Research Journal of Food Science and Nutrition
Volume 7(4), pages 111-119, October 2022
Article Number: B3DC44673
ISSN: 2536-7080
https://doi.org/10.31248/RJFSN2022.133
https://integrityresjournals.org/journal/RJFSN

Full Length Research

Evaluation of improved vegetable baskets for storage of *Amaranthus viridis* (green amanranths) and *Telfaria occidentalis* H. (fluted pumpkin leaves)

Olabisi A. Adekalu, Samuel A. Akande*, Titilope A. Fashanu, Andrews O. Adeiza and Israel O. Lawal

Nigerian Stored Products Research Institute (NSPRI), Headquarters, Km 3, Asa-Dam Road, P.M.B. 1489, Ilorin, Kwara State, Nigeria.

*Corresponding author. Email: akandesa@nspri.gov.ng; Tel: +234 8039693613.

Received 19th January 2022; Accepted 11 March 2022

ABSTRACT: The new vegetable baskets (VBs) were tested for effectiveness in the storage of fresh leafy vegetables. Freshly harvested *Amaranthus viridis* and *Telfaria occidentalis* H. were obtained from farms and transported to Nigerian Stored Products Research Institute (NSPRI), Ilorin, where they were sorted, washed and air-dried. Four different models; namely the pyramidal big basket (PBB), frustum big basket (FBB), polyethene lined small basket (PSB) and foam-lined small basket (FSB) were used while the control sample was left open in a plastic crate on the shelf. The set-up was monitored on 24 hourly bases for wetting, physiological weight loss (PWL) and physical observations until decay was observed. Sensory attributes and physicochemical properties were evaluated before and after storage using standard methods. Results obtained indicated that fresh green amaranths and fluted pumpkin leaves were rated higher in colour and appearance than the stored leaves. The PWL ranged from 16.18–100% and 18.42–99.62% for *A. viridis* and *T. occidentalis* H. respectively. The proximate composition analysis conducted showed that moisture, protein, fibre and ash contents ranged between 66.45-89.32, 20.32-44.36, 12.18-41.17, 5.48-15.40% respectively for *A. viridis* and 65.34-79.94, 12.57-26.09, 19.37-44.12 and 3.31-11.29% respectively for *T. occidentalis*. Conclusively, PBB, FSB and PSB conserved more weight, chlorophyll and vitamin C contents respectively in *A. viridis*; while FSB and PSB conserved more weight and chlorophyll respectively in *T. occidentalis* H. Thus, the three models; PBB, PSB and FSB were most effective in the storage of *A. viridis* and *T. occidentalis* H.

Keywords: Dietary fibre, evaporative cooling, leafy vegetables, perishable crops, vitamins, minerals.

INTRODUCTION

Vegetable production has great economic importance in the agricultural sector of which the value chain can provide income, reduce poverty and generate employment (Adeoye, 2020). Leafy vegetables perform a key role in the diet of humans, most especially the provision of some water and fat-soluble vitamins, dietary fibre and appreciable quantities of other minerals such as iron, calcium including carotenoids, riboflavin and folic acid (Sobowale *et al*., 2010; Kamalajja *et al*., 2019; Park and Ellis, 2020). Essentially, they are important in maintaining good health in humans due to the various antioxidant properties of their components (Ubani and Okonkwo, 2011; Gogo *et al*., 2016; Adeoye, 2020; Park and Ellis, 2020).

However, these crops in their fresh forms are highly perishable because they contain a high amount of moisture (Sobowale *et al*., 2010; Ubani and Okonkwo, 2011; Ibeawuchi *et al*., 2015). Also, the fact that vegetables are still living entities even after harvest makes them carry out their normal physiological activities of respiration (absorbing and releasing gases with other materials from and to the environment); pre-dispose them to high rate of impairment on transit and storage (Ibeawuchi *et al*., 2015). These physiological activities are even more rapid under the conditions of high temperature and humidity such as we have in the West African sub-region (Ubani and Okonkwo, 2011; Ibeawuchi *et al*., 2015). These factors and many others have led to heavy post-harvest losses being encountered in the vegetable value chain that no one can exactly know how to quantify what is being lost between harvest and consumption (Ibeawuchi *et al*., 2015).

The common sights of vegetable handlings in the value chain include; open bulk packaging in vehicles or packaging in polypropylene bags and stacked in vehicles for transportation, marketing and home storage (Ubani and Okonkwo, 2011). This practice has added to the problems of postharvest losses considerably in the country. To achieve meaningful results in postharvest losses reduction in Nigeria, there is a need for the adoption of appropriate technologies that are adequate, available, affordable and easily adaptable to the farmers (Iwuagwu *et al*., 2014).

Thus, the Nigeria Stored Products Research Institute (NSPRI) has developed a technology known as Vegetable Baskets (VBs) of varying models for improved storage of leafy vegetables during transportation, marketing and storage; preventing the exposure of the product to ambient temperature and relative humidity. The vegetable basket was initially designed, constructed and popularized by NSPRI (Iwuagwu *et al*., 2014). The VBs is an evaporative coolant structure (ECS) that works on the principle of adiabatic cooling of unsaturated air when in apposition with water for a sufficient period, causing evaporation that produces cooling effects by lowering the temperature and increasing the relative humidity of the enclosed storage chamber, suitable for prolonging the shelf life of leafy vegetables in the fresh form (Liberty *et al*., 2013; Iwuagwu *et al*., 2014). It has been used in the storage of *Telfairia occidentlis* H. successfully for six days and various other vegetables and fruits (Ubani and Okonkwo, 2011; Iwuagwu et al., 2014).

Therefore, in view of promotion of adoption of these VBs as the technology for fresh storage of leafy vegetables in Nigeria during transportation, marketing and home storage, improved models have been produced by NSPRI. The best four (4) identified new models need to be tested for further popularization. Hence, the main objective of this study is to test the new NSPRI VBs for effectiveness in the storage of two major leafy vegetables (green amaranths and fluted pumpkin leaves) in the fresh form by evaluating their sensory attributes, physiological weight loss (PWL) and physicochemical properties during storage.

MATERIALS AND METHODS

Sources and description of materials

Chemicals and reagents utilized were of analytical grade and were procured from accredited dealers. Four different models of modified vegetable baskets (VBs) were acquired from NSPRI (Figure 1). The *Amaranthus viridis* (green amaranth) was obtained from Oko-Olowo Area, Ilorin while *Telfaria occidentlis* H. (fluted pumpkin leaves) was obtained from Flower-Garden Vegetable Cluster Farm GRA, Ilorin, Kwara State, Nigeria.

The baskets were made up of two big and two small sizes with different shapes and volumes; the first one from left (Figure 1) was foam-lined truncated rectangular pyramidal shape big basket (PBB) and the volume was 55.664 litres. The second was foam-lined frustum (bucket) shaped big basket (FBB) and the volume was 54.428 litres. The two small baskets were similar; frustum (bucket) shaped. One is a polypropylene lined small basket (PSB) that had a volume of 19.226 litres while the other was a foam-lined small basket (FSB) and its volume was 19.846 litres.

Sample treatments

Green amaranths

The method of Ubani and Okonkwo (2011) was modified and used in the treatment of green amaranths *(Amaranthus viridis*). The leaves were being sorted, thoroughly washed with chlorinated water to remove field sands, and allowed to air-dry. Various portions were weighed and then loaded into the various vegetable baskets (VBs); the big baskets (PBB and FBB) were loaded with 3.0 kg each of green amaranths leaves while the small baskets (PSB and FSB) and the control were loaded with 1.5 kg each of green amaranths. The set-up was monitored on 24 hourly bases for wetting, weight loss and physical observations until decay was noticed. The two big baskets (PSB and FBB) and the small baskets (PSB and FSB) were being sprinkled with water until the surface were soaked while the control sample was left without supply of water (being the common practices of most handlers). The sensory evaluation was conducted on the vegetable samples to compare the attributes of colour, appearance, odour, decay and overall acceptability of the vegetables both at the beginning and the termination of the set-up. Physicochemical and nutritional parameters were also monitored at the beginning and termination of the study. These include; pH, moisture, vitamin C, crude fibre and chlorophyll contents.

Fluted pumpkin leaves

The method of Ubani and Okonkwo (2011) was modified and used in the treatment of fluted pumpkin leaves (*Telfiaria occidentalis* H.). The leaves were sorted and washed thoroughly with chlorinated water and allowed to air dry for some hours before being loaded into the various vegetable baskets. The big baskets (PBB and FBB) were loaded with 1.0 kg each of fluted pumpkin leaves while the

Figure 1. Four different models of new vegetable baskets (from left; foam lined pyramidal shaped big basket denoted as PBB, foam lined frustum (bucket) shaped big basket denoted as FBB, polypropylene lined frustum (bucket) shaped small basket PSB and foam lined frustum (bucket) shaped small basket. FSB respectively).

small baskets (PSB and FSB) and control (ambient) were loaded with 0.5 kg of fluted pumpkin leaves each. The two big baskets (PSB and FBB) and the small baskets (PSB and FSB) were being sprinkled with water until the surface were soaked while the control sample was left without supply of water (being the common practices of most handlers). The sensory evaluation was conducted to compare the attributes (colour, appearance, odour, decay and overall acceptability) both at the beginning and the termination of the study. Physicochemical and nutritional parameters were also monitored at the beginning and termination of the study. These include; pH, moisture, vitamin C, fibre and chlorophyll contents.

Sensory evaluation

The method reported by Sobowale *et al.* (2010) was modified and used in the determination of sensory qualities of freshly harvested and stored vegetables. Attributes such as; colour, appearance, odour, the incidence of decay and overall acceptability were tested on a 9-point hedonic scale where 9 represents like extremely, 8 represents like very much, 7 represents like moderately, 6 represents like, 5 represents neither like nor dislike, 4 represents dislike, 3 represents dislike moderately, 2 represents dislike very much and 1 represents dislike extremely.

Determination of physiological weight loss (PWL)

Physiological weight loss was estimated by using a digital balance (CAMRY ACS-30-JE11) cumulatively, expressed as a percentage using the following relation as reported By Ambuko *et al.* (2017) and Ayanda *et al*. (2019):

$$\text{Physiological Weight Loss } (\%) = \frac{\text{W1} - \text{W2}}{\text{W1}} \times 100$$

Where: W_1 = Initial weight, W_2 = Final weight.

Chemical analysis

The methods of the Association of Official Analytical Chemists (AOAC, 2019) was used in the determination of the chemical properties (pH determination, moisture contents, crude protein content, ash content, crude fibre content, vitamin C content and chlorophyll content) of leafy vegetables.

Statistical analysis

All data collected were pooled and partitioned through the use of One-Way Analysis of Variance (ANOVA) on SPSS Software Package Version 20.0.0 (IBM Statistics Inc). Means were separated by the use of the New Duncan Multiple Range F-Test (DMRT) at a 95% confidence limit ($p \leq 0.05$).

RESULTS AND DISCUSSION

Effect of storage method on sensory attributes of *Amaranthus viridis* and *Telfaria occidentalis* H.

The various models of vegetable baskets (VBs) tested in this study were able to keep fresh green amaranths for 96 hours (4 days) while the control got rotten after 48 hours (2 days). Fresh fluted pumpkin leaves were stored for a period of 144 hours (6 days) using the same set of vegetable baskets, while the control got withered and badly affected due to the effect of uncontrolled harsh weather. The sensory attributes of fresh green amaranths and fluted pumpkin leaves before and after storage were as shown (Table 1).

The results showed that the fresh green amaranths sample was rated best in colour, appearance and absence of decay over those stored in different vegetable baskets. Nevertheless, there was no significant difference ($p = 0.05$) in the overall acceptability of the fresh green amaranths and the ones stored with pyramidal-shaped big baskets (PBB). Similarly, the fresh fluted pumpkin was rated best in colour and appearance over those stored with various vegetable baskets. Furthermore, the results showed no significant difference ($p = 0.05$) in the incidence of decay in all the four different baskets (PBB, FBB, PSB, and FSB) as well as the overall acceptability of fresh fluted pumpkin leaves and those stored with the two small baskets (PSB and FSB).

Effect of storage method on physiological weight loss (%) of *Amaranthus viridis* and *Telfaria occidentalis* H.

The physiological weight damage or dropping (%) of green amaranths and fluted pumpkin leaves were as presented (Figure 2). Accordingly, the sample stored in the pyramidal big baskets (PBB) lost 16.18% of initial weight, the frustum big basket (FBB) lost 20.78% of its weight, the polypropylene lined small basket (PSB) lost 25.81%, the foam-lined small basket (FSB) lost 17.05% while the ambient or control has gone bad (100%) within the same period. This result was represented on a pie chart for clarity as shown (Figure 4 left). Inherently, the result has demonstrated the efficiencies or effectiveness of pyramid big basket (PBB) and the foam-lined small basket (FSB) in the storage of green amaranths over the other two models of vegetable baskets.

Furthermore, after six days' storage period of fresh fluted pumpkin leaves, the sample stored in the pyramid big basket (PBB) lost 18.42%, frustum big basket (FBB) lost 28.95%, polypropylene lined small basket (PSB) lost 24.68%, foam-lined small basket (FSB) lost 17.57% while the control lost 99.62% of its original weight. These results were represented on the pie chart as shown (Figure 4 right). Generally, the trends of the physiological weight loss in this study have reflected the extent of wilting where vegetables stored with baskets decayed at a much slower rate compared to those kept under the ambient room conditions. Similarly, some other authors reported similar results of higher physiological weigh loss in the ambient stored sample compared to treated ones. For instance, when ECS was used in the storage of *Amaranthus viridis* and *Telfaria occidentalis* H. in separate studies respectively (Ambuko et al., 2017; Balogun and Ariahu, 2020). Also, Ubani and Okonkwo (2011) reported that vegetable baskets extended the shelf life and retained the freshness of *Telfaria occidentalis* H. for six days.

Physiological weight loss (PWL) during storage is an important index or factor to consider for choosing an evaporative cooling structure. Generally, physiological losses in weight of different leafy vegetables during storage might be due to either transpiration water loss and/or falling/decay of leaves. Transpiration water loss is one of the physiological processes that result in deterioration of leafy vegetables which results in loss of freshness and leafy vegetables may be rendered unsalable if they lose more than 3% of their original fresh weight (Ambuko et al., 2017; Balogun and Ariahu, 2020).

Effect of storage method on the proximate compositions of *Amaranthus viridis* and *Telfaria occidentalis* H.

The effect of storage with vegetable baskets on the proximate compositions of green amaranths and fluted pumpkin leaves were as shown (Table 2). The results showed that moisture, protein and ash contents of green amaranths and fluted pumpkin leaves decreased significantly ($p = 0.05$) during storage (4-6 days). Notwithstanding, the crude fibre contents of green amaranths increased significantly ($p = 0.05$) in samples stored with the small baskets (PSB and FSB) while that of fluted pumpkin leaves increased significantly ($p = 0.05$) in samples stored with frustum big basket (FBB) and foam-lined small basket (FSB). Increased crude fibre contents observed in this study during storage might probably indicate the progression of growth in the vegetable tissues during the storage period. The ash content of the vegetables is directly proportional to the mineral contents and the reduction in mineral contents is possible during storage probably because of various metabolic processes occurring in the tissues since leafy vegetables are still physiologically alive even after harvest. Furthermore, no significant difference ($p = 0.05$) was observed in the moisture contents of green amaranths stored in baskets PBB, PSB and FSB; and that of fluted pumpkin leaves stored in baskets PBB and PSB. However, most of the parameters reported in this work were close to available data while some were relatively higher. For instance, we reported the protein content of fresh *T. occidentalis* to be 26.09% while Ifesan *et al*. (2014) reported the protein content of fresh and fermented *T. occidentalis* as 24.29 and 25.65% respectively. On the contrary, the protein content reported in this work for *A. viridis* was as high as 44.35% but Gogo *et al*. (2016) reported the protein content of the same variety as 4 to 5%.

Table 1. Sensory attributes of the fresh and stored vegetables (*Amaranthus viridis* and *Telfiaria occidentalis* H.).

Sample	Colour	Appearance	Odour	Incidence of decay	Overall acceptability
Amaranthus viridis					
Fresh	$8.20^{d}\pm0.45$	$8.60^{c}\pm0.55$	$8.80^{c}\pm0.45$	$8.60^{d}\pm0.55$	$8.20^{d}\pm0.45$
PBB	$7.40^{c}\pm0.55$	$7.60^{b}\pm0.55$	$8.20^{c}\pm0.84$	$7.20^{c}\pm0.45$	$7.80^{d}\pm0.45$
FBB	$7.00^{bc}\pm0.00$	$7.40^{b}\pm0.55$	$8.20^{c}\pm0.84$	$6.40^{b}\pm0.55$	$7.00^{c}\pm0.00$
PSB	$7.00^{bc}\pm0.71$	$7.20^{b}\pm0.45$	$6.80^{b}\pm0.45$	$6.20^{b}\pm0.45$	$6.80^{c}\pm0.84$
FSB	$6.40^{bc}\pm0.89$	$6.80^{b}\pm0.84$	$6.60^{b}\pm0.55$	$6.40^{b}\pm0.55$	$6.20^{b}\pm0.45$
Control	$1.20^{a}\pm0.45$	$1.20^{a}\pm0.45$	$2.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$1.20^{a}\pm0.45$
Telfaiaria occidentalis H.					
Fresh	$8.60^{b}\pm0.55$	$8.80^{c}\pm0.45$	$8.60^{a}\pm0.55$	$8.60^{a}\pm0.55$	$8.40^{c}\pm0.55$
PBB	$6.00^{a}\pm1.87$	$5.80^{b}\pm1.10$	$8.40^{a}\pm1.34$	$7.60^{a}\pm2.07$	$6.20^{b}\pm2.05$
FBB	$6.00^{a}\pm0.71$	$5.60^{b}\pm0.89$	$7.60^{a}\pm2.19$	$7.20^{a}\pm2.17$	$6.00^{b}\pm1.58$
PSB	$6.20^{a}\pm1.48$	$6.60^{b}\pm0.89$	$7.20^{a}\pm2.17$	$7.80^{a}\pm1.10$	$7.00^{bc}\pm0.71$
FSB	$6.20^{a}\pm1.48$	$6.00^{b}\pm0.71$	$8.00^{a}\pm1.41$	$7.60^{a}\pm1.67$	$7.00^{bc}\pm0.71$
Control	$6.00^{a}\pm1.00$	$2.80^{a}\pm1.48$	$6.80^{a}\pm2.68$	$6.40^{a}\pm3.58$	$1.40^{a}\pm0.55$

Results showed Mean ± SD of 10 panelist's members. Means with the same superscripts are not significantly different ($p>0.05$). PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket.

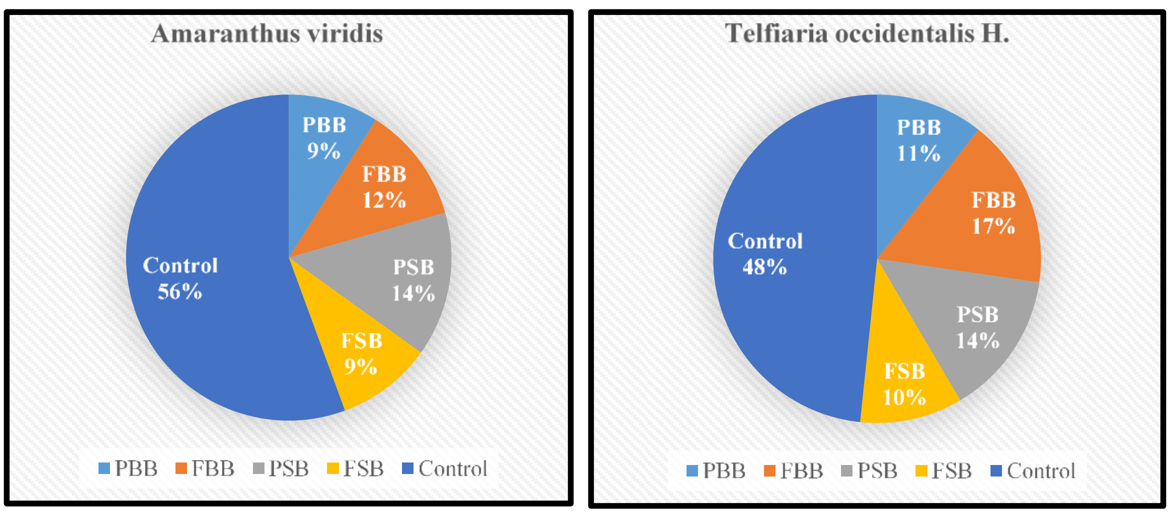

Figure 2. Weight loss (%) of *Amaranths* spp. and *Telfaria occidentalis* H. in different VBs during storage (4-6 days). PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket.

Effect of storage method on the pH values of *Amaranthus viridis* and *Telfaria occidentalis* H.

The influence of storage with different vegetable baskets on the pH of green amaranths and fluted pumpkin leaves were as presented in Figure 3. The observed pH values for fresh and stored fluted pumpkin (left) ranged from 5.99 to 7.12 units while the observed values of pH for fresh and stored green amaranths (right) was between 7.63 to 8.23 units. These properties have shown that whereas fluted pumpkin is slightly acidic, green amaranth is naturally alkaline. Not only that, storage with vegetable baskets caused a decrease in the acidity of fluted pumpkin leaves (increase in pH values) while the same process had minimal effect on the alkalinity of green amaranths.

Effect of storage method on losses in total chlorophyll content (%) of *Amaranthus viridis* and *Telfaria occidentalis* H.

The chlorophyll content is an important quality parameter

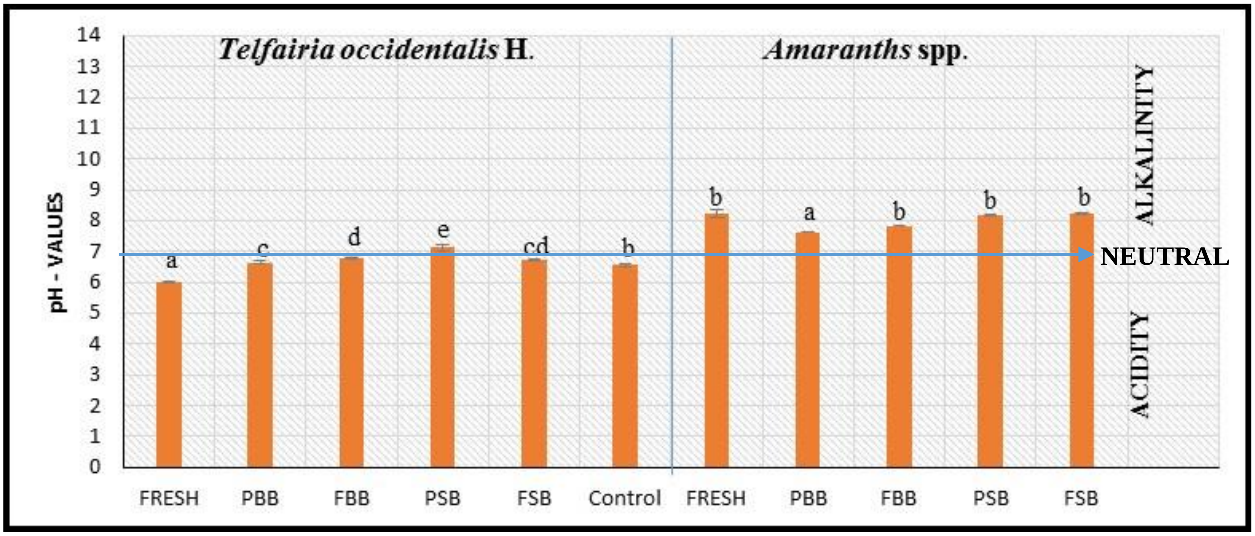

Figure 3. The effect of storage on pH values of *Amaranthus viridis* (green amaranths) and *Telfaria occidentalis* H. (fluted pumpkin) in different vegetable baskets during storage (4-6 days). Each bar represents mean of triplicate readings while the error bar represents the standard deviation of each reading. Bars with different alphabets in each side of the chart are significantly (p=0.05) different. PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket.

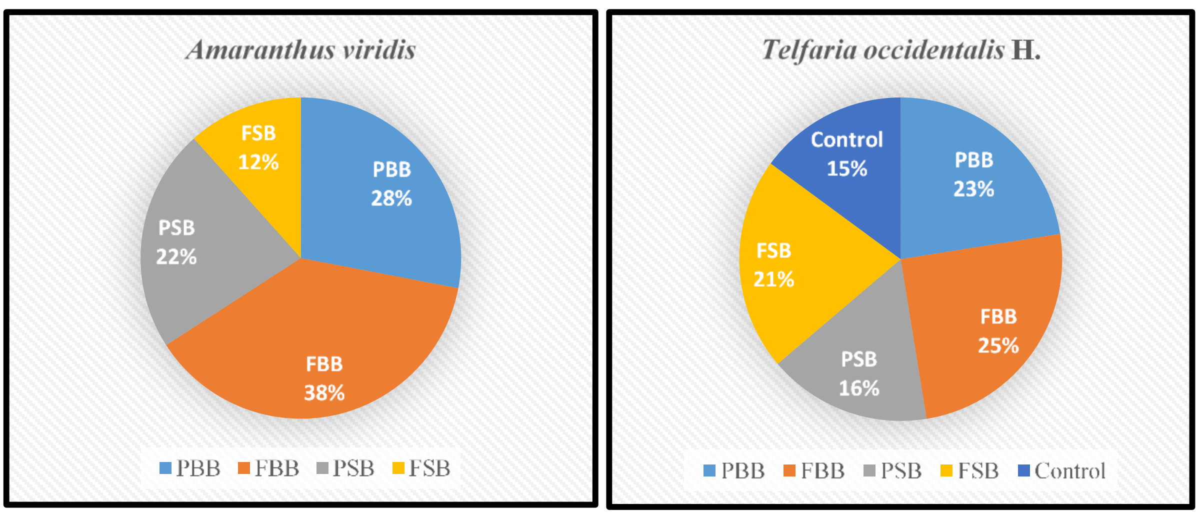

Figure 4. Effect of storage (4-6 days) in different vegetable baskets on the percentage loss in total chlorophyll content of *Amaranthus viridis* (green amaranths) and *Telfaria occidentalis* H. (fluted pumpkin leaves). PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket.

that determines the freshness and appeal of a leafy vegetable. The percentage loss in total chlorophyll contents during storage of *A. viridis* (green amaranths) and *T. occidentalis* H. (Fluted pumpkin) stored with different VBs was as shown in Figure 4. After four (4) days of storage, the total chlorophyll contents of fresh and stored green amaranths varied from 2.84 to 16.04 mg/100g dry weight. The results showed a significant decrease ($p = 0.05$) in the total chlorophyll content during storage. It was observed that green amaranths stored with PBB lost 60.85% of their original total chlorophyll content, those stored with FBB lost 82.29% of their original total chlorophyll, those stored with PSB lost 48.88% of their original total chlorophyll contents while those stored with FSB lost 25.25% of its original total chlorophyll.

These results were presented as a pie chart for clarity

Table 2. Effect of storage (4-6 days) with vegetable baskets on the proximate compositions (dry basis) of *Amaranthus viridis* (green amaranths) and *Telfaria occidentalis* H. (Fluted pumpkin).

Sample	***Amaranthus viridis***				***Telfaria occidentalis* H.**			
	Moisture (%)	**Protein (%)**	**Fibre (%)**	**Ash (%)**	**Moisture (%)**	**Protein (%)**	**Fibre (%)**	**Ash (%)**
Fresh	$89.32^{c} \pm 0.67$	$44.35^{c} \pm 2.71$	$36.51^{b} \pm 5.21$	$15.40^{c} \pm 1.38$	$79.94^{d} \pm 0.29$	$26.09^{c} \pm 1.16$	$26.09^{c} \pm 0.21$	$11.29^{d} \pm 0.85$
PBB	$81.59^{b} \pm 1.37$	$37.84^{bc} \pm 2.74$	$16.58^{a} \pm 1.23$	$8.82^{b} \pm 1.13$	$76.62^{bc} \pm 0.42$	$21.22^{c} \pm 3.90$	$23.27^{b} \pm 0.42$	$9.02^{c} \pm 0.18$
FBB	$66.45^{a} \pm 2.51$	$20.32^{a} \pm 1.46$	$12.18^{a} \pm 4.85$	$5.48^{a} \pm 6.32$	$65.70^{a} \pm 0.39$	$15.80^{b} \pm 0.07$	$37.99^{d} \pm 0.46$	$7.12^{b} \pm 1.14$
PSB	$80.74^{b} \pm 0.27$	$33.81^{b} \pm 0.46$	$38.45^{b} \pm 7.70$	$8.89^{b} \pm 1.29$	$76.93^{c} \pm 0.41$	$23.67^{bc} \pm 1.94$	$19.37^{a} \pm 1.82$	$9.66^{c} \pm 0.43$
FSB	$83.63^{b} \pm 3.57$	$42.26^{c} \pm 8.19$	$41.17^{b} \pm 13.33$	$6.91^{ab} \pm 1.01$	$75.93^{b} \pm 0.41$	$23.71^{bc} \pm 0.27$	$44.12^{e} \pm 1.61$	$7.74^{b} \pm 0.26$
Ambient	NAA	NAA	NAA	NAA	$65.34^{a} \pm 0.09$	$12.57^{a} \pm 2.27$	$23.70^{b} \pm 1.76$	$3.31^{a} \pm 0.51$

Results show Mean ± SD of triplicate determinations. Means with different superscripts along the same column are significantly (p=0.05) different. *Amaranths viridis*. was stored for 96 hours (4 days) while *Telfaria occidentalis* H. was stored for 144 hours (6 days). NAA=not available for analysis). PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket; Ambient=Control.

(Figure 4 left). The total chlorophyll contents of fresh and stored fluted pumpkin leaves ranged from 1.72 to 9.71 mg/100g dry weight. A significant decrease (p = 0.05) in total chlorophyll contents was recorded during storage (6 days) of fluted pumpkin leaves. Fluted pumpkin leaves stored with PBB lost 74.25%, those stored with FBB lost 82.29%, those stored with PSB lost 53.96%, those stored with FSB lost 70.24% while the control sample (stored at ambient) lost 49.23%. The results were presented as a pie chart for clarity (Figure 4 right). The chlorophyll content of leaf tissue is directly related to the amount of light received by the tissue. Minimal loss in total chlorophyll was experienced by the control sample of fluted pumpkin leaves probably because the leaves were opened to daylight while others were enclosed.

Effect of storage method on changes in vitamin C (ascorbic acid) content of *Amaranthus viridis* and *Telfaria occidentalis* H.

The effect of storage (4–6 days) with vegetable baskets on the changes in vitamin C contents of green amaranths and fluted pumpkin leaves were as presented (Figure 5). The vitamin C content of green amaranths stored with different vegetable baskets ranged from 38.60 to 86.42 mg/100g dry weight. A significant decrease (p = 0.05) in vitamin C contents of green amaranths was recorded after storage (4 days). The green amaranths stored with PBB lost 29.19% of their initial vitamin C content, those stored with FBB lost 55.33% of their original vitamin C contents, green amaranths stored with PSB lost 31.1% of their original vitamin C content while those stored with FSB lost 43.1% of its original vitamin C content. The observation was represented on the pie chart in Figure 5 (left). The vitamin C content of fluted pumpkin leaves stored with different vegetable baskets (6 days) ranged from 68.67 to 147.48 mg/100g dry weight. Conversely, there was a significant increase (p = 0.05) in the vitamin C contents of stored fluted pumpkin leaves in all the various baskets including the control sample. Fluted pumpkin leaves stored with PBB gained 53.44% of their original vitamin C content during storage, those stored with FBB gained 3.65% of their original vitamin C content, the leaves stored with PSB gained 4.92% of the original vitamin C content, those stored with FSB gained 32.09% of its original vitamin C content while the control sample also gained 16.41% of its original vitamin C content. These observations were presented on the pie chart for clarity (Figure 5 right). The vitamin C content reported in this study (86.42 and 147.48 mg/100g for *A. viridis* and *T. occidentalis* respectively) could be well compared with available data; Solanke and Awonorin (2002) reported the vitamin C content of *T. occidentalis* as 221.1 mg/100g dry weight, Ariahu and Egwujeh (2009) reported the vitamin C contents of *A. hybridus* and *T. occidentalis* as 155.1 and 158.2 mg/100 g respectively. Babalola *et al*. (2010) reported the vitamin C contents of *A. viridis* and *T. occidentalis* as 24.00 and 62.50 mg/100g respectively. Edeh *et al*. (2013) reported the vitamin C contents of *A. caudatus* and *T. occidentalis* as 39.08 and 63.00 mg/100g respectively. Similarly, Akande *et al*. (2018) also reported the vitamin C contents of *A. viridis* and *T. occidentalis* as 575.75 and 1999.23 mg/100g respectively.

Vitamin C (ascorbic acid) contents differ in

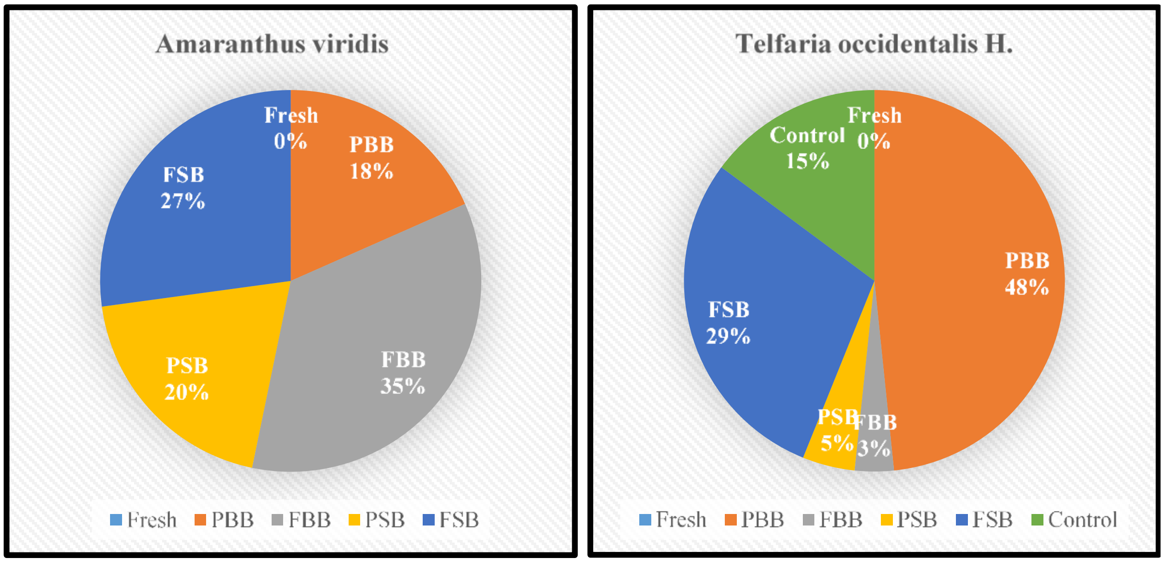

Figure 5. Effect of storage (4-6 days) in different vegetable baskets on changes in the vitamin C content of *Amaranthus viridis* (green amaranths) and *Telfaria occidentalis* H. (fluted pumpkin leaves). PBB=Pyramidal shaped big basket; FBB=Frustum shaped big basket; PSB=Polypropylene lined small basket; FSB=Foam lined small basket.

variegated tissues and organs, habitually being elevated in leaves, meristemic tissues, flowers or tender fruits but reduced in non-photosynthetic organs like the stem and root (Paciolla *et al*., 2019). Among the factors that cause an increase in ascorbic acid components of fruits and vegetables postharvest to comprise the following; genotypic differences, pre-harvest climatic conditions, cultural usage, stage of development, harvesting methods, postharvest handling procedures (Lee and Kader, 2000).

These authors further stated that temperature management during postharvest is the most relevant factor for the subsistence of ascorbic acid contents of fruits and vegetables. Thus, the use of vegetable baskets in the storage of fluted pumpkin leaves in this study demonstrated an agreement with the statement of Lee and Kader (2000). However, a decrease was recorded in the ascorbic acid component of the green amaranths after storage (4 days) with vegetable baskets; which according to Lee and Kader (2000) again stated that some chilling sensitive crops show more dropping in ascorbic acid at lower temperatures. This might probably explain why losses in ascorbic acid contents were observed in the green amaranths being more sensitive to chilling effects. Other factors that favour losses of ascorbic acid include; high-temperature conditions, rapid water losses after harvest, bruising, other spontaneous damage and excessive trimming (Lee and Kader, 2000). Dropping in ascorbic acid is frequently used to denote quality impairment during postharvest management comprising movement, storage and processing because it is highly susceptible to chemical and enzymatic oxidation and is highly water-soluble (Ambuko et al., 2017, Balogun and Ariahu 2020).

Conclusions

This study has shown that the newly modified vegetable baskets (VBs) can be used for improved storage of fresh leafy vegetables. These various models of modified baskets successfully stored *Amaranthus viridis* for four (4) days or 96 hours. However, the results further showed that Pyramidal Shape Big Basket (PBB), Foam Lined Small Basket (FSB) and Polypropylene Lined Small (PSB) were more effective in the storage of fresh *Amaranthus viridis*. Also, fluted pumpkin leaves were stored successfully with various models of the modified VBs for six (6) days (144 hours). The results further revealed that storage of fluted pumpkin leaves was favoured by the use of Pyramidal Shape Big Basket (PBB), Polypropylene Lined Small Basket (PSB) and Foam Lined Small Basket (FSB). Based on the outcomes of this work, Pyramidal Shape Big Basket (PBB), Foam Lined Small Basket (FSB) and Polypropylene Line Small Basket (PSB) could be utilized effectively for postharvest handling (transportation and storage) of *Amarabthus viridis* for up to four (4) days and *Telfaria occidentalis* H. for six (6) days.

ACKNOWLEDGEMENT

Authors wish to acknowledge the Management Team

(IMT) of Nigerian Stored Products Research Institute, Ilorin for funding this research work under the 2020 project.

CONFLICT OF INTEREST

Authors declare no conflict of interest in this work.

REFERENCES

Adeoye, I. B. (2020). Factors affecting efficiency of vegetable production in Nigeria: A review. In: Amao, I. O., & Adeoye, I. B. (eds.). *Agricultural Economics.* ItechOpen. Pp. 73-86.

Akande, S. A., Inana, M. E., Ugama, E. E., Azeke, A. E., Owuno, F., Oledibe, C. F., Adindu, M. N., Adedokun, A. O., Roberts, S. I., & Nze-Dike, O. U. (2018). Ascorbic acid retention of freshly harvested seven Nigerian green leafy vegetables after soaking in water. *Ruhuna Journal of Science*, *9*, 32-43.

Ambuko, J., Wanjiru, F., Chemining'wa, G. N., Owino, W. O., & Mwachoni, E. (2017). Preservation of postharvest quality of leafy amaranth (*Amaranthus spp*.) vegetables using evaporative cooling. *Journal of Food Quality*, Volume 2017, Article ID 5303156, 6 pages.

AOAC (2019). Association of Official Analytical Chemists. *Official Methods of Analysis of AOAC International*. 21st Edition, Rockville, Maryland, 20850–3250, USA.

Ariahu, C. C., & Egwujeh, S. I. D. (2009). Effect of blanching and drying conditions on the sensory quality, chlorophyll and ascorbic acid retention of leafy vegetables. *Nigerian Food Journal,* 28(2), 96-101.

Ayanda, I. S., Ibrahim, A. S., Adebayo, O. B., Afolayan, S. S., Akande, S. A., & Lawal, I. O. (2019). Effect of storage medium on the sensory attributes, physicochemical properties and nutritional compositions of ripe tomato (*Solanum lycopersicum* L.). *Nigerian Journal of Post-Harvest Research*, 2(2), 34-44.

Babalola, O. O., Tugbobo, O. S., & Daramola, A.A. (2010). Effect of processing on the vitamin c content of seven nigerian green leafy vegetables. *Advance Journal of Food Science and Technology* 2(6), 303-305.

Balogun, A. A., & Ariahu, C. C. (2020). Quality evaluation of fresh fluted pumpkin leaves stored in evaporative coolers. *Asian Food Science Journal, 18*(3), 12-23.

Edeh, R. I., Adeniji, P. O., & Salau, B. A. (2013). The effects of household processing on ascorbic acid and moisture content of some selected Nigerian vegetables. *IOSR Journal of Environmental Science, Toxicology and Food Technology;* 6(4), 52-54.

Gogo, E. O., Opiyo, A., Ulrichs, C., & Huyskens-Keil, S. (2016). Postharvest treatments of African leafy vegetables for food security in kenya: A review. *African Journal of Horticultural Science*, 9, 32-40.

Ibeawuchi, I. I., Okoli, N. A., Alagba, R. A., Ofo, M. O., Emma-Okafor, L. C., Peter-Olona, C. A., & Obiefuna, J. C. (2015). Fruits and vegetables crop production in Nigeria; The gains, challenges and the way forward. *Journal of Biology, Agriculture and Healthcare*, 5(2), 194-209.

Iwuagwu, C. C., Mbah, B. N., & Nwogboga, A. C. (2014). Identification and control of mycopathogens associated with storage of five horticultural produce in evaporative coolant-vegetable basket. *European Journal of Biotechnology and Bioscience*, 2(2), 24-27.

Kamalajja, T., Rajeswari, K., & Prashanthi, M. (2019). Analysis of Bioactive Compounds in Leafy Vegetables. *International Journal of Chemical Studies*, 7(1), 1663-1668.

Lee, S. K., & Kader, A. (2000). Pre-harvest and postharvest factors influencing Vitamin C contents of horticultural crops. *Postharvest Biology and Technology*, 20(3), 207-220.

Liberty, J. T., Ugwuishiwu, B. O., Pukuma, S. A. & Odo, C. E. (2013). Principles and application of evaporative cooling systems for fruits and vegetables preservation. *International Journal of Current Engineering and Technology*, 3(3), 1000-1006.

Paciolla, C., Fortunato, S., Dipierro, N., Paradiso, A., De Leonardis, S., Mastropasqua, L., & Conetta de Pinto, M. (2019). Vitamin C in plants: From functions to biofortification. *Antioxidants*, *8*(11), 519.

Park, H. A., & Ellis, A. C. (2020). Dietary antioxidants and Parkinson's disease. *Antioxidants*, *9*(7), 570.

Sobowale, S. S., Olatidoye, O. P., Olorode, O. O., & Sokeye, O. K. (2010). Effect of preservation methods and storage on nutritional quality and sensory properties of leafy vegetables consumed in Nigeria. *Journal of Medical and Applied Biosciences,* 2, 46-56.

Solanke, O. E., & Awonorin, S. O. (2002). Kinetics of vitamin C degradation in some tropical green leafy vegetables during blanching. *Nigerian Food Journal*, *20*, 24-32.

Ubani, O. N., & Okonkwo, E. U. (2011). A review of shelf-life extension studies of Nigerian indigenous fresh fruits and vegetables in the Nigerian Stored Products Research Institute. *African Journal of Plant Science*, *5*(10), 537-546.