as shown in table 1. This suggests that packaging plays a significant role in restricting respiratory and transpiratory activities of samples, thus impeding moisture loss that will lead to subsequent weight loss. Loss of moisture through transpiration is known to be responsible for rapid loss of weight in fresh Horticultural produce (Kays 2002).

Sankat and Maharaj (1994) stated that packaging of *Colocassia* leaves restricted weight loss by 0.3-0.7% compared to 2.7-7.3% in unpacked ones per day. They further reported that, after 24 days under refrigerated storage all packed samples recorded 1 to 10% weight loss whilst unpacked samples recorded 50 to 100% weight loss.

#### **4.1.2 Viscosity of fresh okra fruits stored at 7- 9 °C**

From Table 2, okra Fruit samples from both stages of maturity, 4days and 6days after setting, lost a greater proportion (49.6 % and 48.3% respectively) of their viscosity during the first eight days of storage. Thus, okra fruits from both stages of maturity loss nearly half of their initial viscosity within 8 days of storage. The results indicate that viscosity of the okra mucilage decreases with increasing storage time.

#### **4.1.3 Nutrient content of fresh okra fruits stored at 7- 9 °C**

From Table 3, Mean calcium content of fresh Okra fruits harvested at 4 days after fruit set was 20.50 g/100g and that for fruits harvested at 6 days after fruit set was 21.00g/100g before

packaging and storage. After the storage period of 24 days the control sample (unpacked) of fruits harvested 4 days after setting have their mean calcium content reduced to 18.7g/100g and 19.3g/100g for the control (unpacked) sample of fruits harvested 6 days after setting. The mean calcium content of Okra fruits from the two maturity stages packed in Polypropylene and Polyethylene bags ranged between 17.00 and 21.00g /100g after 24 days of storage.

Statistically there was no significant difference among the means for calcium content of the samples before and after storage. This indicated that stage of maturity, packaging in perforated and unperforated Polypropylene and Polyethylene bags have no significant effect on the calcium content of the Okra fruits. Similarly, the calcium content was not significantly affected by storage time.

## **4.2 EXPERIMENT TWO**

### **4.2.1 Weight Loss of Okra fruits dipped in hot water at 50 and 75 °C**

Packaging in this regard help to restrict weight loss to a significant level in packed samples compared to unpacked ones. In a related experiment on packaging of *colocasia* leaves, Sankat and Maharaj (1994) reported that packaging markedly restricted weight loss by 0.3-0.7% per day in packed leaves compared to 2.7-7.3% in unpacked ones. Packaging, according to the authors, have the advantage of longer shelf life over non-packaging (Table 4).

### **4.2.2 Viscosity of Okra fruits dipped in hot water at 50 and 75<sup>0</sup>C, stored for 24 days at 7-9<sup>0</sup>C**

Okra fruit samples harvested at 4days after setting lost 53-55% of their viscosity after 8days of storage whilst those harvested at 6days after setting lost 51-60% of their viscosity during the same period. The control for samples harvested at 4and 6 days after setting lost 66 and 65% of their viscosity respectively after the 8days of storage as shown in Table 5.

The loss in viscosity was very high, 88.7-98.4%, among all the hot water treated samples regardless of age at harvesting, dipping temperature and packaging material. The controls (unpacked samples) also demonstrated the same high level of viscosity lost which were not different from the packed samples. The mucilage of okra is known to be composed of long - chain carbohydrate molecules and very highly soluble in water (Tulasidas, *et al.*, 1993). It is likely that the heating process might have interfered into the structure of the carbohydrate molecules leading to its breakdown. Heating might have also increased the solubility of the mucilage and couple with hydrolysis will lead to reduction in viscosity of the fruits during storage.

### **4.3 EXPERIMENT THREE**

#### **4.3.1 Weight loss in sliced okra fruits after drying**

Differences in slice thickness among okra fruit samples from the same stage of maturity dried for the same time period have very little influence on the degree of weight loss. Thus, slice thickness of 0.5, 1.0 and 1.5 cm did not show marked differences on weight loss for the samples from the two stages of maturity of 4 and 6 days after fruit set as indicated in table 6.

The observed differences in weight after drying is due to the drying period rather than slice thickness. Thus, loss in weight is the direct effect of moisture loss during drying indicating that longer drying time resulted into more moisture loss and a subsequent loss in weight.

In an experiment on the drying of Okra, Adom *et al* (1995) reported that during solar drying of Okra moisture content decreases significantly and this is influence by slice thickness and drying time.

#### **4.3.2 Viscosity of sliced and dried Okra fruits stored for 90days.**

It was observed from Table 7 that samples dried for 24 hours from both stages of maturity were less viscous than those dried for 48 hours irrespective of slice thickness. It is probable that the samples dried for a shorter period still have some of the mucilage in solution of moisture retained in the sample. Whilst those dried for a longer might have loss more moisture resulting in the mucilage becoming more concentrated hence the more viscous product. The mucilage is known to be soluble in water, but the water is loss through evaporation during the process of drying resulting in more concentrated mucilage as moisture is removed. Viscosity is therefore caused by mucilage which becomes concentrated in the product as moisture is removed. There was a negative correlation ( $r = \sim 0.96$ ) between viscosity and moisture content confirming that increased viscosity was the result of concentration effect (Diameh *et al*, 2015).

#### **4.3.3 Nutrient content of dry okra fruits**

The highest mean protein content of 2.70% was recorded for materials harvested at 4 days after fruit set sliced 0.5 cm and thick and dried for 24 hours as shown in Table 8.

Observed difference among treatments indicated that slice thickness, drying time and stage of maturity have not significantly affected the protein content of okra fruit. Also drying in general does not alter the protein content to a significant level. Ghori *et al* (2000), reported from an experiment on drying *Solanum scarbum* that the level of crude protein and minerals nutrient were not affected by drying. Carbohydrate content for fresh fruits (controls) from both stages of maturity was 7.10 and 7.00%. These were significantly different ( $P < 0.05$ ) from all the samples after drying. Materials from samples harvest 4days after fruit set sliced 0.5cm thick and dried for 24hours have carbohydrate content which was not different significantly from the controls.

## 5.0 CONCLUSION

Judging from the results of these three experiments it can be concluded that packaging and storage of fresh okra fruit enables the fruit to keep longer and remained in the useable state than unpacked storage. Harvesting fruit at 4 and 6 days, after setting for storage is appropriate, however those harvested at 6 days after setting will come out with greater number of unusable fruits after the storage period. On the choice of packaging material, one should prefer polypropylene to polyethylene for better results. Also, perforation of the chosen material had advantages over the imperforated ones. Hot water treatment of okra fruits can be applied under situations where the fruits may be used within 16 days or less but not longer. Drying invariable should be considered as the best method of processing large volumes of okra fruits and for longer storage period. When properly done large quantities of okra fruits that will otherwise go waste can be saved during the peak season. Also, for bulk haulage to distant markets, drying provides the convenient of lighter load weight and easy handling.

### **COMPETING INTERESTS DISCLAIMER:**

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## 6.0 REFERENCES

- Adegoreye, A.S, Eniayeyi, D, & Ajibola O.O. (1990) *Tensile and compressive strength of two horticultural packaging materials, cane and palm fronds*. Short commercial Int. J. Food Science and Tech.25:226-229.
- Adom K.K., Dzogbefia V.P., Ellis W.O., Oldham J.H. & Simpson B.K.(1995) *Solar Drying of Okra: Effects on some nutritional and sensory qualities of dried Okra*. Journal of the Ghana Science Association (special edition) Vol.2 NO. 3(1999), 35-39.
- AOAC (1990), *Official Methods of Analysis* 5<sup>th</sup> Edition Association of Official Analytical Chemistry, Washington D. C.
- Djameh, C., Saalia, F. K., Sinayobye, E., Budu, A., Essilfie, G., Mensah-Brown, H., & Sefa-Dedeh, S. (2015). *Optimization of the sorghum malting process for pito production in Ghana*. *Journal of the Institute of Brewing*, 121(1), 106–112
- F A O, (2015) Food loess prevention in perishables. *FAO Agricultural services. Bulletin N P* 43, pp 1-6.
- Ghana Export Promotion Council, (2016) *Export performance report 2016*.
- Ghori, M. U., Alba, K., Smith, A. M., Conway, B. R., & Kontogiorgos, V. (2015). Okra extracts in pharmaceutical and food applications. *Food Hydrocolloids*, 42, 342–347
- Kapelis J.G. ed. (1987) *Objective methods of food quality assessment*. Boca, Raton F.I. CRC. Press.
- Kays, S.J. (1991) Post harvest physiology of perishable plant products. *Products, A.V.I. Book*. Pubs. Norstrand Reinhold New York, NY 23-75 pg 16, 377-380.
- Sankat C.K. Mmharaj V. 1994). *Storage of colocasia esculent L*. *Leaves Acta Horticultural* 368, 1994 post-harvest 93 pg 733.

Tulasidas, T.N., Raghavan, G.S.V. & Norris E. R. (1993) *Drying grapes under force convection and (microwave modified) and chemical treated on drying rate*. Transaction of the ASAE (1993) 36(6); 1861-1865.

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