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EFFECT OF HERMETICSTORAGE ON THE QUALITY OF BOMBAX COSTATUM

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ABSTRACT: This study was conducted on *Bombax costatum* calyx obtained from Yandev Community of Gboko Local Government Area of Benue State, Nigeria. Flowers were collected from a chosen tree as they dropped without the influence of any human activity. Calyxes were collected and sun dried to 5.5%wb for the study. The dried samples were milled and sieved using sieve of 0.25mm aperture to achieve uniform particle size. *Bombax costatum* samples were stored in different containers namely; plastic, glass, ceramics, metal and control. The proximate composition analysis of samples was performed to check the nutritional composition of *Bombax costatum* calyx using the AOAC method. The result presented carbohydrate, protein, moisture, fat, ash and fibre to have 78.30, 7.25, 5.50, 1.85, 3.30 and 3.80% respectively. Microbial and bacteria counts were performed before and after storage, to check the level of Microbes infestation and spoilage before and during storage. The mean Total viable counts (TVC) in this study across dilutions and containers showed that Plastic ranged from 3.55logcfu/g^{-1}- 7.12logcfu/g^{-1}, glass ranged from 3.57logcfu/g^{-1} – 6.98logcfu/$g^{-1,}$ metal ranged from 3.60logcfu/g^{-1} to 7.04logcfu/g^{-1}, and ceramic ranged from3.59logcfu/g^{-1} – 7.27logcfu/g^{-1},the control had TVC ranged from 4.15logcfu/g^{-1}-7.95logcfu/g^{-1}. In line with HACCP-TQM technical guidelines, both the sample before storage and samples in containers after storage belong to the category of good food with glass presenting the best protection, followed by metal, ceramic, plastic and lastly control

INTRODUCTION

Bombax costatum is a deciduous, open savannah woodland tree; it is a species from the *Bombaceae* family with *bombax* as Genus name. *Bombax costatum* is common in the savanna zones of West Africa and Central Africa Republic. It is 3 – 30m high and up to 1m in girth and does well on stony soils (Gernnah and Gbakaan, 2003). It produces flowers from November to February and then fruits from February to June. During Hamattan season (from November to March) when most crops are harvested, the flowers become loosened from the stalk and fall freely with little blow of wind (Tingir, 2003). The petals are detached from the calyx which is then dried and ground into powder and stored for reconstitution into soup. Because of the ability of the powder to form a gel when mixed with water, it can be classified as a food gum. Food gums are high molecular weight polymeric compounds, mostly carbohydrates which are characterized by their ability to give highly viscous solution at low concentration (Muhammad et, al 2017). Traditionally foods such as pounded yam and cereals moulded foods are eaten along with slimming soups such as okra, ewedu, ogbono, okoho, ager and stews that are prepared to facilitate the movement of food along the digestive track. One additional of such very popular soups in Nigeria is Genger which is produced from the flowers of the plant *Bombax costatum* both in fresh and dry form, which is the focus of this study. *Bombax costatum* in Tiv land is a delicacy with high viscosity or gelling capacity from November to March. During the wet season, from April to October, Genger does not gel at all because it losses its viscosity and when this happens, it becomes inedible and wasteful. Due to wide acceptability and popularity of the soup, the need to produce data that will aid its handling, processing and storage is gaining prominence. Rheological parameter such as viscosity of *Bombax costatum* is of paramount interest. This study is therefore aimed at investigating the viscosity of *Bombax costatum* for the purpose of achieving quality of finished product. Measurement of viscosity is often very important for quality control, particularly on products that we expect to be of a particular consistency (Mkavga, 2004).

It is no longer news that *Bombax Costatum* calyx which is the target of this study losses its viscosity immediately rain sets in, rendering the stored produce useless. The control of this menace through storage is intended. The broad objective of this study is to control viscosity loss of *Bombax costatum* through hermitic

storage, and the study is specifically aimed at checking the effect of varying the concentration of potassium carbonates on the viscosity of stored *Bombax costatum* calyx. Potassium carbonate (K_2CO_3) also known as potash or pearl ash is a white salt, soluble in water (insoluble in ethanol), which forms a strongly alkaline solution. Potassium carbonate is used in reactions to maintain anhydrous conditions without reacting with the reactants and product formed. It may also be used to dry some ketones, alcohols, and amines prior to distillation. All carbonated salts are on the FDA generally regarded as safe list. There is no evidence in the available information on calcium carbonate, potassium carbonate, potassium bicarbonate, sodium carbonate, sodium bicarbonate, or sodium sesquicarbonate that demonstrates or suggests reasonable grounds to suspect a hazard to the public when used at normal levels that are now current or that might reasonably be expected in the future (Gernnah and Gbakaan,2003).

MATERIALS AND METHODS

This study was conducted on *Bombax costatum* calyx obtained from Yandev Community of Gboko Local Government Area of Benue State, Nigeria. Flowers were collected from a chosen tree as they dropped without the influence of any human activity. Petals were manually detached using hands while the calyxes were sun dried to 5.5%wb and reserved for the study. The dried samples were pounded and sieved using sieve of 0.25mm aperture to achieve uniform particle size. 100ml of distilled water was used along with 10g of sample to form slurries of average consistency for all viscosity experiments. The potassium carbonate used for the study was obtained from the Gboko main market and ground into powder. Dosages of the preservative were computed as percentage of *Bombax costatum* sample (0%, 3%, 6%, 9%) in grams and blended with the sample, which was package into ceramic, metal, plastic and glass containers.

QUANTITIES AND METHODS OF DETERMINATION

(b) Moisture Content of *Bombax costatum* Samples

The moisture content (percent wet basis) was determined by air-oven drying method. Wet basis which is expressed in a lot of literature is mostly used by farmers. Apparatus such as electronic weighing balance, crucibles, oven (gallencarp) and thermometer were used to carry out the experiments, while Equations 1 was used for the calculation of moisture content.

$$Moisture\ content(\%) = \frac{weig\,ht\ of\ water}{weig\,ht\ of initial\ \ samp\,le} * 100 \quad \text{..... (1)}$$

Akinremi (1999).

(a) Temperature and relative humidity

Temperature at all experiments was measured using the mercury in glass thermometer graduated in degree celcius ($^{\circ}C$).

The thermometer head was always positioned to keep contact with the body to be measured. Samples were always stirred for even distribution of heat during measurements. The relative humidity of both the storage environment and the ambient environment were measured with a hygrometer graduated in percentage.

Proximate composition analysis of *Bombax costatum*

The Protein, Moisture content, Fibre, Lipid and ash were determined using the AOAC methods. While Carbohydrate was estimated by difference: (100%- lipid+protein+ash+moisture+crudefibre) (Olutayo et al, 2015).

Crude protein

Crude protein content was determined using the micro-Kjeldahl method as described by Elisa et al (2015). A volume of 10 mL H_2SO_4 added to 3 g of sample was digested with a Kjeldahl digestor (Model Bauchi 430) for $1\frac{1}{2}$ h. A volume of 40 ml water was added and distilled using a Kjeldahl distillation Unit (Model unit B – 316) containing 40% concentrated sodium hydroxide and Millipore water. Liberated ammonia was collected in 20 ml

boric acid with bromocresol green and methyl red indicators and titrated against 0.04 N H_2SO_4. A blank (without sample) was likewise prepared. Percent protein was calculated using equation 31:

$$Crude\ Protein\ (\%) = \frac{Sample\ \ titer - blank\ \ titer\ \ 14 \times 6.25}{Sample\ \ weig\,ht} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (31)$$

(Olutayo et al, 2015)

where 14 is the molecular weight of nitrogen and 6.25 is the nitrogen factor.

Crude fibre

A weighed crucible containing 1 g of defatted sample was attached to the extraction unit (in Kjeldahl, D-40599; Behr Labor-Technik GmbH, Dusseldorf, Germany) and into this 150 ml of hot 1.25% H_2SO_4 was added and digested for 30 min, the acid was drained and sample washed with hot distilled water for $1\frac{1}{2}$ hrs. The crucible was removed and oven dried overnight at 105°C, cooled, weighed, and incinerated at 550°C in a muffle furnace (MF-1-02; PCSIR) overnight and reweighed after cooling. Percentage extracted fibrewas calculated using equation 32:

$$Crude\ fiber\ (\%) = \frac{Weig\,ht\ of\ digested\ \ sampl\,e - Weig\,ht\ of\ \ as\,hed\ sample}{Weig\,ht\ of\ \ smaples} \times 100 \ldots\ldots\ldots\ldots\ldots (32)$$

(Morteza *et al*, 2016)

Lipid

Lipid content was estimated using Tecator Soxtec (Model 2043[20430001]; Hilleroed, Denmark). A quantity of 1.5 g sample mixed with 2.3 g anhydrous sulphate was weighed into a thimble and covered with absorbent cotton, while 40 ml of petroleum ether (40–60°C Bpt) was added to a pre-weighed cup. Both thimble and cup were attached to the Extraction Unit. The sample was extracted using ethanol for 30 min and rinsed for $1\frac{1}{2}$ hrs. Thereafter, the solvent was evaporated from the cup to the condensing column. Extracted fat in the cup was then placed in an oven at 105°C for 1 hr and cooled and weighed. Percent fat was calculated using equation 33:

$$Lipid\ (\%) = \frac{Initial\ cup\ weight - Final\ cup\ weight}{weight\ of\ sample} \times 100 \ldots\ldots\ldots\ldots (33)$$

(Morteza et al, 2016)

Ash

The ash content was determined by ignition of a known weight of the sample at 550°C until all carbon was removed. The residue is the ash and was taken to represent the inorganic constituents of the food. The ash contains organic origin such as sulphur and phosphorus from proteins, and some loss of volatile material in the form of sodium, chloride, potassium, phosphorus and sulphur that took place during ignition. The ash content is thus not truly representative of the inorganic material in the food either qualitatively or quantitatively.

Ash and mineral contents of various samples were determined according to AOAC (Association of Analytical Chemists). Two grams of sample was added into a pre-weighed crucible and incinerated in muffle furnace at 600°C.Equation 3 was used for calculation of ash content

$$Ash\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (34)$$

where w_1 is the weight of cleaned, dried, ignited, and cooled crucible, w_2 is the weight of the crucible and sample after incinerating at 600°C, and w_3 is the weight of the crucible and sample after cooling in an airtight homogenized vessel (Gernah and Gbakaan, 2003).

Carbohydrate

The carbohydrate content was determined by difference, that is, addition of all the percentages of moisture, fat, crude protein, ash, and crude fibre was subtracted from 100%. This gave the amount of nitrogen-free extract otherwise known as carbohydrate (Gernah and Gbakaan, 2003).

3.3 Storage of *Bombax costatum* samples

Powdered samples of *Bombax costatum* was stored hermitically in Metal, Plastic, Ceramic, Glass and Control containers for a period of nine months (Jan 2020 to September 2020). Four dosages of potassium carbonate preservative (0%,3%,6% and 9%) were mixed with sample and stored hermetically for nine months. Proximate composition analysis and functional properties of samples were determined before and during storage. A wooden cupboard inside the laboratory was used for the storage to provide adequate protection of samples from moisture, excessive heat and animals or insects attack. Temperature and Relative humidity of the storage environment were monitored during storage. Both storage and experiments were conducted at the Advanced Bio-chemistry laboratory of the Benue state University Makurdi. Performance efficiencies and viscosity losses of containers and treatments respectively were calculated using equations 35 and 36

$$\text{Container Efficiency (\%)} = \frac{Outputviscosity}{inputviscosity} \text{x}100 \quad \text{.....35}$$

$$\text{Viscosity loss (\%)} = \frac{Initialviscosity \ -Finalviscosity}{Initalviscosity} \text{x}100 \quad \text{.....36}$$

3.3.1 Microbial and Bacteria load

Bombax costatum calyx were collected from *Bombax Costatum* tree aseptically in sterile polyethen bags, sun dried, milled and transported to the Benue State University Microbiology Laboratories for analysis and storage. *Bombax costatum* samples were stored in different containers namely; plastic, glass, ceramics, metal and control as shown inplate 3. Microbial and bacteria counts were performed before and after storage, to check the level of Microbes infestation and spoilage before and during storage. Each sample was homogenized with 9ml of sterile normal saline to prepare stock solution; stocks were serially diluted (1:10) to 10^{-5} by adding 1ml of stock solution to 9mls of normal saline in test tubes. 1ml of the diluted sample was inoculated on Nutrient Agar and MaCconlcay Agar following pour plate method and incubated at 37^0C for 18-24 hours (Cheesbrough , 2006). Two media were used to carry out this analysis, these include nutrient and MaConcay agar which were prepared according to manufacturers instruction. Total number of bacteria cfu/g of the sample was calculated and recorded for interpretation of the result. Cfu/g was converted to logcfu/g^{-1}(Azoro, 20003). The sensitivity of the two media (MA and NA) to microbes and bacteria was calculated using equation 36

$$Sensitivity\ (\%) = \frac{valu\,eafterstorage \ -valuebeforestorage}{valuebeforestorage} \times 100. \text{----------(37)}$$

(Azoro, 20003)

Table 77: Average Moisture Content of *Bombax Costatum* calyx stored with 0% of K_2CO_3 in different containers and control for nine Months at room temperature.

Container	Jan	Feb	March	April	May	June	July	August	Sept.
ramic	5.50	5.50	5.50	5.95	6.20	6.50	6.50	6.50	6.60
Metal	5.50	5.50	5.20	5.30	5.23	5.50	6.30	6.40	6.50
Plastic	5.50	5.50	5.60	5.60	6.20	6.60	6.50	6.60	6.60
Glass	5.50	5.50	5.50	5.80	6.200	6.40	6.50	6.50	6.50
Control	5.50	6.00	6.05	8.50	12.10	12.50	13.50	13.50	13.70

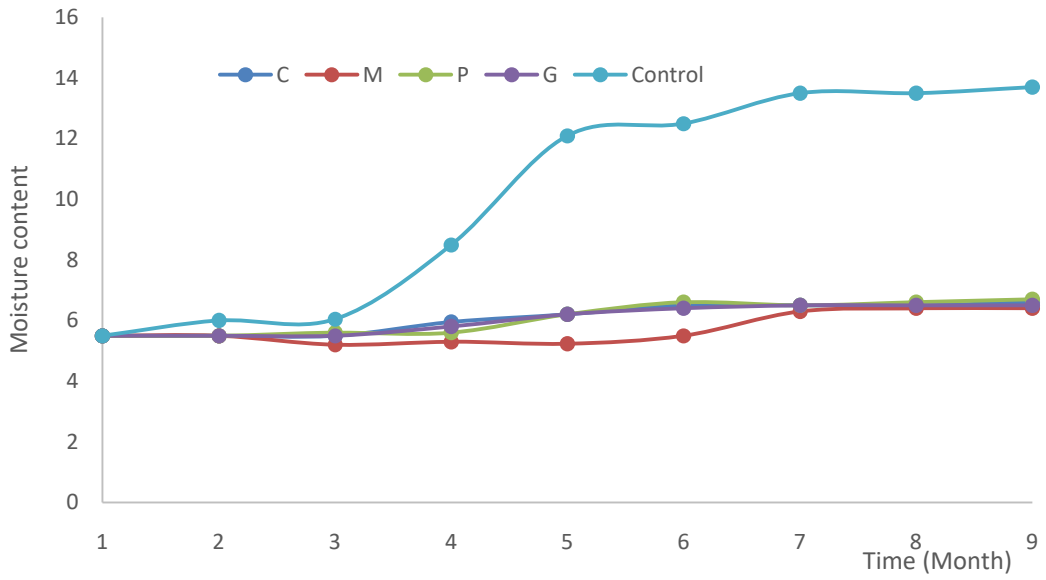

Fig. 20: Plot of moisture content values against time across containers at0% of K_2CO_3 and room temperature

Table 81: Average Temperature and Relative Humidity of Storage Environment during Storage

	Morning		Afternoon		Evening		Average	
Months	Temp. (^{0}C)	RH (%)	Temp. (^{0}C)	RH (%)	Temp.(^{0}C)	RH (%)	Temp. (^{0}C)	RH (%)
1	28.5	35	29.3	29	29.1	25	28.96	29.67
2	29.2	26	29.7	26	29.4	24	29.43	25.33
3	31.3	26	32.3	44	33.7	49	32.43	39.67
4	30.0	62	32.7	65	33.0	64	31.90	63.67
5	28.5	65	29.0	64	28.7	65	28.73	64.67
6	28.0	68	28.5	66	28.5	66	28.33	66.67
7	28.0	72	28.5	68	28.5	70	28.33	70.00
8	28.0	70	29.5	68	29.0	69	28.83	69.00
9	27.5	74	28.5	68	28.0	72	28.00	71.33

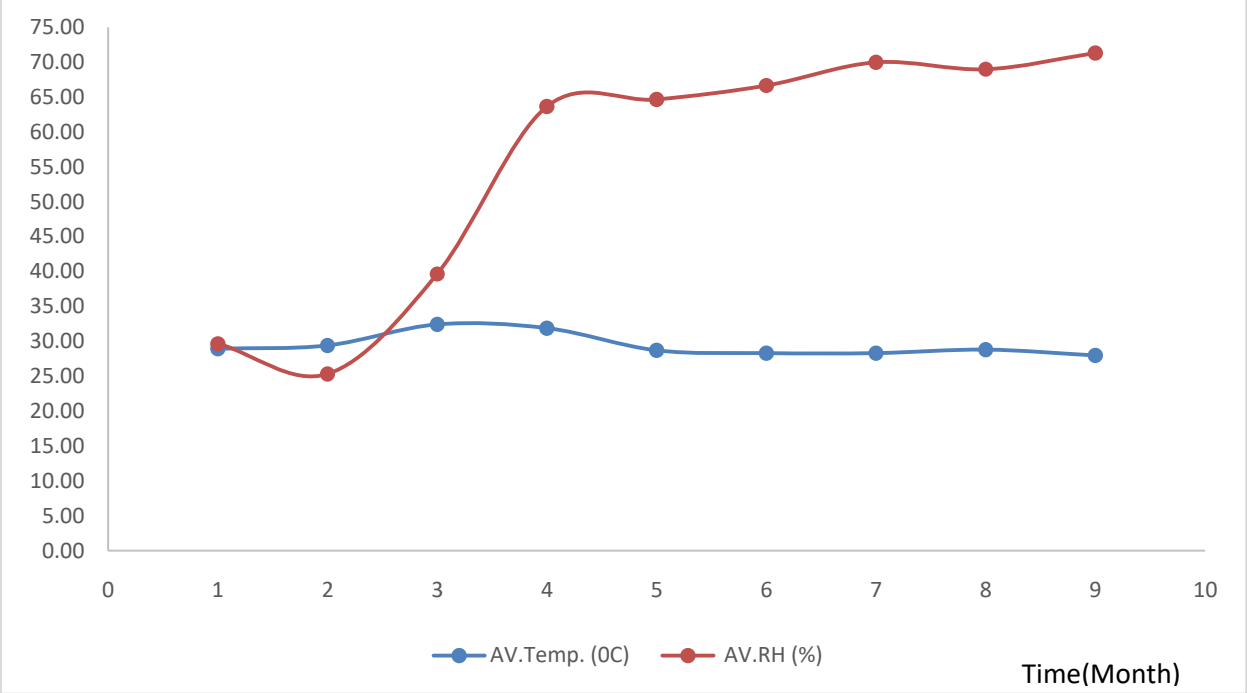

Fig.24: Plot of Average Temperature and Relative Humidity of Storage Environment during Storage against time

Table 82: Proximate analysis result of *Bombax costatum* sample before and after storage at 0% K_2CO_3 in Ceramic, metal, plastic, glass and control Constituents % 0f stored samples across containers

Constituents	Constituents % before storage	Ceramic	Metal	Plastic	Glass	Control
Carbohydrate	78.30	78.08	78.00	78.00	78.00	75.10
Protein	7.25	6.70	6.80	6.80	6.8	4.50
Moisture cont.	5.50	6.60	6.40	6.50	6.50	13.7
Fat	1.85	1.78	1.80	1.70	1.70	1.30
Ash	3.30	3.10	3.25	3.25	3.25	2.40
Fibre	3.80	3.74	3.75	3.75	3.75	3.30

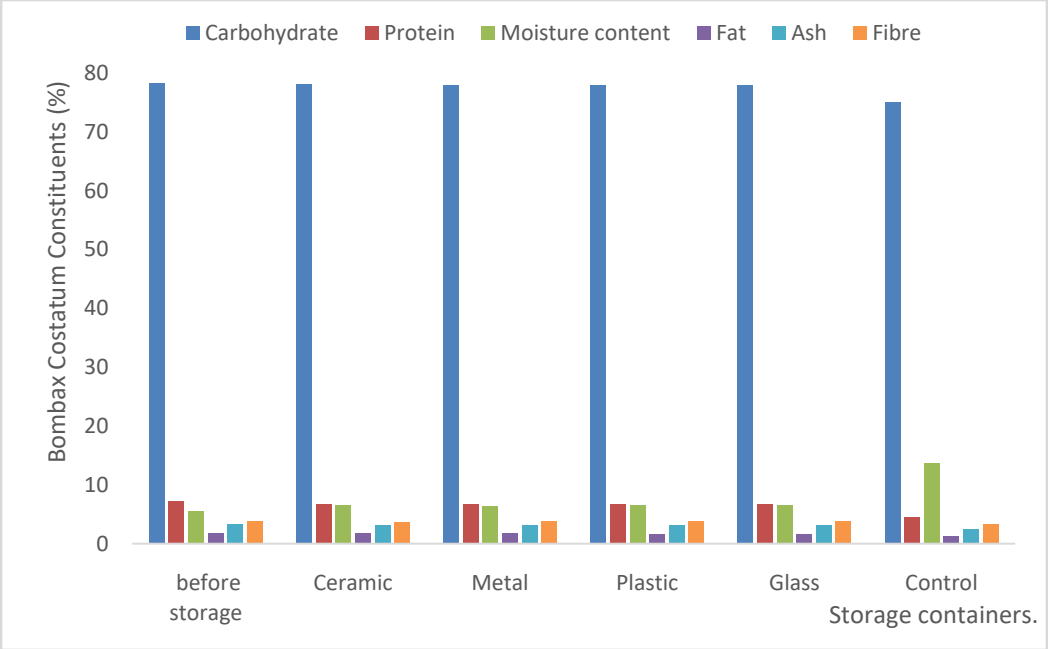

Figure 25: Proximate Constituents (%) of *Bombax costatum* samples before and after storage in different containers at 0% K_2CO_3

Table 83: Microbial Load Count of Bombax Costatum Samples using two media (Nutrient Agar (NA) and Maconcay Agar (MA)

Medium	Dilution Factor	Before Storage (logcfug-1)	Load after Storage (logcfug-1)				
			Control	Plastic	Glass	Ceramic	Metal
Nutrient Agar (Microbial Load)	10.1	3.95	4.50	3.96	3.97	3.97	3.90
	10.2	4.78	5.43	4.85	4.83	4.83	4.86
	10.3	5.60	6.18	5.74	5.70	5.70	5.73
	10.4	6.30	7.12	6.31	6.49	6.49	6.32
	10.5	7.03	7.88	7.28	7.27	7.27	7.04
Average		5.53	6.22	5.63	5.57	5.65	5.57
Maconcay Agar (Microbial load)	10.1	3.51	4.15	3.55	3.57	3.59	3.6
	10.2	4.14	5.11	4.5	4.31	4.3	4.40
	10.3	4.83	6.07	4.9	4.95	5	5.12
	10.4	5.34	7.04	5.61	5.70	5.98	5.96
	10.5	5.95	7.95	6.76	6.48	6.98	6.60
Average		4.74	6.06	5.06	5.00	5.13	5.14

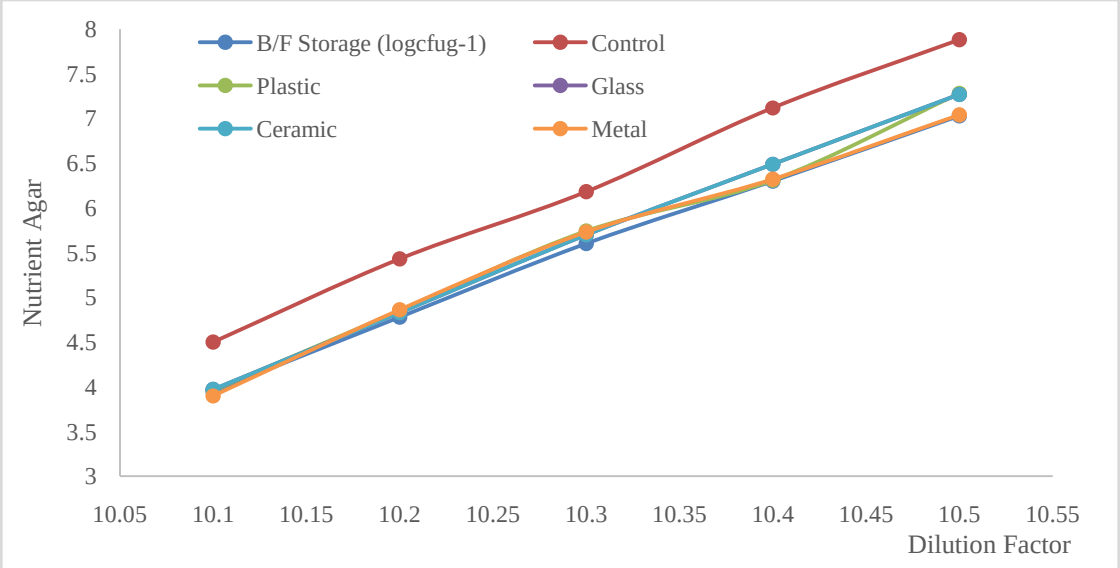

Figure 26: Microbial Load Count of Bombax Costatum Samples Nutrient Agar (NA) medium

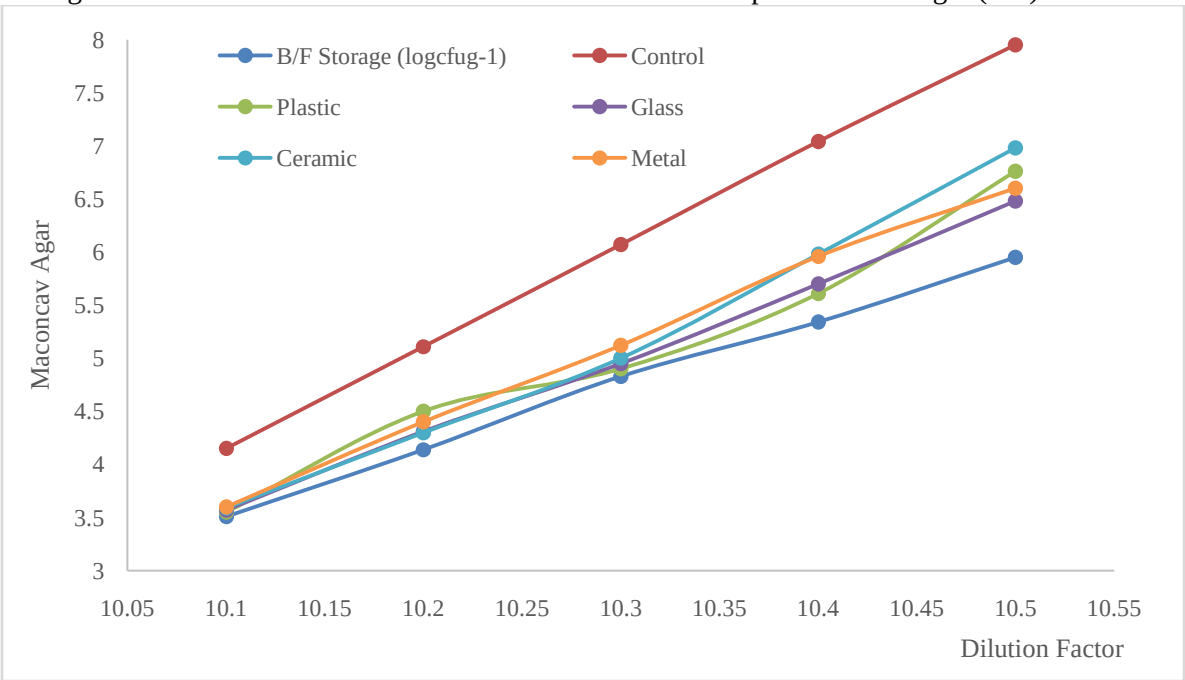

Figure 27: Microbial Load Count of Bombax Costatum Samples using Maconcay Agar (MA) medium

Table 84: Sensitivity of Microbial Load Count of Bombax Costatum Samples after Storage

Medium	Dilution Factor	Before Storage (%)	Control (%)	Plastic (%)	Glass (%)	Ceramic (%)	Metal (%)
NA (Microbial)	10.1	0.00	13.92	-0.25	0.51	0.51	-1.27
	10.2	0.00	13.60	1.46	1.05	1.05	1.67
	10.3	0.00	10.36	2.21	1.79	1.79	2.32
	10.4	0.00	13.02	0.16	3.02	3.02	0.32
	10.5	0.00	12.09	-0.71	3.41	3.41	0.14

MA (Microbial)	10.1	0.00	18.23	1.14	1.71	2.28	2.56
	10.2	0.00	23.43	1.45	4.11	3.86	6.28
	10.3	0.00	25.67	1.45	2.48	3.52	6.00
	10.4	0.00	31.84	5.06	6.74	11.99	11.61
	10.5	0.00	33.61	4.20	8.91	12.31	12.61

5.5 Moisture content

Table 76 and figures 20 contain average Moisture Content of powdered *Bombax Costatum* calyx samples treated with different levels of K_2CO_3 and stored hermetically in four different containers and control, for Nine Months. The moisture content for ceramic, Metal, Plastic, Glass and control containers as determined during the storage increased from 5.5 to 6.60%wb, 5.5 to 6.40%wb, 5.5 to 6.7%wb, 5.5 to 6.50%wb and 5.50 to 13.70%wb respectively. The result showed that all containers provided effective sealing and barrier from external moisture, as the level of moisture increase after nine months of storage was still within the acceptable moisture level for storage of flours. Except the control which showed substantial increase in moisture due to deliberate exposure to the room atmosphere. According to the result, metal provided more effective sealing, followed by glass, ceramic and lastly plastic. The result also showed that moisture content of samples decreases with increase in percentage of K_2CO_3 and increase with time. The effective performance of metal and glass containers is in agreement with result obtained for viscosity, bulk density, water absorption capacity, swelling capacity, proximate constituents and microbial load counts as determined in this study. The low percentage of moisture of *Bombax Costatum* calyx used for this study is in agreement with Mkaanem (2018) for leafy and calyx materials, especially for the purpose of storage. The supposition that moisture affects some functional properties of *Bombax Costatum* is justified by values of viscosity, bulk density, water absorption capacity and swelling capacity of samples exposed to the room environment, which absorbed more moisture than the sealed containers that were adequately protected from moisture invasion, as shown by the moisture content of the control sample.

5.6 Proximate Analysis

Tables 82-84 and figures 25-27 contain proximate composition analysis of *Bombax costatum* samples performed before and after nine months of storage in different containers and treatments. The analysis was done for carbohydrate, protein, moisture content, fat, ash and fibre. The analysis before storage showed that carbohydrate is 79.30, protein is 8.25%, Moisture content is 5.5%, fat is 0.85%, ash is 3.30 and fibre is 2.80%. After storage it was observed that all constituents were reasonably preserved by all containers at all treatments except control, with metal and glass providing more protection, followed by plastic and ceramic respectively. The control sample absorbed high percentage of moisture resulting to sharp drop in all other constituents after storage. The result in tables 82 to 84 confirms the effectiveness of the storage method and materials used for the study, as it gave adequate sealing and barrier against moisture permeability and other external factors such as temperature changes. The result generally agrees with Alobo and Arueya,(2017) that most food gums are polysaccharides. The percentage of carbohydrate and protein in the samples confirms that *Bombax costatum* is polysaccaride in nature, and justifies the high water absorption and viscosity values of *Bombax costatum* determined in this study. The low percentage of moisture agrees with Mkaanem (2018) for leafy and calyx materials. The low percentage of fat is in agreement with Muhammad et al (2017), for his phamacognostic standardization of Bmbaxcostatum stem bark. The fibre content of *Bombax costatum* indicates that it has high percentage of roughages and this is a peculiarity for carbohydrate foods(Muhammad *et al* 2017). The percentage of ash confirms that it contains alot of minerals and is medicinal in nature. This explains the reason why Bombax costatum is consumed by all categories of people (both old and young) and is used for medicinal purposes (Abubakar and Baminars 2017).

5.7 Bacteria and Microbial loads

Tables85-86 and figures 28-29 show the microbial and bacteria counts of *Bombax costatum* sampled from different storage containers in two media, that is Nutrient Agar and Macconcay Agar. The total viable count

(Tvc) of the initial sample (before storage) ranged from 3.51 logcf/g^{-1} to 7.03 logcfu/g^{-1}. After nine months storage of the sample, there was an increase in the microbial count which ranged from 4.15logcfu/g^{-1}- 7.95logcfu/$g^{-1}$for control, while samples stored in plastics, glass, ceramics and metal had microbial counts that ranged from 3.55logcfu/g^{-1}- 7.12logcfu/g^{-1}, 3.57logcfu/g^{-1} – 6.98logcfu/g^{-1}, 3.59logcfu/g^{-1} – 7.27logcfu/g^{-1} and 3.60logcfu/g^{-1} to 7.04logcfu/g^{-1} respectively. The overall mean TVC (Total Viable Count) obtain from this study ranged from 4.75logcfu/g^{-1} to 6.06logcfu/g^{-} The Total Viable Counts (TVC) was high on the control sample after storage with TVC ranging from 4.15logcfu/g^{-1} – 7.95logcfu/g^{-1}. This may be due to exposure of the sample, as it was not covered to avoid air or other particles to come in contact with it. Gilbert et al (2000), states that the presence of microbial load in foods may be due to harvesting methods and also the postharvest handling of such food. Again the control sample after storage has high number of bacteria colonies compared to those in containers, which also is an indication that it was more exposed to this microbes than the later. According to EC (2002), the Hazard Analysis and Critical control point total quality management (HACCP-TQM) technical guidelines lay down the microbial quality for raw foods where the food containing TVC less than 4.4 -6.69, 6.70-7.69 and greater than 7.69logcfu/g^{-1} is rated good, average, poor (spoiled food) respectively. The mean TVC in this study across dilutions and containers showed that Plastic ranged from 3.55logcfu/g^{-1}- 7.12logcfu/g^{-1}, glass ranged from 3.57logcfu/g^{-1} – 6.98logcfu/$g^{-1,}$ metal ranged from 3.60logcfu/g^{-1} to 7.04logcfu/g^{-1}, and ceramic ranged from3.59logcfu/g^{-1} – 7.27logcfu/g^{-1},the control had TVC ranged from 4.15logcfu/g^{-1}- 7.95logcfu/g^{-1}.The average TVC across all dilutions and containers ranged from 4.75logcfu/g^{-1} to 6.06logcfu/g^{-1}. Inline with HACCP-TQM technical guidelines, both the sample before storage and samples in containers after storage belong to the category of good food with glass presenting the best protection, followed by metal, ceramic, plastic and lastly control. This confirms that metal, glass and ceramic are actually good storage systems for storage of *Bombax costatum*, as it has equally preserved viscosity with minimum loss and provided good barrier for moisture permeability and protection of food proximate constituents, especially at 0% of K2CO3. The Presence of these micro organisms reflect that samples or storage containers have been exposed to contaminants and favourable condition for multiplication of the micro organisms (Aycicelc et al (2004). Gilbert et al (2000) also stated that plate count of microorganisms found in food is one of the microbiological indicator for food quality and most foods are regarded as harmful when they have large population of microorganisms, even if the organisms are not known to be pathogenic. Although the result obtained from this study is rated to be good according to HACCP –TQM, proper handling of food during storage should be ensured to avoid contamination to reduce risk of this microorganism getting into human body. The sensitivity percentage of samples was computed to range between -0.25% to 12.61% for sealed containers and 13.92% to 33.61% for control as shown in table 52.

CONCLUSION

The hermitic storage of *Bombax costatum* using ceramic, metal, glass and plastic containers presented effective performance. Both proximate composition analysis and microbial counts performed on *Bombax costatum* before and after storage showed that, the nutritional quality of the food was retained and protected across all containers. The same trend obtained for nutritional constituents, which presented carbohydrate and protein with the highest values repeated out after nine months of storage. Equally the safety of the stored food was established to be good for samples stored in metal and glass, and average for samples stored in plastic and ceramic containers, by comparing the total viable counts of microbes for each container with the HACCP-TQM scale.

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