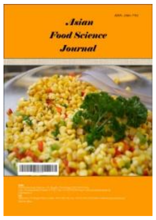

Asian Food Science Journal

18(1): 23-33, 2020; Article no.AFSJ.60489
ISSN: 2581-7752

Quality Evaluation of African Eggplant Stored in Evaporative Coolers

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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/v18i130207
Editor(s):
(1) Dr. Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.
Reviewers:
(1) Josivanda Palmeira Gomes, Universidade Federal de Campina Grande, Brazil.
(2) Rafael Hansen Madail, Instituto Federal Sul-rio-grandense, Brazil.
(3) K. Elumalai, University of Madras, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60489

Original Research Article

Received 23 June 2020
Accepted 29 August 2020
Published 07 September 2020

ABSTRACT

Postharvest cooling of fresh produce is essential to delivering high quality produce to the consumer. African eggplants are chilling sensitive at temperatures below 10°C, there is need to store them at higher temperatures because of their tropical nature. Evaporative coolers suitable for tropical fruits storage were therefore designed and constructed. Essentially, the evaporative coolers comprised of double burnt-brick walls (1.29 × 2.55× 2.56) m external and (1.13 × 1.27 × 2.08) m internal (L × W × H). A study was conducted to evaluate the physicochemical, microbial and sensory parameters of African eggplant stored in two evaporative coolers- aluminum-cladded burnt-clay-brick evaporative cooler (ABBEC) and non-cladded burnt-clay-brick evaporative cooler (NBBEC). Weight loss, total soluble solids, total titratable acidity, beta carotene content, ascorbic acid content, pH and microbial load were assessed during storage. Metabolic rates of African eggplant were highest at ambient storage, intermediate in NBBEC with the least value in ABBEC. Beta carotene, ascorbic acid and acidity decreased while total soluble solids, pH and microbial load increased during storage of African eggplant. The evaporative coolers reduced the storage

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temperature and increased the relative humidity within normal level of storage thereby extending the shelf life of eggplant from ten days at ambient to twenty-one days in ABBEC storage condition. ABBEC storage is therefore recommended for stop gap extension of shelf lives of fresh produce.

Keywords: Eggplants; evaporative coolers; physicochemical; microbial; organoleptic.

1. INTRODUCTION

Fruits and vegetables are important sources of sugars, vitamins A, B group, and C, low protein and lipid. They contain high amounts of minerals, moisture, low ash and crude fibre. In addition, they contain little or no fat or sodium and no cholesterol [1]. Fruits and vegetables constitute a rich source of phytochemicals and other bioactive components with potential anti-carcinogenic and cardio-vascular risk reduction properties [2].

African eggplant belongs to the family Solanaceae and the plant genus, Solanum with over 1000 species worldwide. Asia accounts for 78% of world eggplant production. Turkey, the largest producer in the European Union accounts for 19%. [3] Reported that in 2013, global production of eggplant was 49.4 million tons with 51% of output coming from China alone. African eggplants are annual fruits cultivated in all the agro-ecological zones of Nigeria and also widely distributed in Africa [4].

Eggplants contain essential phytonutrients which improves blood circulation and nourishes the brain. It contains fibre which protects the digestive tract thereby preventing colon cancer. According to Keyla [5], eggplant is high in bioflavonoids which help to maintain a healthy heart by controlling high blood pressure and relieving stress.

Most fruits and vegetables are highly perishable, there is therefore need to store them in storage facilities such as evaporative coolers to prolong their shelf lives. Evaporative cooling is an adiabatic procedure happening at steady enthalpy. Evaporative cooling remains one of the oldest, simplest and least expensive techniques used to delay spoilage of stored fruits and vegetables by lowering ambient temperature and increasing relative humidity.

Various reports [4,6,7] and [8] indicated that evaporative coolers have proved useful for short-term, on-farm storage of fruits and vegetables. Ubani and Okonkwo [4] reported that eggplants stored in evaporative cooler baskets had a shelf life of seven days without spoilage while the control fruits at ambient had shriveled and changed colour within the same period. Islam and Morimoto [6] reported that the shelf life of eggplant inside the evaporative cooler increased from four to nine days. Ogbuagu, et al. [7] observed that their evaporative cooler was able to preserve eggplant for ten days. Ishaque, et al. [8] revealed that the shelf life of eggplant was eleven days in the evaporative cooler compared to only six days in ambient storage.

Being an efficient and economical means of reducing postharvest loss, this study aimed at designing and constructing simple and affordable evaporative coolers for the storage of fruits and vegetables and investigate its performance in the storage of fresh African eggplants.

2. MATERIALS AND METHODS

2.1 Design and Construction of Evaporative Coolers

Two almost identical burnt-clay-brick evaporative coolers were designed and constructed adjacent and about 1m apart under two trees. One cooler (store) had two of its walls cladded with aluminum sheet and designated as aluminum-cladded burnt-clay-brick evaporative cooler (ABBEC). The outer aluminum wall was perforated. The second cooler had no aluminum claddings on the walls and referred to as non-cladded burnt-clay-brick evaporative cooler (NBBEC). Pictorial views of the evaporative coolers are shown in Plate 1.

Essentially, the evaporative coolers consisted of double-walled rectangular burnt-clay-brick structure. The cavity between the inner and outer walls of each cooler was filled with river-bed sand, which was used as wetting medium. Wooden shelves were built inside the coolers for the fresh produce to keep them away from infection of soil borne disease and moulds. The floors were cemented with mortar (cement, sand and water mixture) to an even 2cm thickness. The doors to the storage spaces were made of white wood with zinc roofing sheet cladding for protection against rodents and termites.

2.1.1 Weight loss

Weight loss was measured periodically using a scale as described by Pereira, et al. [9]. The analyses were performed on each of ten samples of African eggplant drawn at random on the 1st, 7th and 21st days of storage. Weight loss for each sample of known initial weight was calculated as follows:

$$\mathrm{PWL}\ (\%) = (\mathrm{Wo} - \mathrm{Wt})/\mathrm{Wo} \times 100 \qquad (1)$$

Where, PWL = Physiological weight loss, W_o = initial weight of sample and W_t = weight of sample after storage for time, t. The mean for the ten samples of each commodity was then reported.

2.2 Chemical Analyses

Chemical analyses were performed according to the standard official methods described in [10]. Clear juice of eggplant sample was extracted by pulping 100 g of edible portions in a house-hold electric blender followed by straining using double-layered muslin cloth. For each storage period and conditions, triplicate analyses were performed on extracts of the edible portions as follows:

2.2.1 Total Soluble Solids (TSS)

The TSS were determined using an Abbe refractometer (Model: Bellingham & Stanley Limited, England) which was previously calibrated with deionized water (refractive index =1.3330 and 0 ^{o}Brix at 20 ^{o}C). A drop of the extract was placed on the refractometer prism, covered, read and the result expressed as ^{o}Brix. The prism was rinsed between tests with distilled water and wiped dry with a soft, lint free tissue paper.

2.2.2 pH and titratable acidity determinations

pH was determined with the electrode of a previously referenced pH meter (model pH 211, HI Hanna Instruments, Italy) which was placed into 20 ml of each extract in a 50 ml capacity glass beaker.

Plate 1. Evaporative coolers 1 and 2.
EC1= Non-Cladded Burnt-clay-brick evaporative cooler (NBBEC)
EC2= Aluminum-Cladded Burnt-clay-brick evaporative cooler (ABBEC)

Titratable acidity was determined using 10 ml extract pipetted into a 50 ml glass beaker. After adding 3 drops of phenolphthalein indicator, the mixture was titrated by running 0.1 M NaOH solution from a 25 ml glass burette into the beaker. Titration was continued with gentle swirling of the solution to a faint pink coloration that persisted for at least 30 seconds. A blank titration was performed for each run using deionized water in place of the juice extracts. The titratable acidity (TA) was calculated as follows:

$$\text{TA}\,(\%) = (\text{Vt} - \text{Vb})\,(0.1\text{M NaOH})\,(100)/\text{Vs} \quad (2)$$

Where, V_t = titre, V_b = blank titre and V_s= volume of sample used.

2.2.3 Ascorbic acid and total carotenoids

Ascorbic acid content was determined on each 10 mL of juice extract (previously adjusted to pH 1.2 with 1.0M metaphosphoric acid solution) by titration with 0.1% 2,6-dichlorophenol indophenol dye solution. In this oxidation-reduction reaction, the ascorbic acid in the extract was oxidized to de-hydro ascorbic acid and the dye reduced to a colourless compound. The end point of each titration was a rose-pink colour which indicated excess unreduced dye in the acidic medium. The ascorbic acid equivalent of the dye was estimated as follows:

$$\text{Ascorbic Acid}\,(\%) = \text{mL dye X } 100/\text{ weight of extract} \quad (3)$$

Total carotenoids were determined by mixing 2 g extract with 20 mL ethanol; 2 mL n-hexane and 30 mL diethyl ether in a 150 mL separatory glass funnel. The mixture was shaken vigorously about 10 times and then allowed to settle for 1 hr. Then, 5 mL each of the upper organic layer was carefully transferred into clean and labelled test tubes. The absorbance of each organic extractive was read at 450 nm wavelength using 1cm cuvette of an ultraviolet/visible spectrophotometer (Model Jenway 7305). The spectrophotometer was calibrated and zeroed with an n-hexane blank while the cuvette was properly cleaned and rinsed several times with the sample prior to taking readings. The total carotenoids (TC) were calculated as follows:

$$TC\,(\mu g/g) = (A)\,(ml\ extractive)\,(104)/(A1\%)\,(1cm)\,(sample\ weight) \quad (4)$$

Where, $A^{1\%}$ = Absorbance coefficient of beta-carotene= 2592

2.3 Microbiological Analysis

2.3.1 Sample preparation

Samples for total plate counts and fungal counts were prepared as described by Kramer and Twig [11]. For storage condition, triplicate 2 g portions of African eggplant were cut using sterile stainless steel knives. Triplicate 2 g sample were aseptically sliced and homogenized in a Warring blender which was previously washed and sterilized using 100 ppm sodium hypochlorite solution and rinsed with sterile deionized water.

Serial decimal dilutions of the homogenate ranging from 10^{-1} to 10^{-5} were obtained using sterile saline solution. Essentially, 1 g portion of the homogenate was diluted with 9 mL of sterile saline to yield an initial 1:10 dilution. Subsequent serial dilutions were made by adding 1.0 mL of the last dilution to 9.0 mL fresh diluents.

2.3.2 Enumerations

Total aerobic plate counts and fungal counts were performed on nutrient agar and Saboraud dextrose agar respectively using the pour-plate method described by Harrigan and McCance [12]. Each growth medium was prepared by mixing 5 g portions with 200 mL deionized water followed by sterilization in a bench autoclave at 15 psi for 15 min. Each molten agar medium was allowed to cool to 40-45°C prior to use for plating.

For each dilution, triplicate 0.1 mL portions were dispensed into separate Petri-plates and 10 mL of warm sterile molten agar medium poured. The mixture was swirled gently for even distribution and allowed to solidify. The plates were then inverted and incubated at 37$\pm$ 1°C in an electric oven for 24 h for total plate counts and 48-72 h for fungal counts. Average counts were obtained from plates having 30 - 300 colonies multiplied by their respective dilution factors.

2.4 Sensory Evaluation

A consistent panel of 12 semi-trained judges was used to evaluate the appearance, texture and overall acceptability of African eggplant using descriptive sensory profiles. The descriptive terms were 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. Each fruit or vegetable was served in transparent tray with three digit random numbers. The degrees of preference based on the descriptive terms were then converted to scores using the 7-point hedonic scale 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 [13].

2.5 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 [14]. For the storage studies with African eggplant, the variables evaluated were influences of 3 storage times (0, 7th and 21st days) and 3 storage conditions (Atmosphere, NBBEC and ABBEC).

3. RESULTS AND DISCUSSION

3.1 Postharvest Loss in Weight

Weight loss is an important index of storage life in fresh produce. It is mainly attributed to the loss of water during metabolic processes like respiration and transpiration. Weight loss in the African eggplant increased significantly (p<0.05) over the storage period for all the different storage conditions. Generally, the ABBEC storage which had the highest relative humidity and the lowest temperature also recorded the lowest weight losses and retained freshness for up to twenty-one days. The produce had the highest weight loss of 42.1% in ambient storage, 13.8% in NBBEC and the least of 5.9% in ABBEC storage condition (Fig. 1). Islam, et al. [15] Reported that the highest percentage weight loss of 2.39% occurred in eggplant stored in ambient temperature of 25°C for nine days whereas the lowest percentage weight loss of 2.27% was recorded for fruits stored inside the passive evaporative cooler.

Shriveling is one of the effects of excessive water loss leading to higher weight loss. Eggplant fruit with higher weight loss also showed higher degree of shriveling as shown in those stored in ambient condition where relative humidity was lower [4].

Islam and Morimoto [6] Revealed that the continuous higher relative humidity and lower inside temperature of evaporative coolers offered unique advantage in maintaining the firmness of fruit and vegetables by lowering ethylene production and thus decreasing postharvest weight loss and other metabolic processes.

3.2 Total Soluble Solids

There was a gradual increasing trend in the TSS of African eggplant during storage. Fig. 2 revealed that within the initial day of storage and the seventh day, there was non-significant (p>0.05) increase in TSS of eggplant in all the storage conditions. However, significant increase (p<0.05) occurred in TSS values within seven days and twenty-one days of storage at ambient and NBBEC storage conditions. TSS values of eggplant stored in ABBEC showed

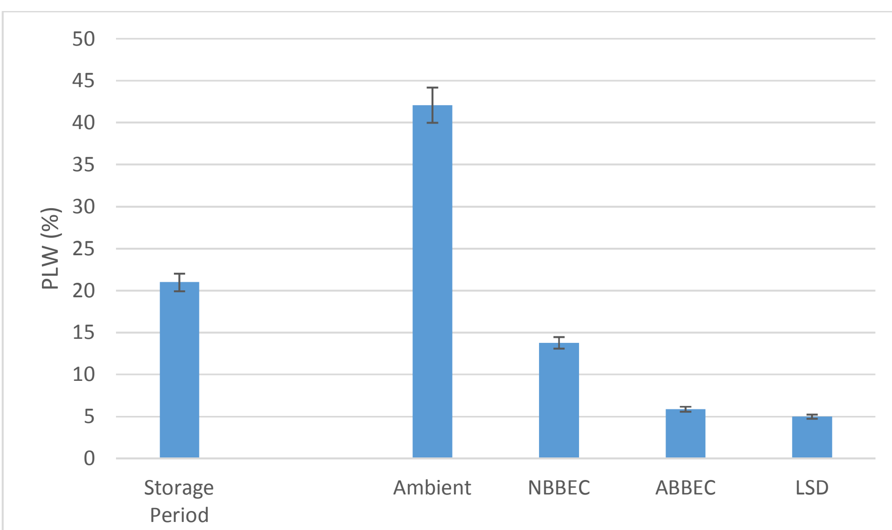

Fig. 1. Effect of storage conditions on physiological weight changes of African eggplant total soluble solids

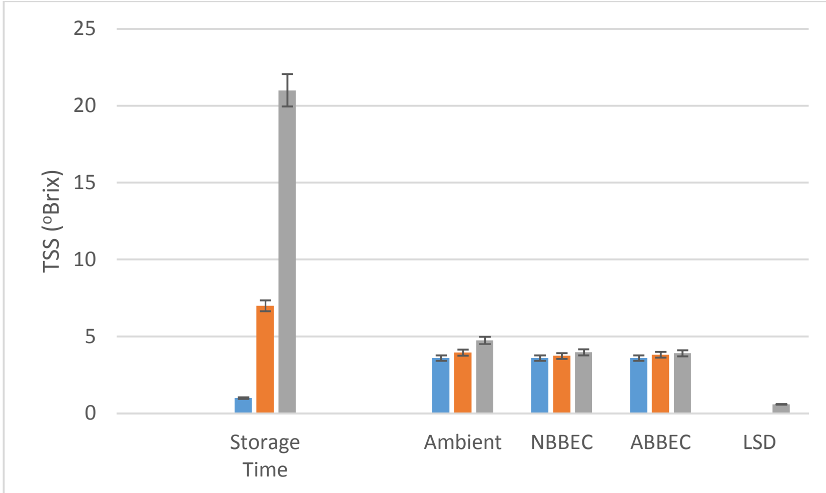

Fig. 2. Effect of storage conditions on TSS of African eggplant

no significant increase within the storage period. The TSS content of eggplant ranged from 3.60 to 4.75°Brix in this study. Similar values within the ranges of 3.02-3.64% and 3.60-6.60% were reported by [16] and [17] respectively. Islam, et al. [15] Revealed that the TSS content depends on maturity stage of the fruit which generally increases progressively during storage due to the hydrolysis of polysaccharides to maintain respiration rate. Similarly, the authors observed that the lower inside temperature of ABBEC delayed the increase in total soluble solids by alternating the cell wall structure and break down of the complex carbohydrates into simple sugars.

3.3 pH and Total Titratable Acidity

A non-significant ($p>0.05$) increase in pH was observed for all the storage conditions during the period of study. However, higher increase in pH was observed in eggplant stored in ambient condition. In this study, the pH of eggplant varied from 5.10 to 5.55. The pH increased gradually with increasing storage duration. The maximum pH of 5.55 was recorded for eggplant after ten days of ambient storage. Changes in pH may be due to metabolic activities of fresh eggplant. This behaviour is consistent with the results obtained for titratable acidity. Similar results were reported by [17] with values ranging from 5.01 to 5.93.

A decrease in titratable acidity and a non-significant effect ($p>0.05$) were observed during the storage period in ABBEC stored eggplants. However, high temperature ambient storage showed a pronounced decline in titratable acidity. This behaviour may be linked to the fact that higher temperatures increase the respiration rate and therefore there is greater degradation of organic acids. Olivas, et al. [18] and [19] observed similar trends for apples during storage at varying temperatures.

The TTA values of eggplant in this study varied from 0.38 to 0.53%. However, [16] reported slightly lower values of 0.20 to 0.32% while [20] reported slightly higher value ranging from 0.46 to 0.72%. This difference in values may be attributed to factors such as variety and growing condition which cause differences in the composition of the fruit.

3.4 Ascorbic Acid and Carotenoids

Ascorbic acid is one of the most important nutritional quality factors in many fresh produce. It is required for healthy skin, bones and muscles. It also plays an important role in the manufacture of collagen, which is the connective tissue that holds bones together.

There was a faster reduction of ascorbic acid for ambient temperature condition compared to evaporative cooler conditions. In this study, the ascorbic acid values of African eggplant varied from 2.57 to 7.30mg/100g (Fig. 2). These values were significantly ($p<0.05$) different at the three storage conditions. The eggplant stored in ambient recorded the highest loss of ascorbic acid (from 7.30 to 2.57mg/100g). However, ABBEC stored eggplants recorded the least loss of ascorbic acid (from 7.30 to 4.48mg/100g). This may be attributed to the lower temperature and higher relative humidity which tends to slow down metabolism and eventually reduce the extent of microbial activities as well as the chemical reactions taking place inside the evaporative coolers. Lower values were observed by Passam and Karapanos [21] who reported ascorbic acid content of 2.2mg/100g. Nunes [22] Reported values ranging from 1.5 to 4.7 mg/100 g. However, [16] and [23] recorded higher values of 9.43 to 16.75 mg/100 g and 16.50 mg/100 g respectively. Weichmann [24] Established the fact that ascorbic acid degrades steadily during prolonged storage due to oxidation. Vanderslice and Higgs [25] Observed that the ascorbic acid content of fruits varies with fruit maturity, genetic variety, climate and sunlight; and maybe responsible for the variation in the ascorbate content reported. Previous studies [26,27] have reported storage duration and condition to be an important parameter in ascorbic acid degradation.

The beta carotene content of eggplant decreased significantly ($p<0.05$) during storage. The beta carotene of eggplant in this study ranged from 187.50 to 1939.23 µg/100 g. The result as shown in Fig. 3 revealed a significant decrease in the carotenoid content of eggplant in the different storage conditions along with the storage duration. However, the rate of decrease in carotenoids was significantly higher in eggplant stored in ambient (1939.23 to 187.50 µg/100 g) as compared with evaporatively stored eggplants (1939.23 to 395.47 µg/100 g) in NBBEC and ABBEC (1939.23 to 444.43 µg/100 g) storages respectively. Carotenoids appear to be less adversely affected in ABBEC storage compared to NBBEC and ambient storage conditions. Chepngeno, et al. [28] reported that beta carotene values of African eggplant declined from 763 µg/100 g to 424 µg/100 g in their study on effect of calcium chloride and hydro cooling on postharvest quality of selected vegetables.

Table 1. Effect of storage conditions on ph and total titratable acidity of African eggplant

Parameter	Storage Time (Days)	Ambient	NBBEC	ABBEC	LSD
pH	1	5.10^{a}	5.10^{a}	5.10^{a}	
	7	5.25^{a}	5.11^{a}	5.10^{a}	
	21	5.55^{a}	5.14^{a}	5.10^{a}	0.48
TTA (%)	1	0.53^{a}	0.53^{a}	0.53^{a}	
	7	0.45^{b}	0.50^{b}	0.51^{a}	
	21	0.38^{b}	0.42^{ab}	0.50^{a}	0.14

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

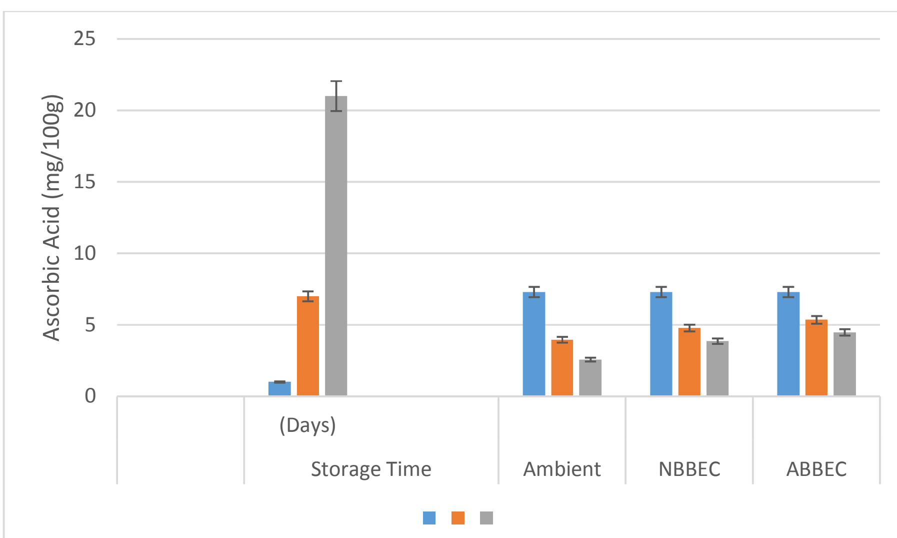

Fig. 3. Effect of storage conditions on ascorbic acid content of African eggplant

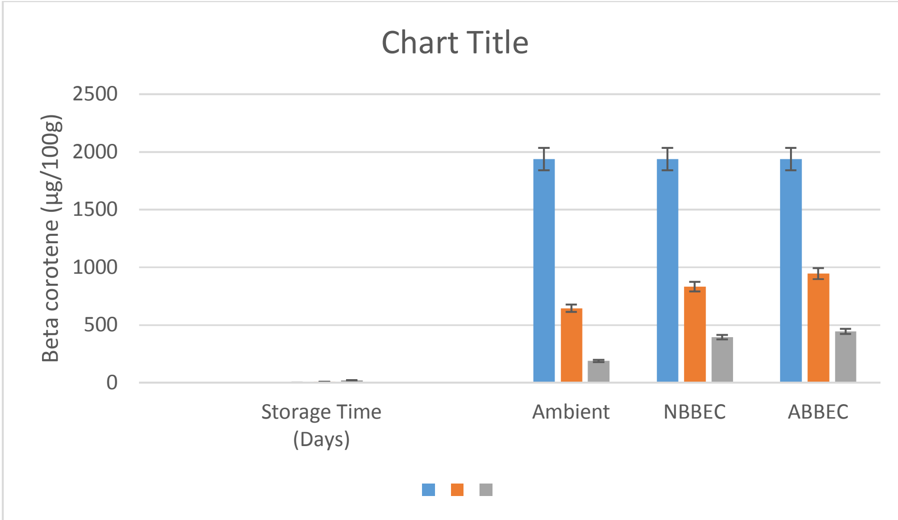

Fig 4. Effect of storage conditions on beta carotene content of African eggplant

3.5 Microbiology of Eggplant

The effect of storage conditions on the microbial load of African eggplant as presented in Table 2 indicated that the total plate count ranged from 1.68 to 3.76 Log_{10} cfu/g while the yeast and mould count varied from 0.69 to 3.13 Log_{10}cfu/g. The initial microbial load of eggplant was low due to the skin cover of the fruit. According to Odumeru, et al. [29], the protective cover of fruits and the possession by some pH values below which many organisms cannot grow, are important factors in the microbiology of these fruits. The microbial load of eggplant was significantly ($p<0.05$) different at the three storage conditions and duration. Lower storage temperature and higher relative humidity in the ABBEC explains the lower metabolic activities in this storage. The microbial load was maximum in ambient storage and minimum in ABBEC storage (Table 2). Murugan, et al. [30] Reported higher total heterotrophic bacterial load in eggplant as 7.03 Log_{10}cfu/g and fungal population as 5.23 Log_{10}cfu/g. Aguoru, et al. [31] reported high level of bacterial contaminants of 7.81 Log_{10}cfu/g while Lennox and Effiuvwevwere [32] recorded lower initial bacterial load of 2.61 Log_{10}cfu/g on freshly harvested eggplant and 3.34 Log_{10}cfu/g on market retailed eggplant respectively. Their study revealed that the microbial load in market retailed eggplant could be due to the unhygienic environment of the market and also the use of contaminated water in washing the eggplant. Generally, the microbial population of eggplant increased with increase in storage time. Eggplant stored at lower temperature exhibited lower microbial loads.

3.6 Sensory Evaluation

Panelists in this study scored fresh eggplant 6.80 out of 7.00 points on the hedonic scale because it was glossy, fresh and whitish green, and very attractive (Table 3). Samples under ambient storage had the least score of 2.94 after ten days of storage while those stored in NBBEC and ABBEC conditions scored 5.00 and 5.05 respectively within twenty-one days' storage duration. Evaporative cooling was best for eggplant storage because they originated from tropical areas and are therefore chilling sensitive. [33] Noted that below 10°C eggplant fruits suffer physiological disorders manifested mainly by appearance of surface injuries such as pitting and scald, seed darkening and flesh browning.

In this study, the colour of eggplant fruit changed from whitish green to yellowish orange on the samples kept under ambient condition whereas those stored in evaporative coolers remained fresh and wholesome for nineteen days and twenty-one days in NBBEC and ABBEC storage conditions, respectively. The passive evaporative coolers maintained the lightness and greenness which prevented skin darkening. The fruits shriveled, wilted due to dehydration after ten days of ambient storage. [34] Reported similar trend that at room temperature, the shelf life of eggplant was only three days whereas it extended up to twenty-one days in the cool chamber where they remained fresh, firm and attractive. Eggplant stored in evaporative coolers maintained the best visual quality.

Table 2. Effect of storage conditions on the microbial load of African eggplant

Parameter	Storage time (Days)	Ambient	NBBEC	ABBEC
Total plate count (Log_{10}cfu/g)	1	1.68[c]	1.68[c]	1.68[c]
	7	1.78[d]	1.74[d]	1.70[d]
	21	3.76[e]	2.08[f]	1.95[g]
Yeast & mould count (Log_{10}cfu/g)	1	0.69[a]	0.69[a]	0.69[a]
	7	1.48[b]	1.12[c]	0.90[a]
	21	3.13[c]	1.54[b]	1.40[d]

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

Table 3. Effect of storage conditions on sensory scores of African eggplant

Sensory attribute	Storage time (Days)	Ambient	NBBEC	ABBEC
Appearance	1	6.80[a]	6.80[a]	6.80[a]
	7	4.86[b]	6.05[b]	6.18[a]
	21	2.94[d]	5.00[c]	5.05[c]
Texture	1	6.50[a]	6.50[a]	6.50[a]
	7	5.48[b]	5.56[ab]	5.82[a]
	21	3.84[c]	5.28[bd]	5.54[b]
Overall acceptability	1	6.31[a]	6.31[a]	6.31[a]
	7	4.55[b]	5.73[c]	6.09[a]
	21	3.45[d]	5.45[bc]	5.85[a]

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

In terms of the degree of shriveling, the African eggplant inside the cooler showed no signs of shriveling, wilting or dryness compared to those in ambient environment. Eggplants in the evaporative coolers showed better conditions in terms of weight loss, visual quality and degree of shriveling compared to those stored in ambient. [4] Observed that there was shriveling due to extensive moisture loss in ambient stored eggplant fruit. Similarly, [35] and [36] observed that during storage, the texture of fruit is likely to soften due to several factors such as loss in cell turgidity pressure, loss of extracellular and vascular air and degradation of the cell wall and consequent loss of water by the cell breakdown.

Panelists scored 6.31 for overall acceptability of fresh eggplant out of 7.00 on the hedonic scale. This decreased to the least mark of 3.45 in ambient, 5.45 in NBBEC and the highest of 5.85 in ABBEC storage conditions. According to [37], sensory quality attributes and nutritive value of fruit play an important role in consumer satisfaction and they influence further consumption.

4. CONCLUSION

The use of evaporative coolers can prolong the shelf life of fresh produce including eggplant. African eggplants stored in the evaporative coolers maintained the best visual quality, exhibited better retention of firmness and nutritional value. The increase in shelf life of eggplants for up to twenty-one days especially in ABBEC would provide marketing flexibility thereby allowing farmers dispose off their fresh produce at the most appropriate time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ogbonna AC, Abuajah CI, Ekpe GE. A comparative study of the nutritive factors and sensory acceptance of juices from selected Nigerian fruits. Croatian Journal of Food Technology, Biotechnology and Nutrition. 2013;8(1-2):47-51.
2. Nunes MCN. Impact of environmental conditions on fruit and vegetable quality. Stewart Postharvest Review. 2008;4(4):1-14.
3. FAOSTAT: Food and Agriculture Organization of the United Nations, Statistics Division; 2015. Retrieved 20th November 2015.

4. 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.
5. Keyla A. All facts about Eggplant Nutrition and incredible benefits for health. Natural health for better life. Powered by Blogger; 2012.
6. Islam MP, Morimoto T. Evaluation of a new heat transfer and evaporative design for a zero energy storage structure. Solar Energy. 2015;118(2015):469-484.
7. Ogbuagu NJ, Green IA, Anyanwu CN, Ume JI. Performance evaluation of a composite-padded evaporative storage bin. Nigerian Journal of Technology (NIJOTECH). 2017;36(1):302-307.
8. Ishaque F, Hossain MA, Sarker MA, Mia MY, Dhoubo AS, Uddin GT, Rahman MH. A study on low cost postharvest storage techniques to extend the shelf life of citrus fruits and vegetables. Journal of Engineering Research and Reports. 2019; 9(1):1-17.
9. 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.
10. AOAC Official Methods of Analysis of the Association of Official Analytical Chemists, 22nd Ed, Association of Official Analytical Chemists, Washington D.C; 2005.
11. Kramer A, Twig BA. Quality Control for the Food Industry, The AVI Publishing Co., Inc., West Port, Connecticut. 1970;1:556.
12. Harrigan WF, McCance M. Laboratory Methods in Food and Dairy Microbiology. Academic Press Inc., London. 1990;25-28.
13. Iwe MO. Handbook of sensory methods and analysis, Enugu Nigeria. Rojoint Communication Science Ltd. 2010;75-78.
14. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. Macmillan Education Ltd London and Oxford. 1985;199-200.
15. Islam MP, Morimoto T, Hotou K. Effect of passive evaporative cooler on physico chemical properties of hot water treated *Solanum melongena* L. Agric. Eng. Int. 2014;16(2):181-186.
16. Kandoliya UK, Bajaniya VK, Bhadja NK, Bodar NP, Golakiya BA. Antioxidant and nutritional components of eggplant (*Solanum melongena*, L.) fruit grown in Sarastra Region. International Journal of Current Microbiology and Applied Sciences. 2015;4(2):806-813.
17. Prohens J, Rodriguez-Burruezo A, Raigon MD, Nuez F. Total Phenolic concentration and browning susceptibility in a collection of different varietal types and hybrids of eggplant: Implications for breeding for higher nutritional quality and reduced browning. Journal of American Society for Horticultural Science. 2007;137:5638-5646.
18. Olivas GI, Mattinson DS, BARBOSA-CANOVAS GV. Alginate coatings of minimally processed 'Gala' apples. Postharvest Biology Technology. 2007; 45(1):89-96.
19. Fagundes C, Carcioff BAM, Monteiro AR. Estimate of respiration rate and physicochemical changes of fresh–cut apples stored under different temperatures. Food Science and Technology, Campinas. 2013;33(1):60-67.
20. Wuzhong N. Yield and quality of fruits of Solanaceous crops as affected by Potassium fertilization. Better Crops International. 2002;16(1):6-8.
21. Passam HC, Karapanos IC. Eggplants, peppers and tomatoes: Factors affecting the quality and storage life of fresh cut and (minimally processed) produce; 2008.
22. Nunes MC. Colour Atlas of Postharvest Quality of fruits and vegetables. John Wiley and Sons. Technology and Engineering. 2009;281-285.
23. Madukwe EU, Ani PN, Ezeonu C. Comparative analysis of antioxidant vitamins in extracts of three vegetables among the commonly consumed in Southeastern Nigeria. Global Research Analysis International. 2013;2(6):94-95.
24. Weichmann J. Postharvest Physiology of Vegetables. Marcel Dekker Inc., New York, USA. 1987;42-44.
25. Vanderslice JT, Higgs DJ. Separation of ascorbic acid and isoascorbic acid, dehydroascorbic acid in food and animal tissue. J. Micronutrient Analysis. 1990;7: 67.
26. Morris A, Barnett A, Burrows O. Effect of processing on nutrient content of foods. Cajanus, 2004;37(3):160-164.
27. Lee HS, Nagy S. Quality changes and nonenzymic browning intermediate in grapefruit juice during storage. Journal of Food Science. 1988;53(1):168-172.

28. Chepngeno J, Owino W, Kinyiru J, Nenguwo N. Effect of calcium chloride and hydrocooling on postharvest quality of selected vegetables. Journal of Food Research. 2016;5(2):23-40.
29. Odumeru JA, Mitchell SJ, Alves DM, Lynch JA, Yee AL, Wang S, Styliadis S, Faber J. Assessment of the microbiological quality of ready-to-eat vegetables for healthcare food services, Journal of Food Protection. 1997;60:954-960.
30. Murugan AM, Ranjith Singh AJA, Vidhya S. Evaluation of shelf-life and organoleptic aspects of fruits stored in a modified earthen pot cool chamber. Indian Journal of Traditional Knowledge. 2011;10(2):375-379.
31. Aguoru CU, Maaji S, Olasan JO. Bacteria Contaminants on Surfaces of Some Edible Fruits Sold in Makurdi Metropolis, Benue State, Nigeria. International Journal of Current Microbiology and Applied Sciences. 2015;4(6):334-340.
32. Lennox JA, Effiuvwevwere. (Microbial Dynamics of Fermenting Garden Egg (*Solanum melongena*): International Journal of Current Microbiology and Applied Sciences. 2014;3(7):950-957.
33. Salunkhe DK, Desai BB. Postharvest Biotechnology of Vegetables. CRC Press, Inc. 1984;1:1-53.
34. Ganesan M, Balasubramanian K, Bhavani RV. Studies on the application of different levels of water on zero energy cool chamber with reference to the shelf life of Brinjal. J. Indian Inst Sci. 2004;84:107-111.
35. Somogyi LP, Ramaswamy HS, Hui YH. (eds) Processing Fruits: Science and Technology. Biology, Principles and Applications. Technomic Publishing Co., Inc. Lancaster, PA. 1996;1:510.
36. Martinez – Ferrer M, Harper C, Perez–Munoz F, Chaparro M. Modified atmosphere packaging of minimally processed mango and pineapple fruits. Journal of Food Science. 2002;67:3365-3371.
37. Escribano S, Sanchez FJ, Lazaro A. Establishment of sensory characterization protocol for melon (*Cucumis melo* L.) and its correlation with physical chemical attributes indications for future genetic improvements. European Food Research Technology. 2010;231: 611-621.

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