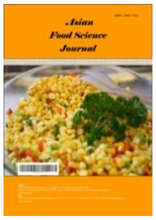

Asian Food Science Journal

18(3): 12-23, 2020; Article no.AFSJ.60490
ISSN: 2581-7752

Quality Evaluation of Fresh Fluted Pumpkin Leaves Stored in Evaporative Coolers

A. A. Balogun[1*] and C. C. Ariahu[2]

[1]Institute of Food Security, University of Agriculture, Makurdi, Benue State, Nigeria.
[2]Department of Food Science and Technology, University of Agriculture, Makurdi, Benue State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author AAB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CCA managed the analyses of the study. Author AAB managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2020/v18i330218
Editor(s):
(1) Dr. Rusu Teodor, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania.
(2) Dr. Samaila James, Federal University of Technology, Nigeria.
(3) Dr. Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.
Reviewers:
(1) T. S. Mishra, Krishi Vigyan Kendra, India.
(2) Mamta Rathore, Chandra Shekhar Azad University of Agriculture & Technology (CSAUA&T), India.
(3) Clement Gyeabour Kyere, Seventh-Day Adventist College of Education, Ghana.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60490

Original Research Article

Received 17 July 2020
Accepted 20 September 2020
Published 28 September 2020

ABSTRACT

A study was conducted to evaluate the quality of fresh fluted pumpkin leaves stored in two different types of evaporative coolers- aluminum-cladded burnt-clay-brick evaporative cooler (ABBEC) and non-cladded burnt-clay-brick evaporative cooler (NBBEC) compared with ambient storage as control. The evaporative coolers consisted of double walled rectangular brick construction (1.29×2.55×2.56) m external and (1.13×1.27×2.08) m internal, (length × width × height) with the inter-space filled with riverbed sand saturated with water. Physiological weight loss, total soluble solids, titratable acidity, pH, ascorbic acid, beta carotene, microbial load and organoleptic qualities of the leaves were the parameters determined. Ascorbic acid, beta carotene and titratable acidity decreased while TSS, pH and microbial load increased with storage duration. The shelf life of fluted pumpkin leaves increased to four days in ABBEC from only two days in ambient storage. ABBEC stored leaves retained its freshness better than leaves in NBBEC and ambient storage.

**Corresponding author: E-mail: adenikebalogun27@yahoo.com;*

Keywords: Evaporative coolers; fluted pumpkin leaves; physiological weight loss; total soluble solids; pH; ascorbic acid.

1. INTRODUCTION

Vegetables are edible parts of plants that are consumed whole or in parts, raw or cooked as part of the main dish. Green vegetables are great sources of minerals (such as zinc, iron and potassium), protein, carbohydrates and vitamins which are needed for normal healthy growth [1]. According to [2], leafy vegetables are also sources of essential and trace elements which play a major role in the normal functioning of the body system maintaining regular metabolic processes and repair of worn out tissues in man. Okpalamma, et al. [3] reported that vegetables are one of the most cost-effective and sustainable solutions to micronutrient deficiencies, which affect far more people than hunger alone, and this is crucial in most sub Saharan Africa.

Fluted pumpkin (*Telfairia occidentalis*) belongs to the genus Cucurbita and the family Cucurbitaceae which comprises a wide range of plants that have common characteristics of large leaves, creeping or climbing stems usually with tendrils, fleshy fruits with many seeds [4]. According to the authors, it is a crop of commercial importance grown across the lowland humid tropics of West Africa with Nigeria, Ghana and Sierra Leone being the major producers. Ogisi, et al. [5] reported that fluted pumpkin leaves is very important in the diet of children, men, women, nursing mothers as well as livestock due to its high nutritive value. In addition, Igbeneghu, et al. [6] reported that fluted pumpkin leaves possess medicinal properties which include antimalarial, antidiabetic, antioxidant and antimicrobial activities.

Despite being an indispensable constituent of human diet, vegetables are highly perishable due to their relatively high moisture content, soft texture and high respiration rate [7]. They therefore require careful storage in order to preserve the nutrients especially the water soluble vitamins. To retard moisture loss in vegetables, the storage environment must be of high relative humidity and low temperature.

Much of the postharvest losses of fruits and vegetables in developing countries are due to lack of proper storage facilities. According to Nnamezie, et al. [8], postharvest losses are one of the main hindrances to the cultivation of fluted pumpkin leaves in Nigeria. This is because the vegetable is highly perishable due to its high water content therefore huge losses are recorded yearly as a result of high volume of production coupled with non-availability of sufficient storage, transport and proper processing facilities. Refrigerated cold stores are the best strategy of preserving fruits and vegetables, yet they are costly. Evaporative cooling is an innovative and environmentally friendly alternative that operates using induced processes of heat and mass transfer using water and air as working fluids [9]. Such a system provides an inexpensive, energy-efficient and potentially attractive cooling system [10]. Evaporative cooling produces low temperature and high relative humidity which slows produce metabolism and reduces the activity of microorganisms responsible for quality deterioration.

Many researchers have investigated different types of evaporative coolers in storing fresh produce. Ronoh, et al. [11] revealed that charcoal cooler was beneficial in extending the shelf life of leafy vegetables (Amaranth and Spinach) and preserving their quality. Iwuagwu, et al. [12] reported that evaporative coolant baskets increased the shelf life of Telfairia occidentalis leaves from three days in ambient storage to seven days in the coolant baskets. According to Ubani and Okonkwo [13], fluted pumpkin leaves stored in evaporative coolant baskets retained freshness for six days while the control in ambient storage had physiological breakdown of tissues which led to total deterioration and total loss within the same storage duration. This study aimed at evaluating the performance of evaporative coolers on fluted pumpkin leaves storage.

2. MATERIALS AND METHODS

2.1 Study Area

Makurdi is the capital of Benue State, Nigeria. The town is dominated by guinea savannah type of vegetation. The mean annual rainfall is favourable for food production. Makurdi has a sub-humid, semi-arid tropical climate with mean annual precipitation at 1200 – 1300 mm. About 90% of total annual rainfall occurs in the months of June to September [14]. Temperature rarely falls below 22°C with peaks of 40 and 30°C in February/March. In the wet season, the average temperature is within the range of 23.0 - 32.7°C.

Data generated were the average for 2014 to 2017 for the evaporative coolers located beside the College of Food Technology and Human Ecology Complex at the University of Agriculture, Makurdi (Latitude:07°45'23" N, Longitude 08°34'23" E).

2.2 Design and Construction of Evaporative Coolers

Two almost identical burnt clay bricks evaporative coolers were designed and constructed adjacent and about 1m apart under two trees. One had two internal aluminum claddings and was designated as aluminum-cladded burnt-clay-brick evaporative cooler (ABBEC); the outer aluminum wall was perforated. The other cooler had no internal aluminum cladding and was referred to as non-cladded burnt-clay-brick evaporative cooler (NBBEC). The pictorial views of the cooling structures are shown in Plate 1. Essentially, the evaporative coolers consist of double jacketed rectangular burnt clay brick wall. The cavity between the inner and outer walls of each cooler was filled with river-bed sand. The floors were cemented with mortar (cement, sand and water mixture) to an even 2 cm thickness. Wooden shelves were built inside the cooling structure where the fresh fruits and vegetables were placed to keep them away from infection of soil borne diseases and moulds. The doors to the storage spaces were made of white wood with zinc roofing sheet cladding for protection against rodents and termites. A make-shift thatched roof cover was built above each of the coolers to provide extra protection against direct sunlight in addition to the shade provided by the trees so that the fullest advantage of evaporative cooling could be harnessed. In order to maintain the sand completely wet during the study, 500 litres of water was used to wet the sand twice a day.

2.3 Commodity Storage Test

5 kg of fluted pumpkin leaves were purchased from the University of Agriculture farms and transported to the laboratory in jute bags. They were then washed with tap water to remove adhering sand and other foreign matter.

2.3.1 Weight loss

Weight loss was measured before and after storage using an electronic weighing balance (Model: Mettler P1210). 100 g of fluted pumpkin leaf samples were drawn at random on the 1st, 2nd and 4th days of storage. Weight loss for the sample of known initial weight was calculated as follows [15]:

$$PWL\ (\%) = (Wo - Wt)\ /\ Wo\ x\ 100 \qquad (1)$$

Where, PWL= physiological weight loss; W_o= initial weight of sample and W_t= weight of sample at time, t. The mean for the leaf samples were then reported.

Plate 1. Evaporative Coolers 1 & 2
EC1= Non-cladded Burnt-Clay-Brick Evaporative Cooler (NBBEC)
EC2=Aluminum-cladded Burnt-Clay-Brick Evaporative Cooler (ABBEC)

2.3.2 Chemical analyses

Chemical analyses were performed according to the standard official methods described in [16]. Clear juice of fluted pumpkin leaves was extracted by pulping 100 g of edible portion in a household electric blender followed by straining using double-layered muslin cloth.

2.3.3 Ascorbic acid and total carotenoids

Ascorbic acid and carotenoids were determined by [16] methods. Ascorbic acid content was determined by titrimetric method with the titration of filtrate against 2,6-dichlorophenol indophenols and the result expressed as mg/100 g.

2.3.4 Total Soluble Solids (TSS)

TSS in degree brix was directly measured using Abbe refractometer (Model: Bellingham & Stanley Limited, England) by placing a drop of supernatant on the prism of refractometer.

2.3.5 pH and titratable acidity determination

The digital pH meter (Model pH 211, HI Hanna Instruments, Italy) was used to measure the pH of the fluted pumpkin leaves extract while total titratable acidity was determined by titrating 5ml of leaves extract with 0.1N sodium hydroxide-using phenolphthalein as an indicator [16].

2.4 Microbiological Analysis

Samples for total plate counts and fungal counts were prepared as described by [17]. Triplicate 2 g portions of fluted pumpkin leaves were sliced and homogenized in a Warring blender which was previously washed and sterilized with 100ppm sodium hypochlorite solution and rinsed with sterile deionized water. Serial dilutions of homogenate ranging from 10^{-1} to 10^{-5} were obtained using sterile saline solution. Total aerobic plate counts and fungal counts were performed on nutrient agar and Saboraud dextrose agar respectively using the pour-plate method described by [18].

2.5 Sensory Evaluation

A consistent panel of 12 semi-trained judges was used to evaluate the appearance, texture and overall acceptability of fluted pumpkin leaves sample using the descriptive sensory profile developed based on perceptions of the judges for quality of fruits and vegetables. Sensory evaluation was conducted under fluorescent light in a special sensory testing room with partitioned booths [19]. The degrees of preference based on the descriptive terms using the 7-point hedonic scale were then converted to scores with 7=very firm and 1=Putrid/mushy for texture, 7=very fresh and 1=extremely mouldy for appearance and 7=highly acceptable and 1=disgusting for overall acceptability.

2.6 Statistical Analysis

The results obtained were evaluated using the analysis of variance with the aid of Statisca 6.0 software package (Stafso, Inc. USA). The means of factors showing significant (p=0.5) differences were separated using Tukey's LSD test [20]. For the storage studies with fluted pumpkin leaves, the variables evaluated were influences of 3 storage times (1st, 2nd and 4th days) and 3 storage conditions (Atmosphere, NBBEC and ABBEC).

3. RESULTS AND DISCUSSION

3.1 Physiological Loss in Weight

Physiological weight loss is one of the main factors in determining the quality of stored fruits and vegetables. Weight loss of fluted pumpkin leaves stored inside the evaporative coolers was lower than those stored in ambient condition. The PLW of fluted pumpkin leaves in ambient was highest (87.1%), intermediate in NBBEC (35%) and least (32.5%) in ABBEC storage as shown in Fig. 1. The evaporative cooler microclimate in ABBEC increased the shelf life of fluted pumpkin leaves from two days in ambient storage to four days. This is in agreement with the findings of [21] that fresh horticultural produce should be stored at lower temperatures because of their highly perishable nature. Similarly, Adarkwa [22] reported that leafy vegetables were mostly water (>90%) with a high propensity to loose water through transpiration. He observed that a loss of only 5 to 10% of fresh weight would wilt leafy vegetables making them unmarketable. According to Kenghe, et al. [23], water loss is the primary cause of fresh weight loss and it is more sensitive to changes in relative humidity around the commodity than to the rate of respiration.

3.2 Total Soluble Solids

Soluble sugars are an important component of fresh produce. According to Sanchez-Mata, et al. [24], they have been described as an important factor in sensory attributes such as taste of the vegetables and a component of dietary importance. TSS is the parameter used to rapidly determine the quality of fresh produce [25]. According to Chepngeno [26], the TSS content in perishable produce is unique to the produce. However, it is affected by storage temperature and degree of senescence or ripening in each product.

An increase in TSS values in fluted pumpkin leaves and a non-significant (p>0.05) effect were observed during the storage period at the two evaporative storage conditions (3.30 to 3.53°Brix). However, higher ambient storage temperature showed a significant (p<0.05) higher TSS value of 3.30 to 4.45°Brix (Fig. 2). This is because higher temperatures increase respiration rates, reduce moisture content and consequently resulting in higher soluble solids. TSS build up during storage may be attributed to moisture loss, where solutes present in the cells become more concentrated. It also correlates positively with the produce weight loss. A positive relationship between weight loss and TSS similarly observed in this study has been reported by [27] in stored carrots. Zinash, et al. [28] reported a great variation in soluble solids content of pumpkin cultivars (4.10 to 10.03°Brix) for fresh fruit quality assessment.

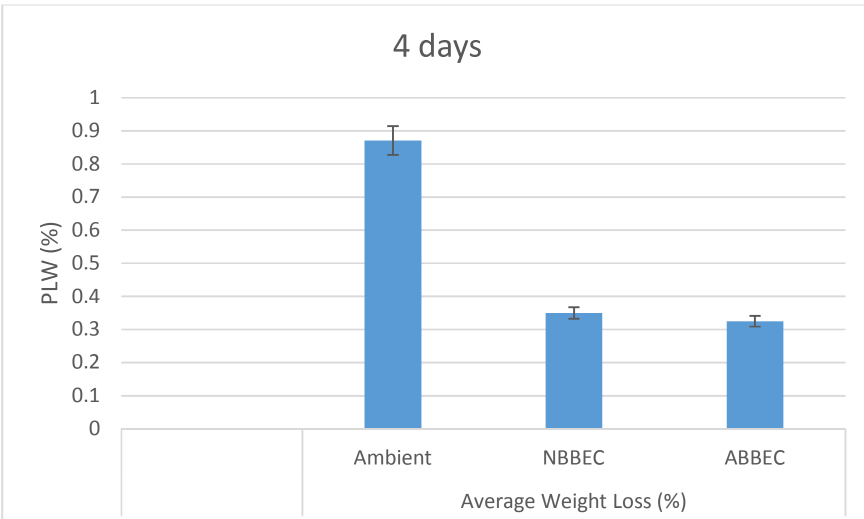

Fig. 1. Physiological loss in weight of fluted pumpkin leaves

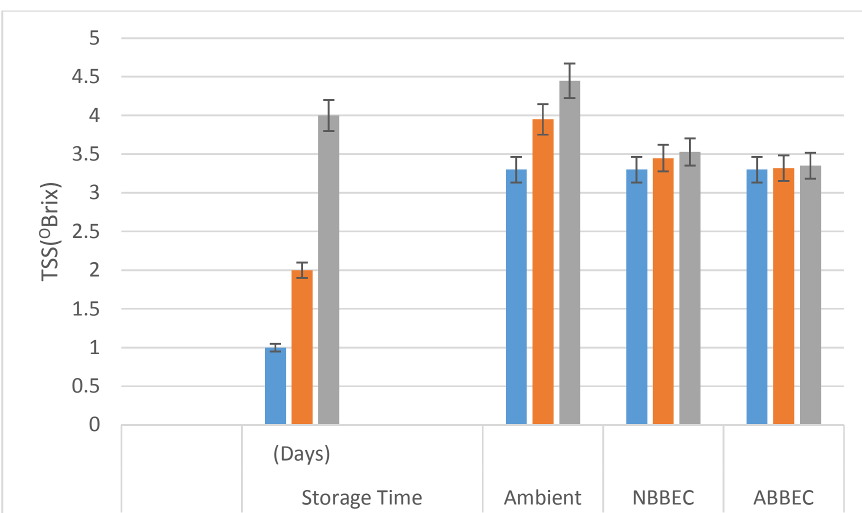

Fig. 2. Effect of storage conditions on tss of fluted pumpkin leaves

3.3 pH and Total Titratable Acidity

The pH varied from 4.73 to 5.30 as presented in Table 1. The pH of fluted pumpkin leaves increased with increasing storage duration. The initial pH value and those for seventh day of storage were not significantly ($p>0.05$) different. The maximum pH content of fluted pumpkin leaves was recorded after four days of storage in ambient condition (4.73 to 5.30). The minimum pH was recorded for fluted pumpkin in ABBEC storage (4.73 - 4.83). Higher pH values were obtained probably due to the metabolic processes of fluted pumpkin leaves stored in ambient condition. Ariahu, et al. [29] reported a higher pH range of 5.0 to 6.5 in fluted pumpkin leaves. They reported that increasing the acidity of pumpkin leaves helped to retain more of its ascorbic acid content during industrial and conventional home processing.

A gradual decrease in titratable acidity and a non-significant ($p>0.05$) difference were observed during the storage period within the storage conditions as presented in Table 1. However, ambient higher temperatures showed a pronounced decline in titratable acidity (0.35-0.25%). This behaviour may be linked to the fact that higher temperatures increase the respiration rate and therefore there is greater degradation of organic acids. Ifesan, et al. [30] reported that lower values were observed which ranged from 0.133 to 0.035% when compared to the results obtained in this study. This difference may be caused by factors such as variety and growing conditions, which result in differences in the composition of the fruit and vegetable. According to Chepngeno [26], during storage periods; the concentration of organic acids decreases due to their use as a substrate in the respiration or their transformation into sugars.

3.4 Ascorbic Acid and Carotenoids

Ascorbic acid is an organic acid having strong antioxidant properties and one of the most important nutrients obtained from fresh produce in the human diet [31]. Ascorbic acid degradation is directly proportional to increasing temperature as prolonged storage duration increases the likelihood of its oxidation. At higher temperatures, ascorbic acid loss is accelerated, [32].

Ascorbic acid values of fluted pumpkin leaves in this study decreased significantly ($p<0.05$) from 107.72 to 51.50 mg/100 g in ambient storage, from 107.72 to 73.21 in NBBEC and from 107.72 to 83.22 mg/100 g in ABBEC storage conditions (Fig. 3). Okpalamma, et al. [3] observed values of 88-160 mg/100 g. Musa and Ogbadoyi [33] reported that the concentration of vitamin C in fresh fluted pumpkin leaves decreased significantly ($p<0.05$) during one week of freezing from 192.28 to 19.15 mg/100 g. Earlier workers, for example Adegunwa, et al. [34] reported a value of 104.1 mg/100 g which decreased to 67.8 mg/100 g after blanching. Similarly, Mepba, et al. [35] reported ascorbic acid value of 160 mg/100 g in fresh pumpkin leaves. They observed a decrease to 85.3 mg/100 g after blanching; 100.6 mg/100 g for sun dried leaves and 53.8 mg/100 g for the cooked vegetable. The retention of ascorbic acid has often been used as an estimate of the overall nutrient retention in food products as it is the most unstable nutrient [36]. The results obtained in this study showed that ascorbic acid decreased as the storage period increased. This might be due to auto oxidation and enzymatic degradation occurring in the leaves. Previous studies [37]; Lee and Nagy [38] have reported storage duration and condition to be an important parameter in ascorbic acid degradation.

Table 1. Effect of storage conditions on the titratable acidity of fluted pumpkin leaves

Parameters	Storage time (Days)	Ambient	NBBEC	ABBEC	LSD
TTA (%)	1	0.35^{a}	0.35^{a}	0.35^{a}	
	2	0.32^{a}	0.32^{a}	0.33^{a}	
	4	0.25^{b}	0.30^{ab}	0.32^{a}	0.26
pH	1	4.73^{b}	4.73^{b}	4.73^{b}	
	2	4.98^{b}	4.93^{b}	4.78^{b}	
	4	5.30^{b}	5.15^{a}	4.83^{b}	0.29

Each value is the mean of triplicate determinations for 2014-2017. Values for each parameter with common superscripts are not significantly (p>0.05) different.
NBBEC=Non-cladded burnt-clay-brick evaporative cooler
ABBEC=Aluminum-cladded burnt-clay-brick evaporative cooler
TTA= Total Titratable Acidity
LSD = Least Significant Difference

Beta carotene is a compound of great nutritional importance due to its pro-vitamin A activity, especially in developing countries where it constitutes about 82% of vitamin A intake, as other sources are expensive [39]. Beta carotene content in fluted pumpkin leaves under study was significantly affected by the storage duration and condition. Beta carotene decreased from 1436.70 to 433.20 µg/100 g in the leaves stored in ambient. Conversely, samples in aluminum-cladded burnt-clay-brick evaporative cooler storage attained a maximum of 531.10 µg/100 g. Musa and Ogbadoyi [33] reported higher beta carotene values which ranged from 14690 to 18859 µg/100 g for *Telfairia occidentalis* leaves. The huge difference between these authors and the findings in the present study could be due to differential geographical derivation and varietal differences. According to Bolanle, et al. [40], the differences in beta carotene concentrations between fruits and vegetables may be a reflection of differences in species/cultivars, which is genetically determined.

3.5 Microbial Load of Fluted Pumpkin Leaves

The effect of storage conditions on the microbial load of fluted pumpkin leaves as presented in Table 2 indicated that the total plate count ranged from 1.48 to 4.45 $Log_{10}cfu/g$ and 1.30 to 2.93 $Log_{10}cfu/g$ for fungal count. These values were significantly ($p<0.05$) different at the three storage conditions. The lower microbial count recorded in ambient could be due to the loss of moisture by transpiration resulting in lower microbial activities, hence lower rate of spoilage. The bacterial load in this study was higher than the fungal load. This is in agreement with [41] who reported that a large number of bacteria are common agents of vegetable and fruits spoilage. They also stated that the higher the water content of fruits and vegetables, the higher the growth and expansion of the bacteria causing spoilage. The high relative humidity favoured the growth of microorganisms which intensified the deterioration of samples in NBBEC storage. This is in agreement with [42] who reported that storage humidity manipulations could cause decay by mycopathogens. According to Nnamezie, et al. [8], the high moisture content of fluted pumpkin leaves in the NBBEC predisposed it to spoilage because microorganisms thrive well in perishable foods. Ikhajiagbe, et al. [43] recorded total plate count of 5.08 to 5.43 $Log_{10}cfu/g$ and total fungal count of 4.60 to 5 $Log_{10}cfu/g$. Obieze, et al. [44] observed that the moist condition of vegetables fostered by sprinkling of water facilitate direct contamination by microorganisms through the handlers (buyers and sellers). Indirect contamination may also occur as a result of poor hygienic environment of the market; consequently, harvested vegetables soon begin to spoil if not sold immediately.

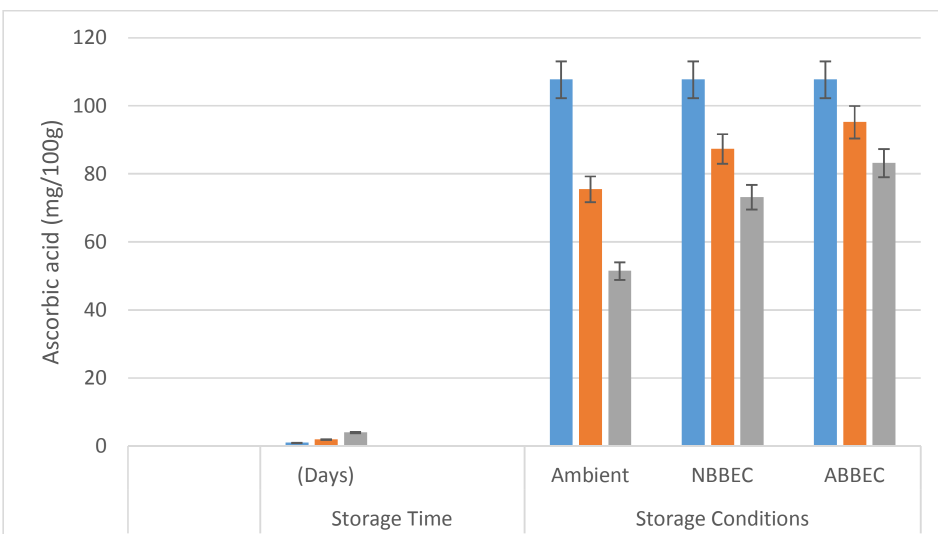

Fig. 3. Effect of storage condition on ascorbic acid content of fluted pumpkin leaves

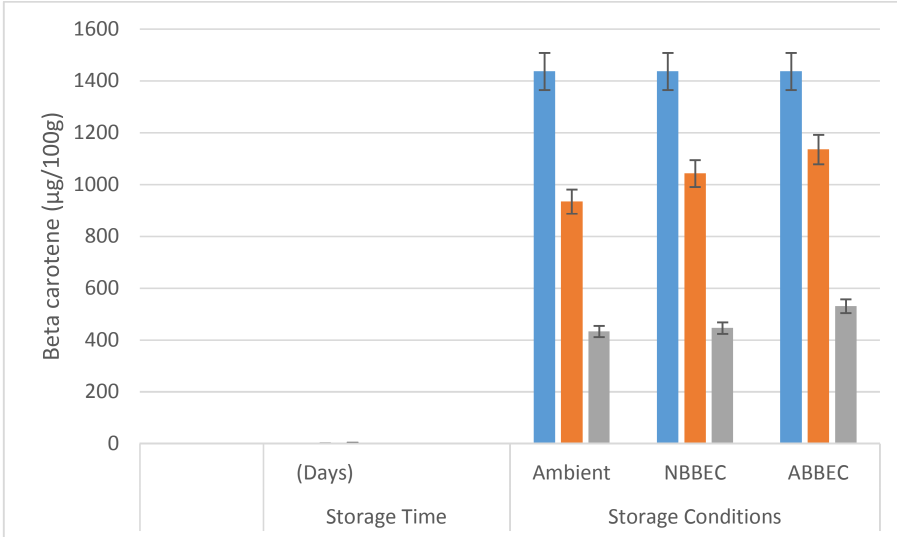

Fig. 4. Effect of storage condition on beta carotene of fluted pumpkin leaves

Table 2. Effect of storage conditions on the microbial load of fluted pumpkin leaves

Microbial parameter	Storage time (Days)	Ambient	NBBEC	ABBEC
Total Plate Count	1	1.48^{a}	1.48^{a}	1.48^{a}
(Log_{10}cfu/g)	2	2.40^{c}	2.00^{ac}	1.78^{ac}
	4	2.43^{c}	4.45^{c}	2.48^{c}
Yeast &Mould Count	1	1.30^{a}	1.30^{a}	1.30^{a}
(Log_{10}cfu/g)	2	2.17^{b}	1.85^{ab}	1.70^{ab}
	4	2.93^{b}	2.00^{b}	1.81^{b}

NBBEC= Non-cladded burnt-clay-brick evaporative cooler
ABBEC= Aluminum-cladded burnt-clay-brick evaporative cooler
Values for each parameter with common superscripts are not significantly (p>0.05) different

3.6 Sensory Evaluation of Fresh Fluted Pumpkin Leaves

The fresh fluted pumpkin leaves were dark green, fresh and very attractive before storage. This made panelists to score it 6.95 which decreased significantly ($p<0.05$) to 3.23 in ambient storage. This was similar to the findings of [45] who reported that vegetables stored in evaporative coolers retained their fresh appearance and dark green colour. However, due to water loss (loss in saleable weight) and wilting, the leaves became unusable after two days in ambient storage, three days in NBBEC and four days in ABBEC storage. In this study, the high humidity in NBBEC encouraged microbial growth which resulted in leaves deterioration.

On texture, the panelists indicated variations in the preference of the texture of the fluted pumpkin leaves. They scored fresh sample 6.71 which decreased significantly ($p<0.05$) to 3.26 in ambient storage. The softness of the stored sample increased as the storage period increased. This pattern might be attributed to the gradual loss of turgidity of the evaporatively cooled samples. The high relative humidity in the NBBEC cooler might have encouraged the continued enzymatic activities within the samples. However, as a result of water loss in ambient stored sample, there was serious shriveling and wilting on the second day of storage. Wills, et al. [46] reported that textural quality is reduced by enhanced softening, loss of crispness and juiciness, followed by reduction in nutritional quality. Adindu, et al. [47] confirmed that the firm texture of fluted pumpkin leaves wilts and loses freshness within a few hours in ambient because of the harsh weather conditions. It subsequently becomes less turgid and unacceptable to consumers creating handling problem after harvest and during sales. Ubani, et al. [48] reported similar findings that

Table 3. Effect of storage conditions on sensory scores of fluted pumpkin leaves

Sensory attribute	Storage time (Days)	Ambient	NBBEC	ABBEC
Appearance	1	6.95^{a}	6.95^{a}	6.95^{a}
	2	4.98^{b}	5.45^{b}	6.67^{a}
	4	3.23^{c}	3.45^{c}	3.67^{b}
Texture	1	6.71^{a}	6.71^{a}	6.71^{a}
	2	4.15^{bd}	4.26^{b}	4.35^{b}
	4	3.26^{c}	3.38^{c}	3.42^{cd}
Overall Acceptability	1	6.68^{a}	6.68^{a}	6.68^{a}
	2	4.35^{bc}	5.43^{b}	5.56^{b}
	4	3.67^{c}	4.77^{b}	4.88^{b}

Values for each attribute with common superscripts are not significantly (p>0.05) different. Each result is the mean of 12 panelists responses on a scale with 7=excellent and 1= very poor
NBBEC=Non-cladded burnt-clay-brick evaporative cooler
ABBEC= Aluminum-cladded burnt-clay-brick evaporative cooler

there was massive deterioration of fluted pumpkin leaves in terms of leaf decay and chlorophyll loss on the seventh day of storage. According to Phirke [49], leaves senesce rapidly resulting into loss of their turgidity, attractiveness and nutritive value.

Overall acceptability is the cumulative effect of each of the sensory characteristics evaluated. Like other sensorial parameters evaluated, the overall acceptability decreased significantly ($p<0.05$) with storage duration. Panelists scored fresh fluted pumpkin leaves sample 6.68 which decreased to 4.88 in ABBEC storage. Panelists preferred the ABBEC stored leaves to those of NBBEC and ambient because they retained better appearance, better firmness, better nutritive value and better marketability.

4. CONCLUSION AND RECOMMENDATIONS

Fresh fluted pumpkin leaves stored in ABBEC exhibited lower biochemical and physiological reaction rates, hence tissue breakdown, colour changes, pH and TTA were lower in ABBEC than in NBBEC and ambient. Aluminum sheets being good thermal and electrical conductors improved the heat transfer in aluminum burnt-clay-brick evaporative cooler. Aluminum-cladded burnt-clay-brick evaporative coolers are therefore recommended for stop-gap extension of the shelf life of fresh fluted pumpkin leaves.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ogunlade CA, Jaiyeoba KF, Fadara T, Akinsanya O. Development and evaluation of an evaporating cooling system for agricultural products. N Y Sci. J. 2019;12(11):1-6.
2. Bruijnzeel LA, Scatena FN, Hamilton LS. Tropical montane cloud forest. Science for conservation and management. Cambridge, Cambridge University Press. 2010;137.
3. Okpalamma F, Ojimelukwe PC, Mazi EA. Postharvest storage and processing changes in Carotenoids and micronutrients in fluted pumpkin (*Telfairia occidentalis* Hook F.) IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2013; 6(4):43-39.
4. Nkang A, Omokaro D, Egbe A, Amanke G. Variations in fatty acid proportions during desiccation of *Telfairia occidentalis* seeds harvested at physiological and agronomic maturity. Afr. J. Biotechnol. 2003;2(2):33-39.
5. Ogisi OD, Begho T, Ewolor SA. Resource use efficiency and profitability of fluted pumpkin production in Ukwuani local government area of Delta State, Nigeria. American Journal of Agriculture and Forestry. 2014;2(4):129-134.
6. Igbeneghu OA, Abdu AB. Multiple antibiotic resistant bacteria on fluted pumpkin leaves, a herb of therapeutic value. J. Health Popul. 2014;32(2):176-182.
7. Atanda SA, Pessu PO, Agoda S, Isong IU, Ikotun I. The concepts and problems of

postharvest food loss in perishable crops. Afr. J. Food Sci. 2011;5(11):603-613.
8. Nnamezie AA, Famuwagun AA, Gbadamosi SO. Changes in some nutritional and sensory properties of treated and stored fluted pumpkin leaf. Annals Food Sci. and Tech. 2019;20(1):65-81.
9. Babarinsa FA, Omodara MA. Preservation of tomatoes in a brick-walled evaporative cooler. Journal of Postharvest Technology. 2016;04(01):001-005.
10. Zahra G, John AB. A passive evaporative cooling system by natural ventilation. Build Environ. 1996;31(6):503-507.
11. Ronoh EK, Kanali CL, Ndirangu SN, Mang'oka SM, John AW. Performance evaluation of an evaporative charcoal cooler and its effects on quality of leafy vegetables. Journal of Postharvest Technology. 2018;06(3):60-69.
12. Iwuagwu CC, Okonkwo NJ. Effects of moisture barrier and initial moisture content on the storage life of some horticultural produce in evaporative coolant. African Journal of Biotechnology. 2014;13(8):944-950.
13. Ubani ON, Okonkwo EU. 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. 2011;5(10):537-546.
14. Odiaka NI, Akoroda MO, Odiaka EC. Diversity and production methods of fluted pumpkin (*Telfairia occidentalis* Hook F.); Experience with vegetable farmers in Makurdi, Nigeria. Afr. J. Biotechnol. 2008;7(8):944-954.
15. Pereira T, et al. Caracteristicas fisicas equimicas de goiaba cv Cortibel (*Psidium guajava*) estocadas sob refrigeracao em Imes x-tend. Revista Alimentos e Nutricao. 2005;16(1):11-16.
16. AOAC: Official Methods of Analysis of the Association of Official Analytical Chemists, 22nd Ed, Association of Official Analytical Chemists, Washington D.C; 2005.
17. Kramer A, Twig BA. Quality control for the food industry. The AVI Publishing Co., Inc., West Port, Connecticut. 1970;1.
18. Harrigan WF, McCance M. Laboratory methods in food and dairy microbiology. Academic Press Inc., London. 1990;25-28.
19. Iwe MO. Handbook of sensory methods and analysis, 75-78, Enugu Nigeria. Rojoint Communication Science Ltd. 2010;75-78.
20. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. Macmillan Education Ltd London and Oxford. 1985;199-200.
21. Baseldiya A, Samuel DVK, Beera V. Evaporative cooling system for storage of fruits and vegetables- A review. J. Food Sci Technol. 2013;50(3):429-442.
22. Adarkwa I. Assessment of the postharvest handling of six major vegetables in two selected districts in Ashanti Region of Ghana. MSc. Thesis Submitted to the School of Research and Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi; 2011.
23. Kenghe R, Fule N, Kenghe K. Design, development and performance evaluation of an on-farm evaporative cooler. International Journal of Science, Technology and Society. 2015;3(2-2):1-5.
24. Sanchez-Mata MDC, Camara-Hurtado M, Diez-Marques C. Identification and quantification of soluble sugars in green beans by HPLC. European Food Research and Technology. 2002; 214:254-258.
25. Teka TA. Analysis of the effect of maturity stage on the postharvest biochemical quality characteristics of tomato (*Lycopersicum esculentum* M.) International Journal of Pharmaceutical and Applied Sciences (IRJPAS). 2013;3(5):180-186.
26. Chepngeno J. Evaluating the performance of low cost hydrocooling system and effect of sanitizer application in maintaining postharvest quality of selected vegetables. Being a Thesis Submitted in Partial Fulfilment for the Degree of Master of Science in Food Science and Technology. Jomo Kenyatta University of Agriculture and Technology, Kenya; 2015.
27. Hailu S, Seyoum T, Dechassa N. Effect of combined application of organic P and inorganic N fertilizers on postharvest quality of carrot. African J Biotechnol. 2008; 7:2187-2196.
28. Zinash A, Workneh TS, Woldetsadik K. Effect of ascension on the chemical quality of fresh pumpkin. Afric. J. Biotechnol. 2013;12(51):7092-7098.
29. Ariahu CC, Abashi DK, Chinma CE. Kinetics of ascorbic loss during hot water

blanching of fluted pumpkin leaves. J. Food Sci. Technol. 2011;48(4):454-459.
30. Ifesan BOT, Egbewole OO, Ifesan BT. Effect of fermentation on nutritional composition of selected commonly consumed green leafy vegetables in Nigeria. International Journal of Applied Sciences and Biotechnology. 2014;2(3): 291-297.
31. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology. 2000; 20:207-220.
32. Kader AA, Rolle RS. The role of postharvest management in assuring the quality and safety of horticultural produce. FAO Agricultural Services Bulletin. Rome, Italy: FAO; 2004.
33. Musa A, Ogbadoyi EO. Influence of freezing on some phytotoxins and micronutrients in Pumpkin. Journal of Biological Sciences. 2013; 13:217-225.
34. Adegunwa MO, Alamu EO, Bakare HA, Oyeniyi CO. Proximate and bioactive contents of some selected vegetables in Nigeria: Processing and varietal effects. American Journal of Food and Nutrition; 2011. Online: ISSN 2157-1317. DOI: 10.5251/ajfn.2011.1.4.171.177
35. Mepba HD, Eboh L, Banigo DEB. Effects of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. African Journal of Food, Agriculture, Nutrition and Development. 2007;7(1):1-18.
36. Kiremire B, Musinguzi E, Kikafunda J, Lukwago F. Effects of vegetable drying techniques on nutrient content. A case study of South-Western Uganda. African Journal of Food, Agriculture, Nutrition and Development. 2010;10(5):2587-2600.
37. Morris A, Barnett A, Burrows O. Effect of processing on nutrient content of foods. Cajanus. 2004;37(3):160-164.
38. Lee HS, Nagy S. Quality changes and nonenzymic browning intermediate in grapefruit juice during storage. Journal of Food Science. 1988;53(1):168-172.
39. Kidmose U, Yang R, Thilsted SH, Christensen LP, Brandt K. Content of carotenoids in commonly consumed Asian vegetables and stability and extractability during frying. Journal of Food Composition and Analysis. 2006; 19:562-571.
40. Bolanle AO, Olumuyiwa SF, Onome U, Bridget OO, Adele O, Steve RAA. The Effect of seasoning salts and local condiments on mineral availability from two Nigerian vegetables. Pakistan Journal of Nutrition. 2004;3(3):146-153.
41. Tsado EK, Gana AS, Anuonye JC, Yusuf ST, Aghotor PN. Effect of postharvest handling on the bacterial quality of selected vegetables sold in two markets at Abuja, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 2015; 9(2):18-27.
42. Obetta SE, Nwakonobi TU, Adikwu OA. Microbial effects of selected stored fruits and vegetables under ambient conditions in Makurdi, Benue State, Nigeria. Research Journal of Applied Sciences, Engineering and Technology. 2011;3(5): 393-398.
43. Ikhajiagbe B, Odifie UE, Oghogho JI, Omoregbee O. Heavy metal contents and microbial flora of fresh leaves of fluted pumpkin (*Telfairia occidentalis*) collected from road-side open markets in Benin metropolis, Midwestern Nigeria. The International Journal of Biotechnology. 2013;2(2):52-58.
44. Obieze KO, Ogbuagu CN, Asikong BE, Onyido AE, Ogolo BA. Bacteriological study of vegetables from markets of Calabar, Cross Rivers State, Southeastern Nigeria. The Internet Journal of Public Health. 2010;1(2):1-7.
45. Iwuagwu CC, Mbah BN, Okonkwo NJ, Onyia OO, Mmeka FC. Effect of storage on proximate composition of some horticultural produce in the evaporative coolant. International Journal of Agriculture and Biosciences. 2013;2(3):124-126.
46. Wills RBH, Mc Glasson WB, Graham D, Lee TH, Hall EG. Postharvest-An introduction to the physiology and handling of fruit and vegetables; 3rd Ed, New York, USA. Van Nostrand Reinhold. 1989;46.
47. Adindu MN, Imana ME, Israel D, Azeke EA, Adedokun AO, Robert SI, Ugama EE. Selected chemical composition and acceptability assessment of pre-treated dehydrated Telfairia leaves. Food Science and Quality Management. 2016; 50:1-4.
48. Ubani ON, Okonkwo EU, Ade A. Shelf-life of four tomato varieties at ambient conditions. Paper Presented in Nigerian

Stored Products Research In-House Review Meeting held at NSPRI Headquarters, Ilorin, Kwara State, Nigeria; 2010.

49. Phirke PS. Postharvest engineering of fruits and vegetables. CBS Publishers and Distributors, 4596/1-A, 11 Darya Ganj, New Delhi-110 002 (India). 2007;55-64.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60490