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Effect of harvesting stages and postharvest treatments on shelf life and quality of tomato (*Lycopersicon esculentum* Mill. var. Pearson) stored under ZECC condition

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ABSTRACT

Tomato (*Lycopersicon esculentum* Mill) is one of the important commercial high value crops of Afghanistan. Among the different local varieties grown in Afghanistan, the "Pearson" variety is most popular because of its good commercial value due to its uniform globe shape and medium to large size. The study is conducted to understand the effects of different harvesting stages and postharvest treatments on the shelf life and postharvest quality of tomatoes (Pearson variety) stored under the Pusa Zero Energy Cool Chamber (ZECC) at the research farm of Agriculture Faculty, Kabul University. This is the first time that ZECC is introduced in Afghanistan for enhancing fruit shelf life. The standard dimension ZECC was built with 165 x 115 x 67.6 cm dimensions. After harvesting tomatoes at different maturity stages (Turning, Pink, and Light red color stages), fruits were precooled, graded, and treated with different concentrations of $CaCl_2$ and mint leaf extract solutions. Thereafter, the tomatoes were placed in plastic baskets and stored in the Zero Energy Cool Chamber. During storage period, Total Soluble Solids (TSS, ^{0}brix), pH, firmness (gr cm^{-2}), shelf life, pericarp thickness (mm), fruit volume (cc), and fruit density were recorded. Two factorial CRD design was considered with harvesting stages as the first factor and postharvest treatments as the second factor. The data revealed that the shelf life of tomatoes was extended up to 29 days under T_2 (turning color fruits treated with 6% $CaCl_2$) and followed by T_8 (turning color fruits treated with 6% $CaCl_2$ + 6% mint Leaves extract) up to 28 days. Under T_2, quality parameters such as TSS and pH increased from 3.85%brix and 2.85 to 4.4 ^{0}brix and 3.4, respectively. Firmness, pericarp and volume decreased from 1750 grcm^{-2}, 0.75cm and 135 cc to 840 grcm^{-2}, 0.67cm and 127 cc, respectively. At the last observation, density remained unchanged (1.00 gr/cc). In conclusion, tomatoes harvested at the turning-color stage treated with 6% $CaCl_2$ and followed by 6% $CaCl_2$ + 6% mint leaves' extract had a significant effect on the enhancement of shelf life and quality of tomatoes under ZECC condition.

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1. Introduction

The tomato (*Solanum Lycopersicon* Mill) is one of the important commercial crops of Afghanistan. The commercial production of tomatoes is being carried out in the majority of provinces like Paryab, Sarepul, Balkh, Samangan, Baghlan, Kunduz, Takhar, Nangarhar, Laghman, Helmand, Kandahar, Farah, Herat, Kunduz, Mazar- e sharif, Kabul, Parwan, Kapisa, and Logar. In 2018, tomato fields covered 24,892 hectares of land and produced 2,075,222 MT (Agri-Stat Dept, MAIL, 2019). In addition to outdoor cultivation, tomatoes are grown in controlled environments such as greenhouses and plastic tunnels during the off-season in order to increase production and reduce price fluctuations in the country's markets. Historically, the major cultivated varieties in Afghanistan are Roma, Pearson, and Heinz, but more hybrid varieties have recently been grown. The "Pearson" variety is most popular because of its good commercial value, its uniform globe shape, and medium to large size; its taste, flavor, and higher juice and pulp content make it suitable for fresh salads and for processing for sauces. However, Pearson is very sensitive to handling and thus has very short storage life. In fact, harvesting Pearson tomatoes at full red stage has a maximum shelf life about three to six days in Afghanistan [1]. While fresh tomatoes are desired in Afghanistan, dried tomatoes are also used during the off-season as a flavoring agent in food items. Although infrastructure limits distribution of tomato paste and puree, it is available locally among families. In general, farmers face losses of tomato production due to lack of proper postharvest management practices, a low level of knowledge about proper harvesting stages, non-availability of proper postharvest treatments, and the lack of on-farm storage systems to extend the shelf life of fresh tomatoes. As a result, around 40 - 50% of tomatoes are wasted. To extend the shelf life of tomatoes and reduce waste, one should determine the proper harvesting stage of tomatoes, standardize postharvest treatments, and provide low-cost on-farm storage systems like ZECC [2].

The present study studies the effect of harvesting stages and postharvest treatments on shelf life and quality of fresh "Pearson" tomatoes stored in ZECC under dry temperate conditions. Tomatoes at pink stage that were dipped at 6% $CaCl_2$ for 20 minutes maintained their postharvest quality [3]. Mint leaves extract may also be considered due to its antimicrobial [4] and also antifungal

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activities [5]. ZECC is a scientific evaporative cooling system developed at IARI, New Delhi, India [6], which shows a significant effect on enhancing the shelf life of fruits and vegetables. The shelf life of tomato was extended from 7 days in ambient conditions up to 28 days in ZECC [7,8]. We investigate ZECC for the first time in Afghanistan to enhance the shelf life of tomatoes.

2. Methodology

The study has been conducted at the Research Farm of Agriculture Faculty of Kabul University.

Tomato production: Quality seeds of tomato procured from authorized seed production body and sowed on 9 March 2018 at the farm's nursery. Seeds germinated after 9 days, and seedlings were transplanted to the open field next to the nursery after 38 days. The field was managed properly until the harvesting stage.

Establishment of ZECC: Next to the tomato field, a Zero Energy Cool Chamber (ZECC) with a size of 165 x 115 x 67.5 cm was built (Roy & Khurdiya, 1986). The space between two walls of bricks was maintained at 7.5 cm and filled with sand. A drip irrigation pipe was placed on top of the sand and connected to a water tank. The bamboo-framed cover woven with straw or grass provided cover for the ZECC. An additional woven mesh and tarpaulin shade were placed above ZECC (Figure 1-3).

Harvesting and management of fruits: Tomatoes were harvested at three different maturity stages after 101 days from transplanting. Fruits were sorted, graded, and precooled (Figure 2).

Experimental details and treatment application: After the initial data had been recorded for all the parameters, tomatoes of all three stages were treated (dipped for 20 minutes) with 24 treatments with two replications under a two-factorial CRD design. The first factor was harvesting stages at three categories (Turning, Pink and Light red color), and the second factor was postharvest treatments at eight levels (0%, 6% $CaCl_2$, 2% mint leaves extract, 4% mint leaves extract, 6% mint leaves extract, 6% $CaCl_2$ + 2% mint leaves extract, 6% $CaCl_2$ + 4% mint leaves extract and 6% $CaCl_2$ + 6% mint leaves extract).

Treatment details: T_1(Turning color fruits dipped in distilled water), T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution), T_3 (Turning color fruits dipped in 2% mint leaves' extract solution), T_4 (Turning color fruits dipped in 4% mint leaves' extract solution) T_5 (Turning color fruits dipped in 6% mint leaves' extract solution), T_6 (Turning color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution), T_7 (Turning color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution), T_8 (Turning color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution), T_9 (Pink color fruits dipped in distilled water), T_{10} (Pink color fruits dipped in 6% $CaCl_2$ solution), T_{11} (Pink color fruits dipped in 2% mint leaves' extract solution), T_{12} (Pink color fruits dipped in 4% mint leaves' extract solution) T_{13} (Pink color fruits dipped in 6% mint leaves' extract solution), T_{14} (Pink color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution), T_{15} (Pink color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution), T_{16} (Pink color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution), T_{17} (Light red color fruits dipped in distilled water), T_{18} (Light red color fruits dipped in 6% $CaCl_2$ solution), T_{19} (Light red color fruits dipped in 2% mint leaves' extract solution), T_{20} (Light red color fruits dipped in 4% mint leaves' extract solution) T_{21} (Light red color fruits dipped in 6% mint leaves' extract solution), T_{22} (Light red color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution), T_{23} (Light red color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution), T_{24} (Light red color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution). The mint leaves were processed with a juicer machine to extract water without adding any chemical or organic reagents; 12 kg of mint extracts 1 liter of water. After treatment application, 500 gr fruits from each experimental treatment were put in plastic trays and subjected to storage under ZECC condition.

Figure 1. ZECC construction.

Figure 2. ZECC construction and related water tank.

Data recording and analysis: While the shelf life of tomatoes were observed daily, quality parameters were

recorded at ten-day intervals for the fruits' firmness ($grcm^{-2}$), pericarp thickness (cm or mm), volume (cc), density (gr/cc), pH and TSS (^{0}brix). The data were analyzed through a statistical analysis program (Excel) to analyze ANOVA and considered LSD at 5% level of significance.

Figure 3. ZECC construction and related water tank completed.

Figure 4. Three categories of tomato's fruits.

3. Results and Discussion

The evaporative cooling system (Zero Energy Cool Chamber) is an extremely innovative, low-cost farm storage system solution. It reduces the average temperature from 30 to 12^{0}C and increased the average relative humidity from 25 to 95% during one month of storage. The low cost on-farm storage (ZECC) is not only effective for extending tomato shelf life but also the shelf lives of other vegetables and fruits in Afghanistan. Because of the nation's dry temperate climate, suitable wind could further increase the efficiency of ZECC. The best treatment T_2 (harvesting of turning color fruits dipped in 6% $CaCl_2$ solution) under ZECC condition increased the shelf life up to 29 days compared to 17 days under ambient conditions on our farm or just 3 to 6 days shelf life under ambient conditions in the literature [1]. This agrees with the ZECC results reported by Islam et al. [8], and Esa Abiso *et al.* [9], also reported that ZECC had a significant effect on tomato shelf life and postharvest quality compared to ambient storage conditions. Furthermore, the results on shelf life and other parameters of Pearson tomatoes are discussed below.

3.1. Shelf life

Under ZECC conditions, harvesting stages and postharvest treatments enhanced the tomatoes' shelf life. Treatment T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) increased the shelf life up to 29 days (Figure 3). Based on LSD analysis, treatment T_8 (Turning color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution) is on par with T_2 and extended the shelf life of tomatoes up to 28 days. Four treatments T_{11} (pink color fruits dipped in 2% mint leaves' extract solution), T_{17} (light red color fruits dipped in distilled water), T_{20} (Light red color fruits dipped in 4% mint leaves' extract solution) and T_{21} (Light red color fruits dipped in 6% mint leaves' extract solution) had the same lowest shelf life of about 20 days. The results show that the combined effect of both factors (harvesting of turning color fruits and application of 6% $CaCl_2$ solution) as in T_2 was significantly different from other treatments presented in Table 1. The difference might be due to harvesting tomatoes at earlier maturity stages to maintain the fruits' quality and enhance shelf life, similar to results from studies in [10–13]. Fruits at earlier stages (turning color) could have longer shelf life due to low physiological activity compared to later stages under ZECC condition. The antifungal application maintains firmness through 6% $CaCl_2$, saving its quality attributes and further enhancing shelf life, similar to reports by Arthur *et al*. and Chepngeno *et al*. [3,14].

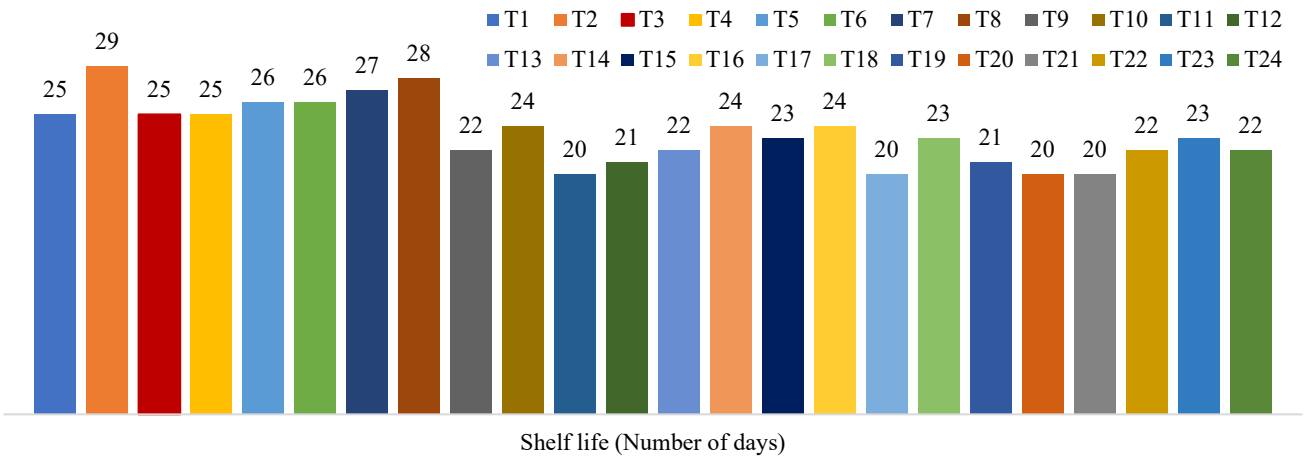

Figure 5. The shelf life of marketable fruits affected through combined treatments (Harvesting stages and postharvest treatments) stored in ZECC storage system provided an average 12 °C temperature and 95% relative humidity.

Table 1: The LSD analysis of shelf life among treatments presented at 5% level of signifcance.

Trt. No.	Treatments' details	Shelf life (Number of storage days)
T1	Turning color fruits dipped in distilled water	25^{cdef}
T2	Turning color fruits dipped in 6% $CaCl_2$ solution	29^{a}
T3	Turning color fruits dipped in 2% mint leaves' extract solution	25^{cdefg}
T4	Turning color fruits dipped in 4% mint leaves' extract solution	25^{cdefgh}
T5	Turning color fruits dipped in 6% mint leaves' extract solution	26^{bcd}
T6	Turning color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution	26^{bcde}
T7	Turning color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution	27^{abc}
T8	Turning color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution	28^{ab}
T9	Pink color fruits dipped in distilled water	22 ^{ijklmno}
T10	Pink color fruits dipped in 6% $CaCl_2$ solution	24 ^{cdefghi}
T11	Pink color fruits dipped in 2% mint leaves' extract solution	20 ^{op}
T12	Pink color fruits dipped in 4% mint leaves' extract solution	21 ^{lmnop}
T13	Pink color fruits dipped in 6% mint leaves' extract solution	22 ^{ijklmnop}
T14	Pink color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution	24 ^{defghij}
T15	Pink color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution	23 ^{fghijkl}
T16	Pink color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution	24 ^{defghijk}
T17	Light red color fruits dipped in distilled water	20^{op}
T18	ight red color fruits dipped in 6% $CaCl_2$ solution	23 ^{fghijklm}
T19	Light red color fruits dipped in 2% mint leaves' extract solution	21 ^{lmnop}
T20	Light red color fruits dipped in 4% mint leaves' extract solution	20 ^{op}
T21	Light red color fruits dipped in 6% mint leaves' extract solution	20 ^{op}
T22	Light red color fruits dipped in 6% $CaCl_2$ + 2% mint leaves' extract solution	22 ^{ijklmnop}
T23	Light red color fruits dipped in 6% $CaCl_2$ + 4% mint leaves' extract solution	23 ^{fghijklmn}
T24	Light red color fruits dipped in 6% $CaCl_2$ + 6% mint leaves' extract solution	22 ^{ijklmnop}
	F-test	**

** (Highly significant level at 1%)

4. Total Soluble Solid (TSS ^{0}Brix)

TSS increased up to 20 days of storage for all the treatments. While there were no significant differences among treatments, the lowest changes of TSS were 4.25 and 4.40 ^{0}Brix, under treatment T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) on the 10th and 20th day of storage, respectively (Table 2). The combination of harvesting stages and postharvest treatments did not significantly affect TSS, in agreement with results from Senevirathna & Daundasekera [15]. But maintaining tomatoes to small TSS changes under T_2 could be explained by being slightly physiologically active at the color-turning stage and the 6% $CaCl_2$ application, agreeing with the report from [3].

5. pH of tomatoes

Differences of pH were also not significant among treatments. As shown in Figure 2, pH increased during the storage period. The smallest changes were observed under T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) recorded on the 10th and 20th days of storage as 3.25 and 3.40, respectively. We conclude that the combination of harvesting stages and postharvest treatments did not significantly affect the pH. These results on tomato pH agree with results from Senevirathna & Daundasekera [15] and Casierra [10]. The small pH changes under T_2 might be due to slow physiological activity during the turning-color phase and the 6% $CaCl_2$ application, similar to results by [3].

Table 2: **Table 2**: The LSD analysis of fruits firmness at 5% level and also presenting the significance level of TSS (^{0}Brix) and pH of stored fruits under ZECC system.

	TSS (^{0}brix)			pH			Frimnes gr cm^{-2}		
Trt. No.	Initial	10th day	20th day	Initial	10th day	20th day	Initial	10th day	20th day
T1	3.85	5.00	5.50	2.85	3.45	3.60	1750	900^{bc}	775 ^{abcdef}
T2	3.85	4.25	4.40	2.85	3.25	3.40	1750	1123^{a}	840 ^{a}
T3	3.85	4.75	4.80	2.85	3.35	3.50	1750	850	800 ^{abc}
T4	3.85	4.50	4.90	2.85	3.65	3.55	1750	900^{bcd}	775 ^{abcdefg}
T5	3.85	4.65	5.30	2.85	3.45	3.40	1750	650 ^{ijklm}	598 ^{abcdefgijklm}
T6	3.85	4.40	4.75	2.85	3.45	3.45	1750	750 ^{cdefgij}	710 ^{abcdefgij}
T7	3.85	4.75	5.25	2.85	3.45	3.45	1750	900^{bcde}	800 ^{abcd}
T8	3.85	4.50	5.00	2.85	3.35	3.40	1750	975^{ab}	825 ^{ab}
T9	4.25	5.50	5.75	2.95	3.60	3.60	950	590 ^{jklm}	450 ^{jklm}
T10	4.25	4.35	4.75	2.95	3.25	3.50	950	900 ^{bcdef}	775 ^{abcdefgh}
T11	4.25	4.90	5.00	2.95	3.35	3.90	950	750 ^{cdefgijk}	550 ^{cdefgijklm}
T12	4.25	5.25	4.75	2.95	3.65	3.80	950	625 ^{ijklm}	610 ^{abcdefgijklm}
T13	4.25	4.75	5.25	2.95	3.65	3.50	950	700 ^{gijklm}	495 ^{ijklm}
T14	4.25	4.85	5.20	2.95	3.55	3.55	950	880 ^{bcdefg}	710 ^{abcdefgijk}
T15	4.25	5.10	5.10	2.95	3.30	3.55	950	790 ^{bcdefghi}	785 ^{abcde}
T16	4.25	4.75	4.75	2.95	3.45	3.60	950	750 ^{cdefghijkl}	725 ^{abcdefgi}
T17	4.50	5.15	6.00	3.25	3.40	4.10	750	538^{m}	400 ^{lm}
T18	4.50	4.50	4.75	3.25	3.45	3.50	750	725 ^{cdefghijklm}	660 ^{abcdefgijkl}
T19	4.50	4.75	5.50	3.25	3.65	4.00	750	675 ^{hijklm}	500 ^{ijklm}
T20	4.50	5.10	5.50	3.25	3.75	3.80	750	580 ^{jklm}	400 ^{lm}
T21	4.50	5.25	4.75	3.25	3.70	3.85	750	550^{m}	550 ^{cdefgijklm}
T22	4.50	4.75	5.65	3.25	3.30	4.00	750	600 ^{ijklm}	545 ^{cdefgijklm}
T23	4.50	5.50	5.25	3.25	3.40	3.70	750	700 ^{ghijklm}	625 ^{abcdefgijklm}
T24	4.50	4.75	5.00	3.25	3.40	4.00	750	700 ^{ghijklm}	625 ^{abcdefgijklm}
F-Test		NS	NS	-	NS	NS	-	*	*

NS (Non-Significant), * (Significance level at 5%)

6. Firmness (gr cm^{-2})

Figure 4 shows the effect of harvesting stages and postharvest treatments on tomato firmness under ZECC. Generally, the firmness of fruits decreased during the storage period, but there was significant difference in maintaining the highest firmness among treatments. The highest firmness was observed for T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) as 1123 and 840 grcm^{-2} on 10th and 20th days of storage, respectively. Treatment T_8 is comparable to T_2 on the 10th day of storage as shown on Table 2. Tomatoes remained more firm due to the application of 6% $CaCl_2$, similar to results from Senevirathna et al. [15], Pinheiro *et al.* [16], and Casierra [10]. Harvesting at early stages (turning color stage) might have significant effect on maintaining fruits' firmness, in agreement with Parkar & Maleekuu [13], Wu *et al.* [17], and Moneruzzaman *et al.* [18]. Retaining firmness may also be attributed to both factors of harvesting stages and $CaCl_2$ in agreement with Islam *et al.* [7].

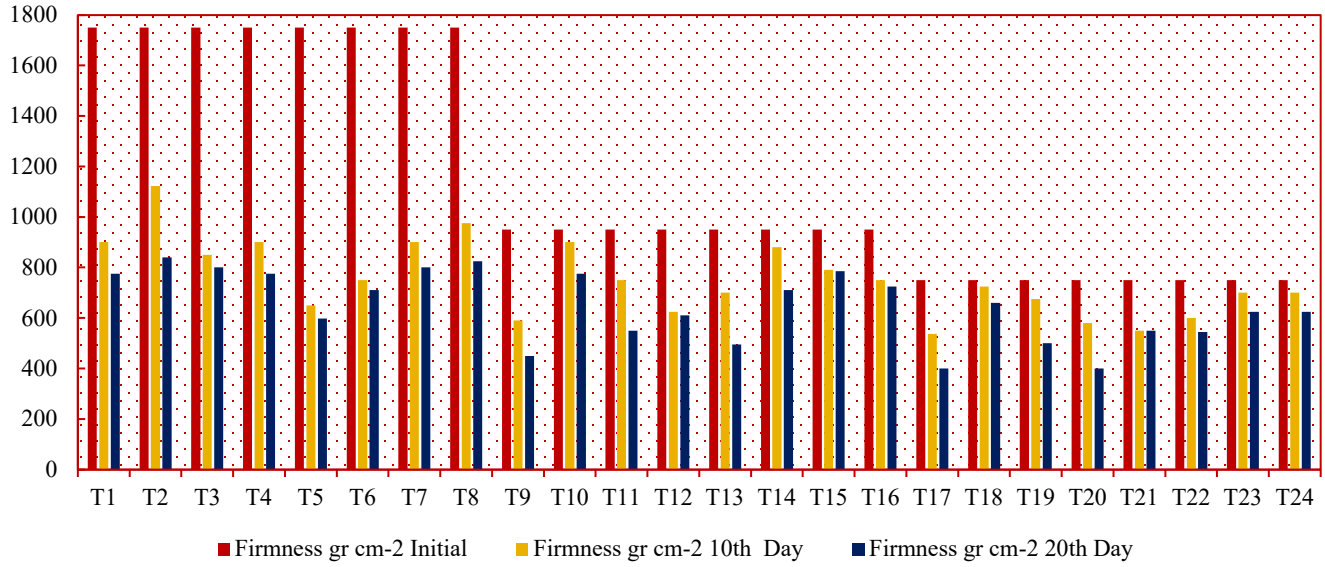

Figure 6. The differences of fruits' firmness affected (grcm-2) through harvesting stages and postharvest treatments stored in ZECC.

7. Volume (cc) and Density (gr/cc)

Table 3 shows that the volume of tomato fruits generally decreased during storage period. All the treatments did not have significant differences with respect to decreasing volume, but the smallest changes of volume were reported as 132.5 and 127 cc recorded under T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) on 10th and 20th day of storage, respectively. Small changes of volume might be due to high firmness and followed by smaller losses of weight of turning-color tomatoes with 6% $CaCl_2$ application under ZECC conditions. Furthermore, the density of fruits under all treatments did not change.

8. Pericarp thickness (cm or mm)

Pericarp thickness of tomatoes became thinner during storage time (Table 3). There was no significant difference regarding pericarp thickness among treatments, but the highest thickness of pericarp was recorded under T_2 (Turning color fruits dipped in 6% $CaCl_2$ solution) as 0.75 and 0.67 cm on 10th and 20th day of storage, respectively. The thickness of pericarp may be due to the harvesting tomatoes at an early stage, similar to results from Parkar & Maleekuu [13]. 6% $CaCl_2$ application might also have affect pericarp thickness by maintaining firmness under ZECC storage, similar to results from Pinheiro *et al.* [16].

Table 3: Data recorded on volume, density and pericarp thickness of tomato stored under ZECC.

Trt. No.	Volume (cc)			Density (gr/cc)			Pericarp thickness (cm)		
	Initial	10th Day	20th day	Initial	10th Day	20th day	Initial	10th Day	20th day
T1	135	121.5	120.0	1.00	1.05	0.99	0.75	0.65	0.55
T2	135	**132.5**	**127.0**	1.00	1.00	1.00	0.75	**0.75**	**0.67**
T3	135	127.5	117.5	1.00	1.00	1.02	0.75	0.65	0.55
T4	135	120.0	120.0	1.00	1.00	0.99	0.75	0.70	0.50
T5	135	125.0	120.0	1.00	0.98	1.00	0.75	0.70	0.55
T6	135	129.0	120.0	1.00	0.99	1.01	0.75	0.70	0.55
T7	135	130.0	125.0	1.00	1.01	1.01	0.75	0.75	0.65
T8	135	130.0	125.0	1.00	0.98	1.01	0.75	0.70	0.60
T9	135	121.5	117.5	1.00	1.01	1.00	0.75	0.65	0.55
T10	135	131.0	125.0	1.00	1.01	0.98	0.75	0.68	0.65
T11	135	127.5	117.5	1.00	0.99	0.99	0.75	0.60	0.45
T12	135	124.5	115.0	1.00	1.00	1.01	0.75	0.55	0.45
T13	135	128.0	115.0	1.00	1.01	0.99	0.75	0.65	0.58
T14	135	120.0	120.0	1.00	0.99	1.00	0.75	0.65	0.60
T15	135	127.5	121.0	1.00	1.05	0.98	0.75	0.68	0.55

T16	135	129.5	122.5	1.00	0.99	1.00	0.75	0.65	0.60
T17	134	121.0	115.0	1.00	1.01	0.97	0.65	0.55	0.45
T18	134	130.0	125.5	1.00	1.00	0.96	0.65	0.65	0.60
T19	134	122.5	120.0	1.00	1.00	0.99	0.65	0.60	0.45
T20	134	119.0	117.5	1.00	0.97	0.99	0.65	0.50	0.45
T21	134	127.5	117.5	1.00	1.00	1.02	0.65	0.58	0.55
T22	134	120.0	120.0	1.00	0.99	1.00	0.65	0.55	0.55
T23	134	125.0	123.0	1.00	1.01	0.95	0.65	0.55	0.55
T24	134	130.0	120.0	1.00	1.02	0.97	0.65	0.63	0.60
F-Test		NS	NS	-	NS	NS	-	NS	NS

NS (Not significant)

9. Conclusion

This study identifies factors that significantly influence the shelf life and quality of Pearson tomatoes in Afghanistan stored with the innovative ZECC system. ZECC extended the shelf life of turning-color Pearson tomatoes up to 29 days of storage with 6% $CaCl_2$ treatment and 25 days of storage without. ZECC enhanced the shelf life of pink color tomatoes up to 24 days with 6% $CaCl_2$ treatment and 20 days without. Light red stage shelf life was increased up to 23 days treated with 6% $CaCl_2$ and 20 days without. In comparison, Pearson tomatoes in Afghanistan harvested at full red color stage has a maximum of 6 days storage under ambient conditions. Harvesting stages and postharvest treatment (6% $CaCl_2$) had significant effects on fruit firmness and shelf life. Postharvest treatments 6% $CaCl_2$ and 6% $CaCl_2$ + 6% mint leaf extract solution had little difference in fruit quality. In conclusion, it is best to harvest Pearson tomatoes at the turning-color stage, which were 5 and 6 days more storage resiliency compared to harvested pink color and light red color tomatoes, respectively. ZECC storage could be the best option for farm storage for small-scale farmers of tomatoes and other important crops in Afghanistan. A $CaCl_2$ of 6% concentration postharvest treatment maintains tomato firmness and increases shelf life. Mint leaf extract did not show significant effect on quality or shelf life, possibly due to its low concentration.

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