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Research Article

Evaluation of Storage Types with Pot-in-Pot Technique for Preservation of Tomato Fruit in Holeta, Western Shewa Zone, Oromia, Ethiopia

Nesru Zeynu*, Abdi Keba

Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, Department of Food Science and Nutrition, Addis Ababa, Ethiopia

Abstract

Tomato is one of the most widely cultivated and extensively consumed horticultural crops worldwide. However, it is more vulnerable to post harvest losses than other crops due to its more perishable property. This experiment was, therefore, conducted to evaluate the effectiveness of different storage methods in improving shelf life of tomato fruits. The experiment consisted of three treatments (storage using pot in pot technique, cooling (Refrigerator) and room temperature (control). Which were laid out in completely randomized design (CRD) with three replications. A total of 138 tomato fruits with uniform maturity stage, shape and size were collected from Holeta Horticulture research field and 46 fruits were randomly assigned to each treatment. Highly significant ($P<0.001$) minimum loss of physicochemical properties (pH, TA and TSS) along time (1, 5, 10, 15, 20, 25 and 30 days) was observed for fruits stored using pot in pot technique. The highest mean weight loss percentage was observed for fruits stored under room temperature. Results of sensory evaluation along time revealed that there was highly significant difference ($P<0.001$) among the treatments. Accordingly, the highest mean scores of firmness (4.07+0.87), color (4.08+1.03) and overall acceptability (4.00+0.92) were recorded for tomato fruits stored using pot in pot technique at 18°C, while the value for general appearance (3.92+0.94) was higher for fruits in refrigerator at 13°C. In general, pot in pot method was found to be best suited for 30days storage period at 18°C without much affecting quality of tomato fruits.

Keywords

Cooling, Evaporative, Physicochemical, Pot in Pot, Shelf Life, Tomato

1. Introduction

Reduction of post-harvest loses of horticulture crops are crucial tasks in ensuring food and nutrition security [20]. Fruit and vegetable crops play a great role in food security, poverty reduction and economic growth in Ethiopia the [6]. They are important sources of minerals and vitamins for human health and wellbeing. However, their production level is still far below their potential [8], primarily because of tremendous post-harvest losses.

Farmers are facing high economic loss, because they have no means of increasing the shelf life of fruits and vegetables. Hence, the post-harvest losses of perishable foods like fruits and vegetables are estimated at about 30%. High moisture

*Corresponding author: nesruzeynu325@gmail.com (Nesru Zeynu)

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content and insect infestation and damage during handling (packaging, storage and transportation) are among the main causes of crop losses [7].

The majority of Ethiopia's population resides in rural areas, where approximately 60% of households lack access to electricity. This lack of electricity hinders the use of modern preservation technology like refrigerators, which are essential for preserving agricultural produce such as tomatoes, carrots, and fruits. As a result, farmers in rural areas face challenges in preserving their produce under normal conditions due to the shortage of energy [5]. In response to this a post-harvest handling techniques and technology are substantial role for the farmers.

Evaporative cooling is a method that lowers the temperature of a substance through the cooling process of water evaporation. To preserve fruits and vegetables, proper storage is essential, which involves controlling the temperature and humidity of the storage area. This can be achieved by wetting a surface and allowing the water to evaporate, resulting in temperature reduction and increased humidity [18]. Pot-in-pot technology consists of a smaller clay pot placed inside a larger clay pot with sand in between for watering. This method operates on the principle of cooling by lowering the temperature and raising the relative humidity. It is recognized as an eco-friendly and inventive solution as it provides effective cooling without relying on external energy sources like electricity. This makes it a cost-effective option for storing fruits, helping to prolong the shelf life of agricultural products by minimizing the chilling impact on fruits and vegetables. The aim of this study was, therefore, to evaluate the efficiency of pot in pot preservation technique to maintain the physicochemical properties and sensorial attributes of tomato fruits along storage period.

2. Material and Methods

2.1. Experimental Materials

A total of 138 matured tomatoes fruits were collected from Holeta Agricultural Research Center Horticulture research field. The fruits were uniform in maturity, shape and size and free from physical damage and infection by biotic factors. The harvested fruits were transported to laboratory and first washed by cold water to lower the fruit temperature and, then, gently washed again by warm water (40-45°C) so as to minimize surface load of microorganism. Finally, the fruit samples were surface dried with muslin cloth and randomly assigned to three storage methods (pot in pot, refrigerator and basket storage). The pot in pot technique was maintained by placing a smaller clay pot within a larger clay pot with wet sand in between the pots and closed with plate with porous holes. It is assumed that this device cools as the water in the wet sand evaporates. It was placed in a dry, ventilated space for the water to effectively evaporated towards the outside area. The basket storage was maintained at ambient temperature with average room temperature of 22°C, which was used as a control [22].

2.2. Treatments

The fruits were randomly assigned to the three treatments (T1=pot in pot, T2=refrigerator and T3=room temperature (control). Each treatment contained 46 tomato fruits. Physicochemical properties and sensory attributes were evaluated at five days intervals for 30days is shown below by Figure 1.

Figure 1. *Various storage techniques for extending the shelf life of tomato fruits.*

2.3. Sample Preparation for Analysis

Tomato juice was prepared by using pistol and mortar and stained through muslin cloth to remove seeds and other extraneous materials. Since the nature of tomato fruit juice is semi-thick, it was thoroughly mixed. In order to determine the total soluble solids content, the first pressed part of samples was rejected and the reserved part was taken for analysis [11].

2.4. Temperature and Relative Humidity (RH)

Temperature and Relative humidity were measured to evaluate the efficiency of storage methods in minimizing temperature and increasing relative humidity. The temperature and relative humidity inside storages were recorded two times per day (in the morning and afternoon) by using thermohygrometer (Vici, 288B-CTH, China).

2.5. Physicochemical Analysis

Percentage of weight loss: All tomato samples were weighed on the first day to determine their initial weights. The weight of tomato samples was measured for the respective storage methods at five days interval. Hence, weight loss was expressed as percentage decrease in fruit water content. Percent weigh loss was calculated using the following formula:

$$Weight\ \ loss\ \ (\%) = \frac{[(Wo - Wf)]}{Wo} \times 100$$

Where Wo indicates the initial weight at the time of harvest and Wf is the fruit weight after a given period of storage [9].

pH Value: The pH of tomato fruit juice samples was measured using a glass electrode digital pH meter after calibrating with standard buffer solution of pH 4 and 7 [1].

Titratable acidity was determined by titration method [23] and tomato juice sample was taken into a 100ml, beaker and diluted in 50ml of neutralized distilled water. The diluted sample was titrated by 0.1N of NaOH using 0.3 ml phenolphthalein as indicator until an end point of 8.2 (measured with the pH meter or phenolphthalein indicator as ml of NaOH used per 6g of the sample). Then, titratable acidity was calculated using the following formula:

$$Acidity\ \ (\%) = \frac{[mls\ \ NaOH\ \ used]x[0.1N\ \ NaOH]xMilliequivalent\ \ factor}{gram\ \ of\ \ sample} \times 100$$

Where, 0.064*=acid mill-equivalent factor

Total Soluble Solids (Brix): Total concentration of total soluble solids was determined using digital portable ATAGO refractometer (0-32 °). Initially, the refractometer was calibrated with distilled water. Then, small quantity of tomatoes fruit portion (2-3 drops) of the homogensed sample was placed on to a fixed prism surface at 20°C and the reading was taken. The result was expressed as °brix [1].

3. Sensory Evaluation

The sensory attributes including general appearance, color, firmness and overall acceptability of tomato fruits were evaluated by ten trained panelists at five days interval using five hedonic scale (i.e 5=like very much, 4= like moderately, 3= neither like nor dislike, 2= unlike moderately and 1= unlike very much) [3].

4. Statistical Analysis

All the measurements of physicochemical and sensory attributes were analyzed using SAS (Version 9.0) and SPSS statistical package program (SPSS, Inc., Chicago, II, USA) Version 22. Analysis of variance was performed by using one way ANOVA at 95% confidence interval and 5% level of significance. Mean separation was carried out using Duncan's multiple range test.

5. Result and Discussion

Temperature: Figure 2 clearly revealed that there was significant difference (*P<0.001*) among storage methods in maintaining the storage temperature, while average best result was recorded for pot in pot storage. Pot in pot storage method reduced the temperature from 20°C to 18°C and appeared to be efficient. This might be due to evaporative cooling effect of the moist sand between the two clay layers. Even though modern refrigerator could decrease average temperature from 20°C (room temperature) to 13°C, which is also considered as optimum for fruit preservation, it is not affordable by most users. The present result was also similar with the findings of [10], who reported that evaporative cooling can drop temperature considerably and relative humidity increase to the suitable level for short term on farm storage of perishables. Tomatoes stored at room temperature showed fast ripening which might be due to fast metabolic changes such as color change, cell wall degradation and enzymatic reaction. In line with this, [12] has reported that, for short term storage (up to a week), tomato fruits can be stored at ambient condition if there is enough ventilation to reduce the accumulation of heat from respiration. On the other hand, tomato stored in pot in pot method showed slow ripening, indicating extended shelf life.

The result of the present study was in agreement with the work of [4], who reported that, for longer term storage, ripe tomato can be stored at temperature of about 10-15°C and relative humidity of 85-95%. At these temperatures, both ripening and chilling injuries use reduced to a minimal level. Such as s shortening of storage in a refrigerator was reported by [2], where low temperature of refrigeration caused chilling injuries, which resulted in pitting, uneven ripening and fungal infestation of stored fruits. From result of the present study, it could also be concluded that refrigeration may not be an effective method of storing tomato for a long period.

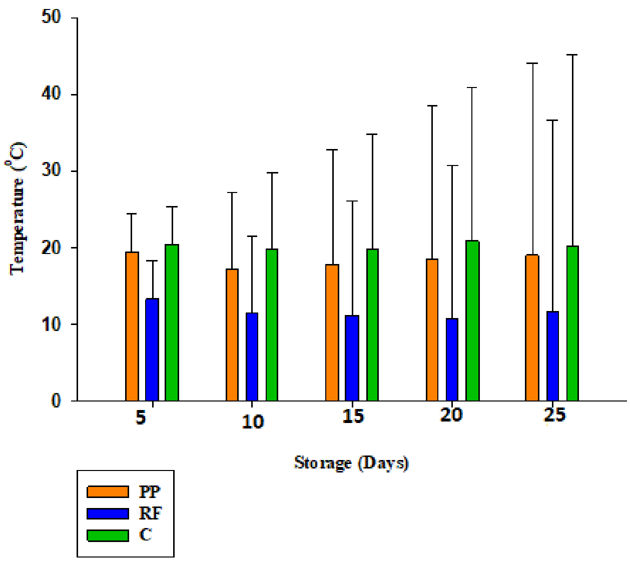

Figure 2. *Average storage temperature in PP (pot in pot), RF (Refrigerator), and C (Control) system for 25 days storage period.*

Relative humidity (RH): Figure 3 clearly revealed that the average inside storage relative humidity for pot in pot method was 62.3% and for refrigerator was 54.11%, while it was 51.8% for open room temperature. In agreement with the present study, [16] have reported that earthen pot cool chamber increase the inside storage relative humidity to 70%.

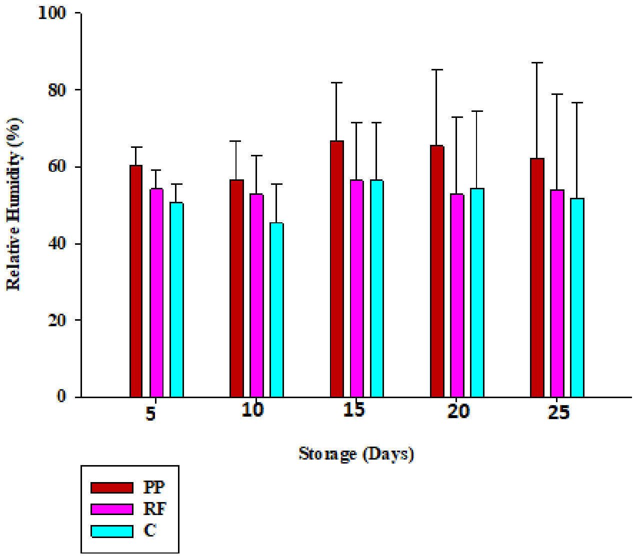

Figure 3. *Average relative humidity of storage conditions in PP (Pot In Pot, RF (refrigerator), and C (Open Room) for 25-days storage period.*

Fruit Weight Loss (FWL): Table 1 shows that there was highly significant difference (*P<0.001*) between storage methods for FWL along storage time. The minimum mean weight loss at 1st day of storage was recorded for pot in pot method (0.34+0.01) at 18°C, while relatively higher values were recorded for samples stored inside refrigerator (0.71+0.00) at 13°C and for those stored at room temperature (22°C) (0.75+0.01). Maximum mean of FWL after 10days of storage was observed for samples stored inside refrigerator (5.41+0.00) at 11°C as well as for those at room temperature (9.65+0.00), while the minimum mean loss of weight was recorded for tomatoes stored inside pot in pot (2.18+0.01). Relatively higher mean FWL values recorded after 30days of storage were for refrigerator (9.54+0.01) and room temperature (13.57+0.01), while the minimum mean loss of weight was for tomatoes stored inside pot in pot (2.93+0.00) at 18°C. But, the highest mean score of weight loss at 25^{th} day of storage was recorded for inside pot in pot (4.91+0.00) at 18°C, while the minimum value was for refrigerator (4.60+0.00) at 11°C. In general, fruits stored in pot in pot showed minimum weight loss compared to those maintained at room temperature, which might be due to minimum reduction in water at room temperature, which might be due to minimum reduction in water content through respiration and transportation from the fruit. Hence, the rate of weight loss was minimum for tomatoes stored inside the evaporative coolers.

Table 1. *Percentage of weight loss in tomato fruits over time intervals under various storage conditions.*

Storage (days)	Storage Types		
	PP	**RF**	**RT**
1^{st}	0.34+ 0.01^{u}	0.71+0.00^{t}	0.75+0.01^{u}
5^{th}	1.02+ 0.00^{r}	1.11+0.00^{q}	2.66+0.00^{l}
10^{th}	1.43+0.00^{p}	1.51+0.00^{o}	4.36+0.01^{i}
15^{th}	2.18+0.01^{n}	4.24+0.00^{j}	9.65+0.00^{b}
20^{th}	2.07+0.01^{n}	5.41+0.00^{f}	9.04+0.01^{e}
25^{th}	4.91+0.00^{g}	4.60+0.00^{h}	9.09+0.01^{d}
30^{th}	2.93+0.00^{k}	9.54+0.01^{c}	13.57+0.01^{a}
P	*<0.001*	*<0.001*	*<0.001*

All values are mean + standard deviation (SD) Figures followed by same letter(s) are not significantly different (P<0.001), PP= pot-in=pot, RF=refrigerator and RT= room temperature (control).

Tomato juice pH: Table 2 shows that there was highly significant difference (*P<0.001*) among the storage methods for pH of tomato juice. The highest mean value was recorded for 1^{st} day among the storage under room temperature (control) (4.41+0.09), while the lowest pH was for refrigerator (4.03+0.04). The mean result of pot in pot storage method was 4.22+0.10. Minimum pH value was recorded for 15, 20 and 30 days of fruit storage inside refrigerator at 11 ℃, while the highest value was recorded for storage at room temperature. In line with this, [17] have reported the pH (4.33) after 10days of storage. The result of the present study was also in agreement with the work of [21] who reported that pH value of tomato increased after 14 days of storage time. In general, pH of the tomatoes increased with advancement of fruit ripening. Since acidity of the fruits was due to various organic acids that are consumed during respiration, it decreased with advancing maturity or increased storage duration with a corresponding increase in fruit pH [15].

Table 2. *pH of tomato fruit over time intervals with various storage methods.*

Storage (days)	Storage Types		
	PP	**RF**	**RT**
1^{st}	4.22+0.10^{cdef}	4.03+0.04^{fgh}	4.41+0.09^{bc}
5^{th}	4.11+0.09^{ef}	4.21+0.05^{def}	4.21+0.05^{def}
10^{th}	4.15+0.06^{ef}	4.06+0.04^{fg}	4.41+0.09^{bc}
15^{th}	4.37+0.11^{bcd}	3.89+0.10^{ghi}	4.28+0.10^{bcd}
20^{th}	4.12+0.07^{ef}	3.86+0.19^{hi}	4.11+0.05^{ef}

Storage (days)	Storage Types		
	PP	RF	RT
25th	4.16+0.05ef	3.79+0.16ij	3.68+0.14j
30th	4.82+0.15a	4.56+0.13b	4.83+0.19a
P	<0.001	<0.001	<0.001

All values are mean + standard deviation (SD) Figures followed by same letter(s) are not significantly different (P<0.001), PP= pot-in=pot, RF=refrigerator and RT= room temperature (control).

Table 3. *Titratable acidity of tomato fruits (%) at various time intervals under varying storage conditions.*

Storage (days)	Storage Types		
	PP	RF	RT
1st	0.22+0.04b	0.31+0.04a	0.13+0.03cdef
5th	0.15+0.03cde	0.12+0.02defgh	0.12+0.01defgh
10th	0.21+0.03b	0.21+0.02b	0.21+0.02b
15th	0.09+0.03fgh	0.31+0.04a	0.16+0.02cd
20th	0.11+0.04gh	0.14+0.02cdef	0.09+0.02gh
25th	0.11+0.02defgh	0.18+0.03bc	0.08+0.02h
30th	0.13+0.02defg	0.16+0.02cd	0.15+0.02cde
P	*<0.001*	*<0.001*	*<0.001*

All values are mean + standard deviation (SD) Figures followed by same letter(s) are not significantly different (P<0.001), PP= pot-in=pot, RF=refrigerator and RT= room temperature (control).

Titratable Acidity (TA): There was a highly significant difference ($P<0.001$) between storage methods for TA of tomato fruits (Table 3). The highest mean score of TA at 1st day was recorded for fruits stored in refrigerator (0.22+0.04) at 11 ℃, while the lowest mean value was for fruits stored at room temperature (0.13+0.03) at 22 ℃. The minimum mean score of titratable acidity at 15th day of storage was recorded for pot in pot method (18 ℃) (0.09+0.03). This might be due to the cooling effect that reduced acidity of the fruit. It is assumed that TA more decreases due to use of organic acid as a substance for respiration. The maximum mean score of acidity was observed for fruits stored inside refrigerator (0.16+0.02, while the minimum mean value was for fruits stored using pot in pot method (0.13+0.02), which might be due to reduction in metabolic changes of organic carbon into carbon dioxide. Hence, TA is directly related to the concentration of organic acids in the fruit. The present result was similar with the findings of [24], who suggested that acidity decreases with fermentation or break down of acids to sugar in fruits during respiration, which reduces the desired quality of fruits.

Total Soluble Solid (TSS): There was a highly significant difference between storage methods ($P<0.001$) for TSS of tomato fruits (Table 4). The highest mean value at 1st day of storage was recorded for refrigerator (4.00+1.00), while the lowest was recorded for fruits stored at room temperature (3.00+0.00). the maximum TSS value was observed for fruits stored for 25 days in refrigerator (4.67+0.58), as compared to those maintained at room temperature (3.00+0.00). At the 30th day, fruits stored in pot in pot, in refrigerator and at room temperature (control) has TSS of 3.33+0.00, 4.00+0.00 and 3.00+0.00 ºBrix, respectively. The value of TSS increased over time during storage, likely because cold storage slowed down the rate of respiration. Therefore, the content of TSS increased slowly with storage period. The present result was in agreement with the findings of [19]. Who reported that changes in TSS content are natural phenomena that are correlated with the hydrolytic changes in carbohydrates during storage.

Table 4. *Total soluble solids content of tomato fruits over time intervals in various storage conditions.*

Storage (days)	Storage Types		
	PP	RF	RT
1st	3.67+0.58bcd	4.00+1.00abc	3.00+0.00d
5th	3.67+0.58bcd	3.67+0.58bcd	3.67+0.57bcd
10th	3.33+0.58cd	4.00+0.00abc	4.00+0.00abc
15th	3.00+0.00d	4.33+0.58ab	4.00+0.00abc
20th	3.33+0.58cd	3.00+0.00d	3.67+0.58bcd
25th	3.67+0.58bcd	4.67+0.58a	3.00+0.00d
30th	3.33+0.00d	4.00+0.00abc	3.00+0.00d
P	*<0.001*	*<0.001*	*<0.001*

All values are mean + standard deviation (SD) Figures followed by same letter(s) are not significantly different (P<0.001), PP= pot-in=pot, RF=refrigerator and RT= room temperature (control).

6. Sensory Analysis

Firmness and Color: it was observed that the difference ($P<0.001$) among storage conditions was highly significant for fruit firmness and color (Table 5). The highest mean score values for firmness after 1, 5 and 10 days of storage were observed for open room at 22 ℃ (4.40+0.52 and 4.80+0.42) and for refrigerator (4.20+1.48) at 11 ℃, respectively, while the lowest values recorded at the same time interval (1, 5 and 10) were for refrigerator (3.60+1.17, 3.70+1.74 and 3.70+0.67, respectively). After 10 days, the quality of fruits stored in open room (control) declined consistently until the 30th days as compared to those maintained using the pot in pot method at 18 ℃. This might be due to deterioration of fruits during breakdown of pectin, which is often inversely related to ripening.

Higher mean score values of color were recorded at the 1st and 5th day of storage in refrigerator (4.50+0.71 and 4.20+0.63, respectively) at 11°C and for open room storage (4.40+0.52 and 5.00+0.00, respectively) at 22°C, while the mean values recorded at the same period were lower for the pot in pot method (4.00+0.94 and 3.10+1.60, respectively) with a temperature of 18°C. The lowest mean score of color was observed at the 25th and 30th days for open room storage (2.40+1.26 and 1.40+0.70, respectively, while the highest mean values of color for the same storage period were observed for fruits stored using the pot in pot method (4.60+0.49 and 4.06+0.72, respectively). This might be due to the lycopene production in the fruit, which brought about gradual change in color depending on the storage condition and temperature. In line with this, it has been reported that high temperatures can inhibit lycopene biosynthesis, and for tomatoes, temperature <12°C were found to interfere with the proper synthesis of lycopene while high temperatures above 32°C bring lycopene biosynthesis to a stop [14].

Appearance and Overall acceptability: The was significant difference (*P<0.001*) among treatments for appearance and overall acceptability of tomato fruits (Table 5). After 5 days of storage, mean score of appearance of tomato fruits increased for open room (5.00+0.00), while the lowest mean value was recorded for the pot in pot method (3.20+1.48). Almost similar mean values of appearance were observed for 1, 5, 10, 15 and 20 days of storage in refrigerator, but the values irregularly varied for the pot in pot method. In contrary, the mean value of appearance declined after the 10th day for open room storage, while the highest mean values were recorded for 10, 15and 20 days storage in refrigerator (4.00+0.67, 4.40+0.70 and 4.10+0.57, respectively. The appearance and thus, fruit quality deteriorated with prolonged with prolonged storage time in refrigerator and open room as compared to the pot in pot method. This might be due to the reduction of respiration and transpiration of the fruit in the latter case. Hence, better appearance of tomato fruits was observed at 20th, 25th and 30th days particularly for the pot in pot method. Mean values of appearance significantly varied for the pot in pot (3.90+1.10), refrigerator (2.80+1.32) and for the control (1.30+0.95) at the 30th day of storage. This might be attributed to the presence and magnitude of defects (i.e, weight loss, decay incidence etc.). In line with this, [13] has reported that the appearance of product usually determines whether a product is accepted or rejected, therefore, this is one of the most critical quality attributes.

Table 5. *Effects of storage time and conditions on the sensory attributes of tomato fruits.*

Sensory attributes	Storage Types	Storage (days)						
		1st	5th	10th	15th	20th	25th	30th
General appear-ance	PP	2.90+1.10de	3.20+ 1.48dc	3.90+0.87bc	3.90+0.87bc	4.40+0.52ab	4.50+0.71ab	3.90+1.10bc
	RF	4.30+0.82ab	4.10+0.99abc	4.00+0.67bc	4.40+0.70ab	4.10+0.57abc	3.80+0.42bc	2.80+1.32de
	RT	4.50+0.53ab	5.00+0.00a	2.80+1.23de	2.80+1.40de	2.80+1.40de	2.00+1.05de	1.30+0.95de
Firmness	PP	3.60+1.17acd	3.70+1.34cde	3.70+0.82cde	3.70+0.67cde	4.80+0.42a	4.50+0.53a	4.10+0.57acd
	RF	4.40+0.70ac	4.50+0.53a	3.20+0.63e	3.80+0.92cde	3.40+0.52de	3.40+0.52de	2.40+0.97e
	RT	4.40+0.52ac	4.80+0.42a	4.20+1.48acd	3.90+0.99cde	3.90+0.99cde	3.10+0.99e	1.40+0.70j
Color	PP	4.00+ 0.94cdfg	3.10+ 1.60a	3.90+0.88cdfg	4.40+0.52ac	4.60+0.52ac	4.80+0.42a	4.20+0.63acd
	RF	4.40+0.70ac	4.20+0.63acd	3.40+0.70fg	4.30+0.82acd	4.10+0.32cdf	3.50+0.97dfg	3.10+1.10i
	RT	4.40+0.52ac	5.00+0.00a	3.20+1.40fg	3.30+0.82fg	3.30+0.82fg	2.40+1.26i	1.40+0.70j
Overall accepta-bility	PP	3.50+1.02df	3.33+1.45f	3.87+0.73cd	4.00+0.61cd	4.60+0.41a	4.60+0.49a	4.06+0.72dc
	RF	4.40+0.72ac	4.27+0.66acd	3.53+0.61df	4.17+0.77acd	3.87+0.39cd	3.57+0.57cdf	2.77+1.10f
	RT	4.43+0.50a	4.93+0.14a	3.40+1.26f	3.34+1.02f	3.34+1.02f	2.50+1.03f	1.37+0.74h

All values are mean + standard deviation (SD). Figures followed by same letter (s) are not (P<0.001). PP=Pot-in-Pot, RF=Refrigerator and RT= Room Temperature (control).

It was observed that, at 1st and 5th day, the highest mean values for overall acceptability were recorded for open room storage (4.43+0.50 and 4.93+0.14, respectively), while the respective lowest values were for refrigerator (3.50+1.02 and 3.33+1.45). After 10 days, fruits stored inside refrigerator and in open room showed lower overall acceptance as compared to those stored using the pot in pot method. At the 30th day, the highest mean value of overall acceptability was observed for the pot in pot method (4.06+0.72), while the values for refrigerator and open room storage were lower (2.77+1.10 and 1.37+0.74, respectively).

7. Conclusion

The results of the present study revealed that proper storage method is essential for extended the shelf life of perishable products. Among the storage method, the pot in pot technique-maintained fruit quality and extended the shelf life of tomato fruits to 30 days, especially when compared to storage at room temperature as compared to storage at room temperature. Generally, the pot in pot technology appears to be cheaper than using refrigerator and is the best alternative approach to reduce the postharvest loss of tomatoes by decreasing the storage temperature and increasing relative humidity. Hence, this technology could be recommended for use by tomato producers and traders.

Abbreviations

PP	Pot in Pot
RF	Refrigerator
RT	Room Temperature
RH	Relative Humidity
TSS	Total Soluble Solid
FWL	Fruit Weight Loss
pH	Concentration of Hydrogen Ion
AOAC	American of Analytical Chemistry
CRD	Completed Randomized Design
SAS	Software of Statistical Analysis
SPSS	Social Science Statistical Package

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Author Contributions

Nesru Zeynu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Abdi Keba: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Validation, Visualization

Data Availability Statement

Data will be available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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