Original article

# Implication of Different Storage Techniques on Physical Attributes of African Okra (*Abelmoschus esculentus* l. Moench)

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## ABSTRACT

This research successfully investigated the surmised implication of different storage techniques on the physical attributes of African okra. That is, employing palm baskets, open sack bags, perforated plastic and wooden cages were all explored in the storage process and statistical techniques of percentage weight loss, average temperature, degree of rottenness analysis as well as a colour variation of the candidate structures were thoroughly understudied. The result indicated weight losses across all the structures. For instance, the basket lost a weight of 0.636 kg, the open sack bag lost a weight of 5.282 kg, the perforated plastic structure lost a weight of 1.288 kg, and the wooden structure lost a weight of 4.765 kg on average. The basket structure was adjudged as the most appropriate structure for storage of African okra as the produce appeared to be fresher and edible when compared to others. The observed average temperature for the storage environment was 23.37$^{o}$C, which is still above the optimum temperature for storing okra crops which is 7-10$^{o}$C (45-50$^{o}$F), to maintain a very good quality. However, the situation under study showed a mark deviation from the mean as the highest temperature recorded on day 2 was 27.5$^{o}$C and the lowest was 20$^{o}$C on day 9. It suffices to note, that the appropriate temperature for African okra storage is somewhat environmental dependent, and a thorough qualitative analysis is needed in any instance, to be carried out in the supposed region to find out the most suitable temperature for storage as climatic signage changes with resident time. It is recommended that optimal storage conditions should be determined for any qualitative analysis, for environmental conditions often vary from place to place.

**Keywords:** African Okra, Temperature, Basket, Storage and Crop

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## INTRODUCTION

Okra is an edible and greenish vegetable. It belongs to the family of Malvaceae [1]. It is an acceptable vegetable with good nutritional and socioeconomic value [2]. The nutritional value of okra as a fruit and vegetable concerning vitamin contents is more than cereals and legumes [3]. According to [4], okra is a medicinal ingredient that contains dietary fibre, vitamin B, carbohydrates, iron, mineral salts, calcium and antioxidant substances. It is utilised in fresh form, canned, dried or grounded to powdery form. Okra has high moisture content and respiratory rates that make it perishable at post-harvest conditions [5]. As reported by BARI (2010) [6] and Mota *et al*. (2010) [5], the content of okra is 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrates, 1% fibre and 0.8% ash. The environmental condition of high temperature and low relative humidity contributes to the dehydration of okra at the post-harvest stage, making it have a short lifespan [7]. African Okra particularly is rich in magnesium, folate, fibre, antioxidants, and vitamins C, K1 and A. It can support healthy pregnancy, heart health, and blood sugar. It may even have anticancer properties. It is a multipurpose vegetable used as food, and in orthodox and traditional medicine [8]. This genetic resource together with indigenous knowledge can be harnessed to improve the livelihood of local communities. It is sad to state that amid all these important criteria of African okra, there is dearth of dedicated documented evident that holistically dealt extensively with African okra or even investigated its storage protocol against conventional type. Therefore, it is against this backdrop that this research is tilted towards probing into the implication of different storage techniques on physical attributes of Africa okra, vis-vis identifying the most storage appropriate structure for it storage amidst arrays of other jested types. It is pertinent to state that this research has successfully closed such a gap.

## MATERIALS AND METHODS

### Perforated Palm Basket

The native basket of 5 kg size was used as a storage structure and was purchased from the market as shown in Figure 1.

### Sack bag

The sack bag of a medium category was purchased from the market as shown in Figure 2.

**Figure 1: Basket and African Okra**

**Figure 2: Sack bag and Africa Okra**

**Perforated Plastic Can**

The plastic can of 5k was purchased from the mandate market Ilorin and was taken to the workshop. It was perforated using a hand drilling machine with a diameter of 1mm for each of the holes. It was perforated 350 points on the wall of the plastic can enable an exchange of air and moisture between the inside and outside environment of the storage structure.

**Wooden Cage**

The materials for the construction of this storage structure were purchased from the market. The wood for the wooden frames was carefully measured and cut into the required sizes. It was constructed in a rectangular form to enable stability during the period of storage. The net was used as the wall to control pests and insects from infecting the crop during the period of storage.

**Sample Collection**

The African okra crop was harvested from the Ilorin farm, in Nigeria and was taken to the laboratory of Nigerian Stored Products Research Institute Ilorin. The crops were carefully cleaned and sorted to remove damaged crops. The samples selected were at room temperature for at least an hour to allow for stabilization. The four storage structures (sack bag, perforated can, locally made basket and constructed wooden cage) were used to preserve the crop for the period of 14 days to determine the effect of temperature and relative humidity on the degree of rottenness, colour change, appearance and weight loss with respect to time.

**Experimental Protocol**

The storage structures were placed in the laboratory and labelled accordingly. Each of the structures was weighed using a weighing balance and the values were recorded as $W_1$. Thirty (30) pieces of African okra crops were put in each of the storage structures. Each of the structures with the okra fruits was weighed and recorded as $W_2$ on each day of observation/sampling during the storage period. The weight loss was determined by analysis method in line with the approach adopted by Babalola, *et al.* [7] that is using a meter balance with an accuracy of 0.01g and the percentage weight loss was recorded using equation 1 as a guide:

$$\text{Percentage weight loss} = \frac{W_2 - W_1}{W_2} \times 100 \quad (1)$$

**b. Determination of Temperature**

The ambient temperature was taken twice daily using a thermometer and recorded as $T_1$ and $T_2$ and the average temperature was determined as

$$T_{avg} = \frac{T_2 + T_1}{2} \quad (2)$$

where $T_{avg}$, $T_2$ and $T_1$ were average, final and initial temperature respectively.

**c. Determination of Relative Humidity**

The relative humidity of the environment was determined by using a hygrometer daily. The process was repeated daily for 14 days and within 7 days of preservation. A colour analyzer was used to check for colour change till the end of preservation, this process was repeated until the crops got rotten.

**d. Degree of Rottenness**

Degree of rottenness was determined through daily visual observation. The development of spot at the surface of African okra was an indication of rottenness. The percentage of rottenness was determined according to Equation 3

$$\text{Degree of Rottenness}(\%) = \frac{N_1 - N_2}{N_1} \quad (3)$$

Where $N_1$ = Initial number of the African okra at the first day of storage in each structure

$N_2$ = Number of the African okra without spots on each day of observation during the storage period.

The obtained results give the percentage of rotten African okra in each storage structure at each day of observation

**c. Determination of Colour Variation**

Red, Green and Blue (RGB) colour analyser/sensor was used to determine the maturity level through the observation of the colour change during the storage period. The RGB values of the African okra were read through the LED light coming from the sensor to the object that was placed 3cm from the sensor as incidence light. The light was reflected to the photodiode that was installed on the colour sensor. The colour analyser has software that is RGB colour reading program. The data received from the colour sensor undergoes processing by the software and the information about the results is displayed on the LCD. The sensor works with a paper calibrator with three basic colours. The value of R is read on red paper, G is read on green paper, and the value of B is read on blue paper using the sensor. The values are to show the level of discolouration of African okra due to pigment changes. The conversion of the RGB values to hexa colour code helps in identifying the colour appearance. The use of hexadecimal numbers is because of the human-friendly nature of how values are represented in binary code. The hex colour codes begin with a pound sign or hashtag (#), followed by six letters and /or numbers. The first two letters/numbers are for red, the next two are for green and the remaining two letters/numbers are for blue. The values of the hexa colour are between 00 and FF as compared to values of 0 to 255 in RGB.

## RESULTS

The results obtained after the storage of African okra for 14 days in the different storage containers were highlighted taking into consideration weight losses as a function of storage time days and overall implication of ambient temperature, relative humidity, associated rottenness, and colour variation was noted. The 48 hours rate of weight losses observed in the stored African okra crop for different storage structures as shown in Figure 3 indicated weight losses across all the structures. For instance, the basket lost 0.636 kg, the open sack bag lost a weight of 5.282 kg, the perforated plastic can lose a weight of 1.288 kg and the wooden can lost a weight of 4.765 kg on average as portrayed in Table 1. From Figure 3 it was glaring that okra fruit continues to lose weight as storage time increases in all the instances studied. However, Figure 3 shows that weight loss in basket structure was fair stable and happens to be the least in terms of weight loss when compared to rest. It was inferred that the basket structure is the most appropriate structure for storing African okra as the produce appeared fresher and edible compared to other structures. Findings here illustrate the fact that weight loss was conditioned by the degree/numbers/size of perforation which a storage container may have. For instance, the findings of Paulus *et al* [9] pointed out that a reduction in the water moisture content of produce often leads to loss of weight. A Similar observation was reported by Babalola *et al.* [7] opines weight loss generally is attributed to some storage factors like environmental temperature, relative humidity, rates of respiration and growth of microorganisms.

From Figure 4 the observed average temperature for the storage environment was 23.37$^{o}$C, which is still above the optimum temperature for storing okra crops which is 7-10$^{o}$C (45-50$^{o}$F), to maintain a very good quality as suggested by Chukunda and Nwonuala [10]. However, the situation under study showed a mark deviation from the mean as the highest temperature recorded on day 2 was 27.5°C and the lowest was 20°C on day 9 (Figure 4). The probable cause of the outrageous temperature was evidence of climatic variability which is well pronounced in the experimentation site Nigerian Stored Products Research Institute (NSPRI) Ilorin

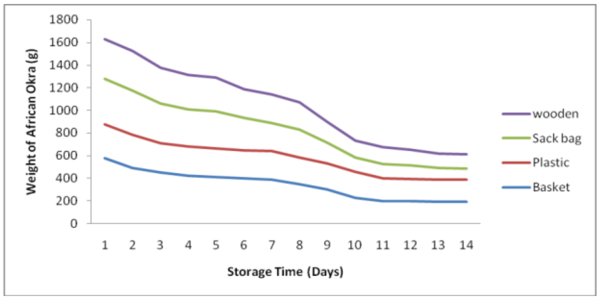


**Figure 3: Weight Loss Verses Storage Period in Different Storage Structure**

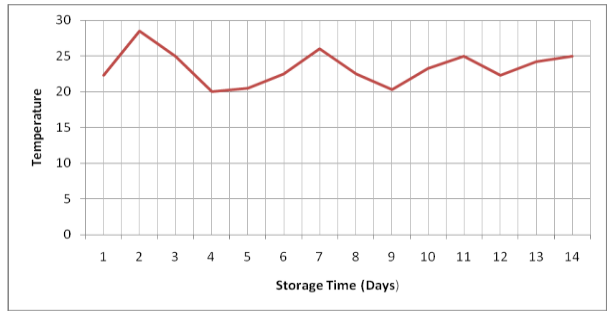


**Figure 4: Observed Temperature Pattern within the Storage Time**

Table 1: Overview of Weight Loss in Stored African Okra

| Sample Time (hr.) | Weight Loss% | | | |
|---|---|---|---|---|
| | Basket | Open Sack Bag | Perforated Plastic Can | Wooden Cage |
| 1st 48 | 1.397 | 3.266 | 0.741 | 0.314 |
| 2nd 48 | 0.208 | 6.281 | 0.987 | 2.997 |
| 3rd 48 | 1.689 | 10.552 | 4.267 | 13.497 |
| 4th 48 | 0.034 | 1.256 | 1.610 | 2.571 |
| 5th 48 | 0.251 | 14.321 | 0.637 | 10.04 |
| 6th 48 | 0.519 | 1.010 | 0.047 | 3.574 |
| 7th 48 | 0.346 | 0.289 | 0.047 | 0.365 |
| *Average* | *0.636* | *5.282* | *1.288* | *4.765* |

**Implication of Relative Humidity in African Okra Storage**

The average Relative Humidity (RH) in the storage environment was 72.39%, as deduced from Figure 5, the RH seems to be steady on days 1 and 2, and a slight increment on day 3 with 0.02% RH. It is obvious that the minimum RH is 62% for days 4 and 5 while the 79% on day 8. However, Boonyaritthongchai [11] confirms that RH of 95 to 100% is required to retard or slow down dehydration, pod toughening, and loss of fresh appearance. In this instance, the observed maximum RH was below the stated throughout the days of the studies. This probably may have accounted for the significant change in physical attributes observed during the experimentation. This probably may have accounted for moisture loss and a few shrivels of the produce observed across the samples on days 4 and 5. In the overall, the findings here strengthen existing the inverse relationship between temperature and RH as espoused by Dejene *et al.* [12] in storing agricultural products, a higher temperature generally requires a lower relative humidity to prevent excessive moisture loss from the product, while a lower temperature allows for a slightly higher relative humidity without promoting spoilage; essentially, the two factors are inversely related, meaning as temperature increases, the ideal relative humidity for storage should decrease to maintain optimal product quality.

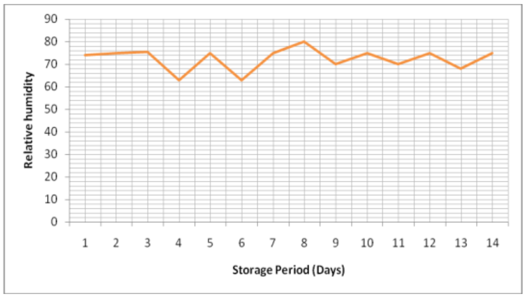


**Figure 5: Observed Relative Humidity during Storage Time.**

## Rottenness Incidence

Figure 6 shows the degree of the observed rottenness during storage time. For instance, it was observed that from one (1) day to day seven (7) the rate or degree of rottenness was approximately zero but somewhat increased in day seven (7). It can be inferred that the degree of rottenness is time-dependent generally, as all the storage structures seemingly experienced the same rate of rotten within two days of the window. Visual inspection of Figure 6 portended a scenario like that of linear inequalities that wooden structure rot is greater than that of the open sack bag and open sack bag greater than that of perforated plastic and the basket been the least. It is glaringly that amidst the explored structures basket structures have minimal rottenness perhaps less post-harvest loss

The storage period on day 14 showed that 40, 50, 55.8 and 60% rottenness had occurred in basket, plastic, sack bag and wooden net cages respectively. The result of this analysis shows that an optimum of 10 days is suggested to be better for basket storage. Though Chukunda *et al.* [10] recommended 11 days without taking into adequate consideration of environmental parameters. Chukunda *et al.* [10] reiterated that basket can prolong the life of crops for few days after harvest and 11 days will be accepted for storage in perforated plastic can, while 13 days of storage is advisable to use for open sack bag and 12 days will be ideal storage of okra crops using wooden net cage structure. It was observed that African okra crops should not be stored beyond day 12 irrespective of the environmental conditions in the storage structures. In the overall, the result of this research is in complete alignment with Chukunda *et al.* [10] and Babalola *et al.* [7].

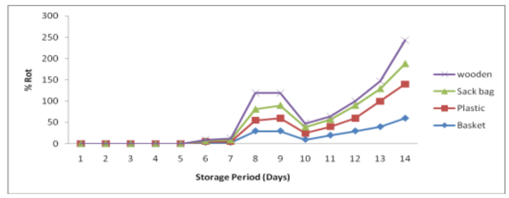


**Figure 5: Observed Degree of Rottenness**

## Colour Analysis

The results obtained after analysing the colour changes in African okra for seven (7) days in the different storage structures are shown in Figures 6,7,8, and 9 respectively. The colours signify Red, Green and Blue (RGB) values during the storage periods. The RGB is used to denote the maturity stages and the edibility of the African okra. During the period of storage of the crop in the basket the physical characteristics (colour) changed gradually from green to dark green (almost blackish green) because of the action of temperature and relative humidity on the crop as a function of time. The seeds changed from white (FFFFFF) to moccasin (FFE4B5) because of loss of moisture on both the crop itself and the seeds within the storage period. The RGB value of the seed was 255, 255, 255 or interpreted as 100% red, 100% green, and 100% blue was achieved by multiplying the first F (15) by 16 and the second F (15) by 1, then add the two together, which sums up 255 which is bright red, the third and fourth Fs indicated the value of green representation, while the fifth and sixth Fs gives the value of blue representation. The combination of these three values of RGB and hex colour code is what produces white. The colour change of these #FFE4B5 means the first two give 255, which is the value of red representation. E4 means E (14) and 4, by conversion, it will be 14 × 16 =224 and 4 × 1 = 4, total is 224 + 1 = 228. B5 means B (11) and 5; by conversion is 11 × 16 = 176 and 5 × 1 = 5, total is 181. It is explained; thus, on RGB colour system value, the red representation is 255, the green representation is 228 and the blue represents 181 is RGB (255,228,181), while the hex colour code was Moccasin for the seed of African okra at the seventh day of storage in the basket. The moccasin is a very light shade of brown with RGB coloured model as 100% red, 89.41% green and 70.98% blue. As illustrated in Figures 6, 7, 8 and 9.

Particularly, Figure 8 represents the open sack bag, during the period of storage of the crop, the physical characteristics (colour) changed from green to dark green (almost blackish green) because of the action of temperature and relative humidity on the crop with respect to the period of storage. The okra seeds changed from white with hexa colour code #FFFFFF to moccasin with hexa colour code #FFE4B5 as at seventh day because of loss of moisture on both the crop itself and the seeds within the storage period. There was a similar colour transformation in the basket with RGB colour model of 100% Red, 89.41% Green and 70.98% Blue in the content of the Moccasin colour. Figure 9 illustrates the use of wooden cage as storage structure for okra crops. The physical characteristics (colour) changed from green to dark green (almost blackish green) because of the action of temperature and relative humidity on the crop. This changing process occurred from white with hexadecimal colour code #FFFFFF to khaki with hexa colour code #F0E68C because of loss of moisture on both the crop itself and the seeds within the storage period. The output of the colour code on RGB colour representation is thus, the first letter F is 15 and the second number is 0 on hexadecimal number, that is by conversion, 15×16 = 240 and 0×1 = 0, total was 240. The third letter E is 14 and the fourth number is 6 on the hexadecimal number, 14 × 16 = 224 and 6×1=6, by addition is 230. The fifth number on the code is 8 and the sixth letter C is 12 by hexadecimal value, by conversion, 8×16=128 and 12×1=12, adding up to 140. The RGB value (240,230,140) means that there was a representation of Red by 240 or 94.12%, Green by 230 or 90.20% and Blue by 140 or 54.90 %. The moisture trapped in the storage structure was absorbed in the structure because it is made of wood and with time wetting the structure led to disruption in the drying process of the crop during preservation, thereby affecting the colour change with time. A similar incident was observed by Babarinde *et al.* [13] that okra changes in colour with the increase in storage time.

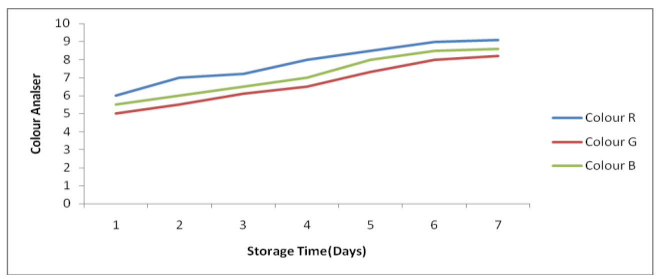


**Figure 6: Observed Colour Attribute in the Basket Structure**

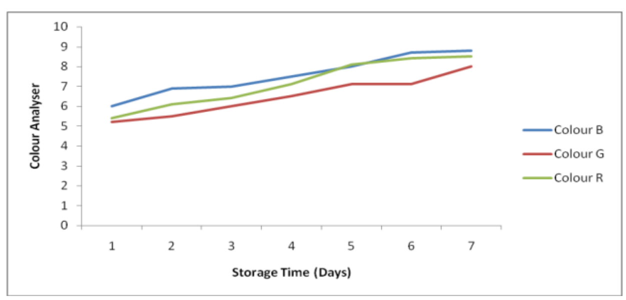


**Figure 7: Observed Colour Attribute in Perforated Plastic Can Structure**

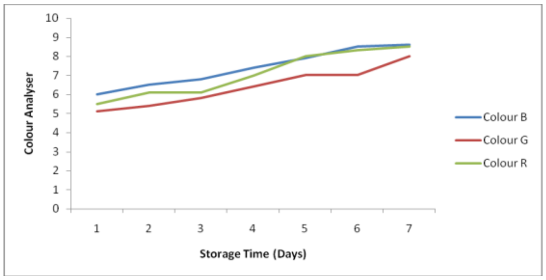


**Figure 8: Observed Colour Attribute in Perforated Sack Bag Structure**

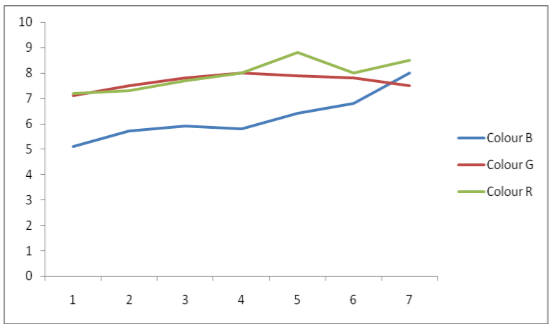


**Figure 9: Observed Colour Attribute in Wooden Net**

## DISCUSSION

It suffices to note, that the appropriate temperature for African okra storage is somewhat environmental dependent, and a thorough qualitative analysis is needed to be carried out in any supposed region to find out the most suitable temperature for its storage as climatic signage changes with resident time. Babalola *et al.* [7] spell out the implication of temperature in okra storage; thus, highlighting that incessant high temperature can increase the rate of respiration, which causes rapid evaporation and vice versa. Rates of respiration are tied to an increase in the temperature of the storage environment. An increase in rates of respiration will increase the heat production in the environment. Storage at higher temperature also leads to dehydration, yellowing, decay and loss of quality. When okra is stored in conducive temperature and environment it improves the shelf life with reduced rate of weight loss.

In addition, it is important to know that the storage environment could resist or inhibit the effects of fungi and bacterial action as exemplified here, especially for the first seven days of storage, and at the same time, the activities of microbes are less in basket structure and most active in wooden structure. The findings here are agreeable to the submission of Chukunda *et al.* [10] that fungi and bacterial activities are highly influenced by the environmental condition of storage.

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