Quality Evaluation of Fresh Fluted Pumpkin Leaves Stored in Evaporative Coolers

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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.
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.

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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]:

\[
PWL (\%) = \frac{(W_o - W_t)}{W_o} \times 100
\]

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 Statistica 6.0 software package (Stafso, Inc. USA). The means of factors showing significant (p<0.05) 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](image1)

![Fig. 2. Effect of storage conditions on tss of fluted pumpkin leaves](image2)
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 Ogbadogyi [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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Storage time (Days)</th>
<th>Ambient</th>
<th>NBBEC</th>
<th>ABBEC</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTA (%)</td>
<td>1</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.30&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.26</td>
</tr>
<tr>
<td>pH</td>
<td>1</td>
<td>4.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29</td>
</tr>
</tbody>
</table>

*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. 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

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

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 wills 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

<table>
<thead>
<tr>
<th>Sensory attribute</th>
<th>Storage time (Days)</th>
<th>Ambient</th>
<th>NBBEC</th>
<th>ABBEC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>6.95a</td>
<td>6.95a</td>
<td>6.95a</td>
</tr>
<tr>
<td>Appearance</td>
<td>2</td>
<td>4.98b</td>
<td>5.45b</td>
<td>6.67a</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.23c</td>
<td>3.45c</td>
<td>3.67b</td>
</tr>
<tr>
<td>Texture</td>
<td>1</td>
<td>6.71a</td>
<td>6.71a</td>
<td>6.71a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.15bd</td>
<td>4.26b</td>
<td>4.35b</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.26c</td>
<td>3.38c</td>
<td>3.42cd</td>
</tr>
<tr>
<td>Overall Acceptability</td>
<td>1</td>
<td>6.68a</td>
<td>6.68a</td>
<td>6.68a</td>
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<tr>
<td></td>
<td>2</td>
<td>4.35bc</td>
<td>5.43b</td>
<td>5.56b</td>
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<tr>
<td></td>
<td>4</td>
<td>3.67c</td>
<td>4.77b</td>
<td>4.88b</td>
</tr>
</tbody>
</table>

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.

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