Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina L
Broj 1., 2025.
Strane: 13 – 22

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year L
No.1., 2025.
pp. 13 – 22

Original Scientific paper
Originalni naučni rad
DOI: 10.5937/POLJTEH2501013B

EFFECT OF PASSIVE EVAPORATIVE COOLING DEVICE ON PROXIMATE COMPOSITION AND PHYSICOCHEMICAL PROPERTIES OF TOMATOES (*Lycopersicon esculentum*)

Rhoda N. Banjo[1], William A. Olosunde[1], Ubong E. Assian*[1]

[1]*Department of Agricultural and Food Engineering, Faculty of Engineering, University of Uyo, Uyo, Akwa Ibom State, Nigeria*

Abstract: To reduce postharvest loss of tomatoes' nutrients during storage, in a rural area where there is no electricity supply, an existing passive evaporative cooler (PEC) which consists of an overhead tank, a single faced pad system, storage chambers, tray, base plate, drain pipe, water distribution network and jute bag material was used. Thirty (30) fresh matured tomato fruits were obtained and divided into two groups. Their initial proximate composition and physicochemical properties were determined using standard methods before stored in the PEC of relative humidity and temperature of 99.0% and 26℃ respectively whereas others were stored on the shelf at room temperature (RT) of relative humidity and temperature of 75.0% and 29℃, respectively. At every 3 days interval, the samples were removed for analyses. Data were obtained in replicate and subjected to analysis of variance using Tukey Honest Significant Difference. Results showed that the shelf life of the tomatoes stored in PEC were prolonged without spoilage for about 18 days while those stored under RT lasted for less than 12 days before spoilage. Also, % moisture, ash, protein, fibre and soluble solid contents of tomatoes stored in the PEC slightly dropped within 18 days whereas those stored on the shelf at RT dropped drastically within 8-12 days. The PEC was found to retain the freshness of the tomatoes.

Keywords: *Passive evaporative cooler, tomatoes, proximate composition, physicochemical properties.*

INTRODUCTION

Fruits and vegetables such as pepper, okra, tomato, etc., being perishable, require immediate post-harvest attention to reduce the microbial load, and increase their availability and shelf life, which can be achieved by storing them at low temperature and high relative humidity conditions.

*Corresponding Author. E-mail: assian4real@yahoo.com
ORCID: 0000-0001-7802-0552

These conditions are usually achieved in cold storages like the passive evaporative coolers [1]. Evaporative cooling is a physical phenomenon in which liquid evaporates into the surrounding air and thereby cools an object or a liquid in contact with it [2]. Evaporative coolers provide cool air by forcing dry air over a wetted pad. The water in the pad evaporates, removes the heat from the air while adding moisture.

When water evaporates, it draws energy from its surroundings and produces a considerable cooling effect [3]. This occurs when air that is not too humid passes over a wet surface; the faster the rate of evaporation, the greater the cooling rate [4]. However, preserving fruits (e.g., pepper, okra, tomato, etc.) in their fresh form demands that the chemical, bio-chemical and physiological changes are restricted to a minimum by close control of certain factors [5]. These factors include: the activities of fungal and bacterial organisms [6]; relative humidity and light intensity [7, 8]; and temperature, which affects the rate of respiration of harvested or stored fruit and reduces the time necessary for its maturity [9, 10, 11]; and a combination of different gases in a storage environment [12]. All these factors can interact and influence the quality of fresh commodities. These can be in form of physical damage or invasion of microorganisms. For instance, very low relative humidity condition (15-22%) can affect the photosynthetic ratio due to the closing of the stomata which result in reduction of plant growth, size and total production [7]. Meanwhile, vegetables are known to enhance the nutritional quality of diet because of their richness in vitamins and minerals. Any deficiency of these nutrients can lead to widespread of diseases which could result in death. Vegetable, like tomato, is also rich in fibre which is essential for good digestion. In this study, there is a need to address the preservation, and storage of tomatoes to reduce death caused by the deficiency of the needed nutrients [13]. Since, tomatoes should be consumed in their fresh state as to gain all the benefits they offer, improper storage can lead to loss in the nutrients inherent in them. Hence, the choice of storage system is very important and it must be able to keep them safe while also maintaining its quality. Therefore, the main objective of this work was to determine the effect of passive evaporative cooling (PEC) on the proximate composition and physicochemical properties of the tomatoes. The study would give an insight on a better storage system / condition which could adopted for commercial scale in a rural area where there is no electricity supply.

MATERIALS AND METHODS

Sourcing of Materials

Matured fresh tomato fruits free from post-harvest treatment were got from one of the farms in Ibesikpo Asutan L.G. A. of Akwa Ibom State, and the matured ones were selected for the experiment.

Storage Conditions

The tomatoes (about 30 fruits) were divided into two groups. Some were stored in the passive evaporative cooler (PEC) of relative humidity and temperature of 99.0% and 26℃ respectively whereas the rest were stored on the shelf at room temperature (RT) of relative humidity and temperature of 75.0% and 29℃, respectively.

The whole research was conducted in Food Engineering Laboratory, Department of Agricultural and Food Engineering, University of Uyo, Uyo, Nigeria, as shown in Figure 1.

Fig. 1. Tomatoes stored in passive evaporative cooler (PEC)

Methodology

The following proximate analysis and physicochemical properties were carried out using the samples stored in both conditions: percentages of weight loss, moisture, ash, protein, crude fiber contents, soluble solids, and color after three days interval.

I. Proximate Analysis

(a) Weight Loss

The samples were weighed using a digital weighing balance. The difference between the initial and final weight during each storage intervals was used to calculate the rate of water loss.

(b) Moisture Content

This was determined using the oven drying method. The moisture content was determined by estimating the samples' weight loss after drying at 105℃ for 3 hrs. until a constant weight was obtained [14]. Then, the percentage moisture was calculated from the Equation 1.

$$\% \text{ Moisture Content} = \frac{W_1 - W_3}{W_1} \times 100\% \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (1)$$

where,

W_1 = initial weight (g) ,

W_3= final / constant weight (g)

(c) Ash Content

This was determined according to AOAC [14]. The tomato was sliced, and about 5.0 g was weighed into a crucible.

The sample was placed in a muffle furnace at 550℃ until the sample was completely charred. The crucible was brought out, cooled in a desiccator, weighed, and the ash content was calculated using Equation 2.

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots(2)$$

(d) Protein Content

Crude protein content of the sample was determined using the standard Kjeldahl method [14]. About 5.0 g of the sliced tomato was digested using 5.0 ml conc sulphuric acid in the presence of Kjeldahl tablets as catalyst. The sample solution was heated slowly for about 30 minutes and rapidly for 2 hours until a clear solution was obtained. After cooling, the sample was transferred to a 100 ml volumetric flask and made to the volume with distilled water. Thereafter, 40 ml of 40% sodium hydroxide was introduced into the flask, and this was allowed to distillate. The distillate was collected into a conical flask containing 25 ml boric acid with mixed indicators. The ammonium borate solution formed was titrated against 0.1 M hydrochloric acid until an end point was reached. Then, the titer value was noted and the crude protein calculated using Equation 3.

$$\% \text{ Crude protein content} = \frac{0.14 \times 6.25 \times \text{titre value}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots \quad (3)$$

(e) Crude Fibre

The defatted sample was first hydrolyzed with sulphuric acid, and then with sodium hydroxide after washing with hot distilled water. It was then neutralized with 1% hydrochloric acid before washing again with hot distilled water. The remains were then dried in an oven before putting it in the muffle furnace until completely charred and the percentage crude fiber was calculated using Equation 4 [14, 15].

$$\% \text{ Crude fibre} = \frac{\text{Weight of fibre}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

II. Physicochemical Properties

(a) Soluble Solids

A digital handled MR-50 refractometer was used at 20^{0}C according to Cole-Parmer [16] to determine the soluble solids in the samples. First, the refractometer was calibrated with distilled water to zero the instrument. Then, its cover was removed and 0.5 ml of sample was dropped on the prism. Thereafter, reading was noted and reported in % Brix.

(b) Colour

Surface colour of the samples were evaluated using colorimeter [16]. The supernatant was taken to measure the values of L^*, a^* and b^* of the samples and the white board was used as a controller. The L^* value represents the degree of brightness of the sample, a^* value represents the degree of redness and b^* value represents the degree of yellowness of the sample. The total colour difference (ΔE) was calculated using the Equation 5.

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Statistical Analysis

Data were obtained in replicate samples and subjected to analysis of variance (ANOVA) and mean differences separated using Tukey Honest Significant Difference (THSD). The results were presented in tables ang charts.

RESULTS AND DISCUSSION

Proximate Composition and Physicochemical Properties of Tomatoes at Different Storage Conditions

The proximate compositions and physicochemical properties of tomatoes stored at room temperature (RT) and passive evaporative cooler (PEC) are presented in Tables 1 and 2.

Table 1. Proximate Composition of Tomatoes Stored at Room Temperature

Days	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Soluble Solids (%)
0	94.221 ± 0.01^d	0.228 ± 0.01^c	0.471 ± 0.011^d	0.368 ± 0.009^d	4.305 ± 0.02^d
3	94.220 ± 0.03^d	0.227 ± 0.01^c	0.469 ± 0.010^d	0.367 ± 0.010^d	4.303 ± 0.01^d
6	90.453 ± 0.05^c	0.202 ± 0.01^{bc}	0.422 ± 0.002^c	0.330 ± 0.004^c	3.990 ± 0.01^c
9	89.713 ± 0.36^b	0.173 ± 0.02^b	0.287 ± 0.003^b	0.259 ± 0.010^b	3.790 ± 0.01^b
12	80.210 ± 0.01^a	0.030 ± 0.01^a	0.140 ± 0.013^a	0.212 ± 0.010^a	1.797 ± 0.01^a

Values are represented as mean ± standard deviation of triplicate (3) replicate. Mean in the same column bearing different superscript differed significantly (p<0.05).

Table 2. Proximate Composition of Tomatoes Stored in PEC

Days	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Soluble Solids (%)
0	94.224 ± 0.03^d	0.208 ± 0.010^d	0.473 ± 0.001^f	0.372 ± 0.002^f	4.301 ± 0.002^f
3	94.223 ± 0.04^d	0.207 ± 0.020^d	0.471 ± 0.001^f	0.370 ± 0.001^f	4.300 ± 0.001^f
6	92.993 ± 0.10^c	0.213 ± 0.010^d	0.440 ± 0.001^e	0.349 ± 0.001^e	4.200 ± 0.001^e
9	92.750 ± 0.13^c	0.195 ± 0.004^d	0.310 ± 0.001^d	0.320 ± 0.001^c	4.007 ± 0.030^d
12	91.430 ± 0.11^b	0.158 ± 0.001^c	0.269 ± 0.002^c	0.290 ± 0.001^b	3.800 ± 0.000^c
15	90.037 ± 0.16^a	0.109 ± 0.001^b	0.220 ± 0.001^b	0.251 ± 0.001^a	3.507 ± 0.006^b
18	89.897 ± 0.01^a	0.074 ± 0.007^a	0.100 ± 0.001^a	0.220 ± 0.001^a	3.200 ± 0.010^a

After the first three (3) days of storage, it was observed that there were no significant changes in the samples' moisture levels stored in RT ($94.22 \pm 0.03\%$ wb) and PEC ($94.223 \pm 0.04\%$ wb). After six (6) days, there was a significant difference in the moisture level of samples stored in RT whereas that of PEC reduced slightly. Beyond twelve (12) days, the samples stored at RT decayed, hence, the experiment was discontinued while that of the PEC continued. The moisture content of the tomatoes decreased with period of storage and the lowest moisture content was found on the 12 days of storage. This occurrence may be due to low relative humidity of surrounding air. The pictorial views of the fresh tomato samples stored in PEC and at RT after 9 days are shown in Figures 2, 3 and 4.

Fig. 2. Fresh tomatoes

Fig. 3. Tomatoes stored in PEC after 9 days

Fig. 4. Tomatoes stored at room temperature after 9 days

However, the ash, protein, fibre and soluble solids contents also decreased with storage period and the optimum proximate composition was observed at the third day of storage. There was significant mean difference in ash content mean values of the samples stored at RT and in PEC. After day 18, the tomatoes stored in the PEC had ash content of $0.074 \pm 0.020\%$ while at day 12, the ash content of those stored at RT dropped significantly $0.030 \pm 0.010\%$. Even at day 18, the fibre content of tomatoes stored in the PEC was more than those stored at RT. More sugars were retained in the tomatoes stored in the PEC compared to those stored at RT.

The PEC storage had significant effect on the proximate composition and soluble solids of tomatoes as nutrient at 12 days of storage was higher than that gotten from RT storage. The protein content of tomatoes, at day 12, stored in PEC was $0.269 \pm 0.002\%$ while that of RT was $0.140 \pm 0.013\%$. Again, the tomatoes remained firm after 12 days of storage. This shows that tomatoes stored in PEC has high nutritive value than those stored at RT.

Besides, the colour properties of tomato samples stored at RT and PEC, and their total colour change for both storage conditions are shown in Figures 5 to 7, respectively.

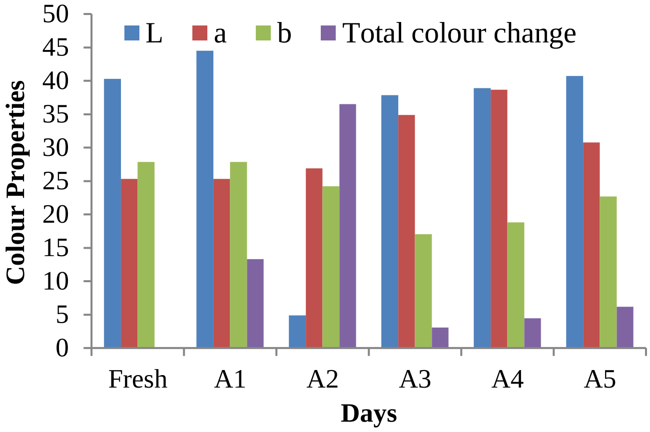

Fig. 5. Colour of the samples stored at RT

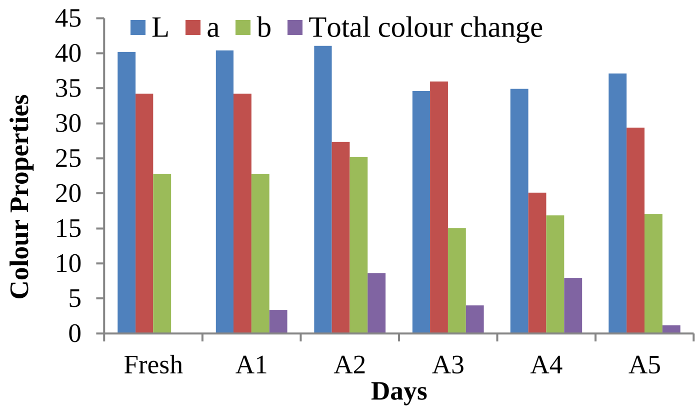

Fig. 6. Colour of the samples stored at PEC

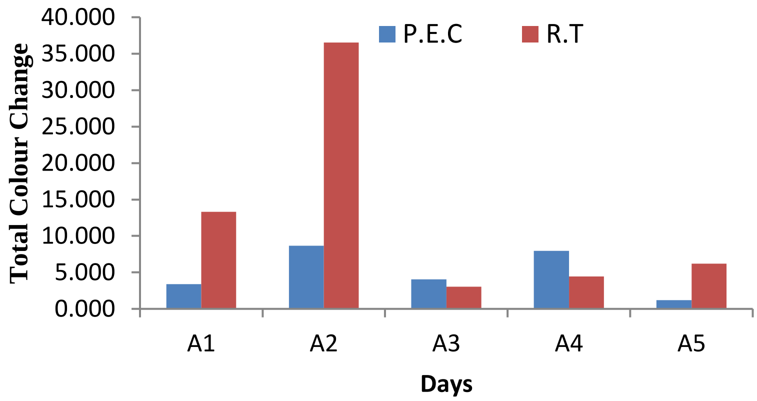

Fig. 7. Total colour difference for both PEC and RT

From Figure 5, the sample stored at RT were lighter in colour than the fresh samples for day 3, 9, 12, 15 and 18 while on day 6, the tomatoes were darker as shown by the low L* value. There was significant total colour differences for all the tomatoes stored at RT compared to the fresh samples. In Figure 6, the colour properties of tomatoes showed that during the first 3 and 6 days of storage, the tomatoes had a lighter colour as compared to others in the subsequent days. The colour difference compared to the fresh samples for 3 and 6 days were very close as there was no significant colour difference. As observed in Figure 7, the tomatoes stored in the PEC retained their colour compared to those stored at RT. The samples stored at RT had higher colour change that those stored in PEC.

CONCLUSION

Based on the results of the study, the proximate compositions were higher in the PEC at about 18 days while that of the RT had lost more nutrients within 12 days duration. The tomatoes stored in PEC retained their freshness in terms of moisture content compared to those stored at RT. Tomatoes stored in the PEC had a longer shelf life compared to those at RT. Colour retained in the tomatoes stored in PEC were better in lightness than those stored at RT. Physically, the tomatoes stored in PEC retained their firmness even after 18 days while those stored at RT lost their firmness at about 12 days. Hence, PEC can be used to store fresh tomatoes in rural area where there is no electricity supply.

CONFLICT OF INTEREST

None is declared.

REFERENCES

[1] Olosunde, W. A. 2006. Performance Evaluation of Absorbent Materials in the Evaporative Cooling System for the Storage of Fruits and Vegetable. M.Sc Thesis, Department of Agricultural Engineering, University of Ibadan, Ibadan.

[2] Watt, J. R. and Brown, W. K. 1997. Evaporative Air Conditioning Handbook (3rd Edition). Prentice Hall PTR, New Jersey. 356 p.

[3] Liberty, J. T., Ugwuishiwu B. O., Pukuma, S. A. and Odo, C. E. 2013. Principles and Application of Evaporative Cooling Systems for Fruits and Vegetables Preservation; International Journal of Current Engineering and Technology, 3(3): pp.1000 – 1006.

[4] Odesola, I. F. and Onyebuchi, O. 2009. A Review of Porous Evaporative Cooling for the Preservation of Fruits and Vegetables. The Pacific Journal of Science and Technology, 10 (2): pp.935 – 941.

[5] Jha, S. N. and Chopra, S. 2006. Selection of bricks and cooling pad for construction of evaporatively cooled storage structure. Inst Engineers (I) (AG): 87. pp.25–28.

[6] Garcia, E. and Barrett, D. M. 2006. Evaluation of processing tomatoes from two consecutive growing seasons: Quality attributes peelability and yield. Journal of Food Processing and Preservation, 30(1): pp.20-36.

[7] Buschermohle, M. J. and Grandle, G. F. 2002. Controlling the environment in greenhouses used for tomato production. Agricultural Extension Service, The University of Tennessee: pp. 1-10.

[8] Preedy, V. R. and Watson, R. R. 2010. Tomatoes and Tomato Products: Nutritional, Medicinal and Therapeutic Properties (1st Edition). CRC Press, Boca Raton, 665p.

[9] FAO 1989. Prevention of post-harvest food losses fruits, vegetables and root crops a training manual. FAO Training Series: No. 17/2

[10] Dorais, M., Gosselin, A. and Papadopoulos, A. P. 2001. Greenhouse tomato fruit quality. Horticultural Review, 26: pp.239-306.

[11] Wilson, C. L.; A. El-Ghaouth and Wisniewski, M. E. 1999. Prospecting in Nature's Storehouse for Biopesticides Conference Magistra Revista Maxicana de Fitopatologia, 17: pp.49-53.

[12] Artés, F., Gómez, P. A. and Artés-Hernández, F. 2006. Modified atmosphere packaging of fruits and vegetables. Stewart Postharvest Review, 2(5): pp.1–13.

[13] Pantheen, D. R. and Chen, F. 2010. Genomics of fungal disease resistance in tomato. Current Genomics, 11(1): 30-39

[14] AOAC (Association of Official and Analytical Chemists) 2012. Official Methods of Analysis. 19th Edition, Association of Official and Analytical Chemists, Washington D.C. 876p.

[15] Muhammad, S., Sheikh, S. and Nizamani, S. M. 2009. Determination of Nutritive Values of Jamun Fruit (Eugenia jambolana) Products. Pakistan Journal of Nutrition. 8. 10.3923/pjn.2009.1275.1280.

[16] Cole-Parmer 2016. What is a Refractometer and How Does It Work? https://www.coleparmer.com/tech-article/refractometer. Accessed on December 4, 2024.

EFEKTI OPREME ZA PASIVNO HLAĐENJE EVAPORACIJOM NA SASTAV I FIZIČKO-HEMIJSKE OSOBINE PARADAJZA (*Licopersicon esculentum*)

Rhoda N. BANJO[1], William A. OLOSUNDE[1] and Ubong E. ASSIAN[1]

[1]*Department of Agricultural and Food Engineering, Faculty of Engineering, University of Uyo, Uyo, Akwa Ibom State, Nigeria*

Apstrakt: Da bi se smanjio gubitak hranljivih materija paradajza (*Licopersicon esculentum*) nakon branja tokom skladištenja, u ruralnom području gde nema napajanja električnom energijom, korišćen je postojeći pasivni evaporativni hladnjak (PEH) koji se sastoji od: nadzemnog rezervoara, jednostranog sistema podmetača, komora za skladištenje, tacne, osnovne ploče, odvodne cevi, mreže za distribuciju vode i materijala za vreće od jute.

Upotrebljeno je trideset (30) sveže zrelih plodova paradajza i podeljeno u dve grupe. Njihov početni približni sastav i fizičko-hemijska svojstva su određeni standardnim metodama pre skladištenja u PEH sa relativnom vlažnosti i temperaturom vrednosti od 99,0% i 26°C, respektivno. Ostali uzorci su čuvani na polici na sobnoj temperaturi (ST) relativne vlažnosti i temperature od 75,0% i 29°C, respektivno. U intervalu od 3 dana, uzorci su vađeni radi analize. Podaci su dobijeni u ponavljanju i podvrgnuti analizi varijanse korišćenjem Tukey Honest Significant testa za utvrđevanje značajnosti razlike. Rezultati su pokazali da je rok trajanja paradajza uskladištenog u PEH produžen bez kvarenja za oko 18 dana. Plodovi paradajza koji su čuvani na sobnoj temperaturi trajali su manje od 12 dana pre kvarenja.

Takođe, procenat vlage, pepela, proteina, vlakana i rastvorljivih čvrstih materija u paradajzu koji se čuva u PEC-u blago je opao u roku od 18 dana, dok je sadržaj uzorka koji se nalazi na polici na sobnoj temperaturi drastično opao u kraćem roku od 8-12 dana.

Utvrđeno je da sistem PEH (pasivni evaporativni hladnjak) duže zadržava svežinu paradajza.

Ključne reči: *Pasivni evaporativni hladnjak, paradajz, proksimativni sastav, fizičko-hemijska svojstva.*

Prijavljen/Registered:
***Submitted*: 27.12.2024.**
Ispravljen:
***Revised*: 15.01.2025.**
Prihvaćen:
***Accepted*: 09.02.2025.**