Research in
AGRICULTURE, LIVESTOCK and FISHERIES
ISSN : P-2409-0603, E-2409-9325
An Open Access Peer-Reviewed International Journal

Article Code: 498/2025/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 12, No. 3, December 2025: 333-352.

Postharvest Quality Attributes and Shelf Life Evaluation of Summer-Grown Tomato Cultivars

Tahamina Akhter, Md. Harun Ar Rashid*, Md. Golam Rabbani and Tamanna Haque

Department of Horticulture, Faculty of Agriculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

***Corresponding author:** Md. Harun Ar Rashid; E-mail: harun_hort@bau.edu.bd

ARTICLE INFO

Received
14 October 2025

Revised
02 November 2025

Accepted
04 November 2025

Key words:
Postharvest quality
Shelf life
TSS
Diseases
Summer season

ABSTRACT

The study was conducted to evaluate 17 tomato cultivars for higher postharvest quality and shelf life under storage condition during the summer season in Bangladesh at the Postharvest Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from May 2025 to July 2025 with the objective of identifying suitable cultivars for storage, transportation, and marketing in the summer season. Postharvest quality parameters were assessed and significant variation was observed among cultivars. In regards to postharvest behavior of tomato, Maximum TSS (9.1%) and pH (4.87) were exhibited by Raja Super and Udayan, respectively. Whereas maximum weight loss (10.91%) and firmness (2.10 kg $cm^{-2)}$ were exhibited by Binatomato-13 and Raja Super, respectively at 10 days of storage. Maximum dry matter content (9.54%) exhibited by Deshi pathorkuchi and conversely maximum moisture content (95.23%) identified in Binatomato-7. Jholmol recorded the highest disease incidence (60%) and severity (55.47%) after 10 days of storage, while Ratan, Raja Super, Rubi, Udayan, Unnayan, and Chakra showed no disease incidence or severity during the storage period. And finally, the longest shelf life (15.17 days) was observed from Chakra, followed by Udayan (15.13 days), Le_{16} (Deshi patharkuchi) (14.83 days) and Le_7 (Raja Super) (14.33 days). Hence, the findings highlight the potential of cultivars such as Chakra, Udayan, and Raja Super for commercial cultivation and long-term storage and transportation during the summer season in Bangladesh.

To cite this article: Akhter T., M. H. A. Rashid, M. G. Rabbani, and T. Haque, 2025. Postharvest quality attributes and shelf life evaluation of summer-grown tomato cultivars. Res. Agric. Livest. Fish. 12(3): 333-352.

DOI: https://doi.org/10.3329/ralf.v12i3.85505

Introduction

Efficient management of postharvest losses has become a critical issue in modern agriculture, especially in an era of globalized food markets where fresh produce often travels long distances from producers to consumers. Among perishable horticultural commodities, tomato (*Lycopersicon esculentum Mill., 2n = 24*), a climacteric fruit belonging to the Solanaceae family, holds immense nutritional, economic, and industrial value. However, it is also one of the most perishable vegetables, characterized by a short postharvest life due to rapid physiological and biochemical changes that begin immediately after harvest. Globally, postharvest losses of tomato are estimated at around 40%, largely resulting from inadequate handling, poor storage infrastructure, and inefficient processing (Nwakuba et al., 2020). These losses not only represent substantial economic setbacks but also exacerbate global food insecurity. Tomato is valued for its rich composition of vitamins (A, C, and E), minerals, antioxidants, and bioactive compounds. Lycopene, β-carotene, and other phytochemicals present in tomato exhibit potent antioxidant and anticarcinogenic properties, offering protection against cardiovascular diseases and certain cancers (Casals et al., 2019). Despite this health promoting attributes, maintaining fruit quality postharvest remains challenging, particularly under tropical conditions where accelerate biochemical degradation primarily influenced by time and temperature interactions affect enzymatic activity, respiration, water loss, and microbial growth (Cherono et al., 2018). Being composed of approximately 90% water, tomato fruits are highly susceptible to desiccation and microbial attack. Their dry matter consists mainly of reducing sugars such as glucose and fructose, which, while contributing to desirable taste, also serve as substrates for spoilage microorganisms. Nutritionally, tomato contains 93.8 g water, 1.2 g protein, 4.8 g carbohydrate, and substantial quantities of essential micronutrients per 100 g edible portion (Nkansah et al., 2003).

In Bangladesh, tomato ranks among the major vegetable crops, covering about 6.5% of the total vegetable cultivation area with an average yield of approximately 14.94 tons per hectare (BBS, 2024). Whereas, postharvest losses at the farm level reach around 25 % of the total production (Khatun & Rahman, 2020) among them tomato contribute 30% postharvest loss in the supply chain of Bangladesh (Hasan 2010). These losses are further aggravated during the summer months, when elevated temperatures and humidity accelerate ripening and decay. Nevertheless, systematic research on the postharvest performance and storability of these summer-grown cultivars remains limited.

Traditional approaches, such as harvesting at the mature-green stage, help reduce mechanical injury during transportation but often compromise flavor and color development. Modern postharvest technologies including temperature regulation, modified atmosphere packaging, and chemical treatments have shown promise in extending shelf life by slowing metabolic processes and suppressing microbial activity. However, these methods may not always be cost-effective, environmentally sustainable, or suitable for smallholder farmers in developing countries like Bangladesh. Therefore, identifying and selecting cultivars with inherently superior postharvest quality traits such as higher firmness, slower weight loss, better biochemical stability, and lower disease susceptibility offer a practical and sustainable solution. Given this context, the present study was undertaken to evaluate 17 tomato cultivars grown during the summer season to assess their postharvest quality and shelf life in order to identify cultivars best suited for storage under summer conditions in Bangladesh. Insights gained from this research will contribute to developing improved postharvest management strategies, guide breeding programs for enhanced storability, and promote year-round tomato availability in the local market.

Materials and methods

Experimental location and material

The present experiment was conducted to study the effect of cultivars on postharvest quality and shelf life of tomato at the Postharvest Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from May 2025 to July 2025. The tomato plants were grown under polytunnel during February 2025- May 2025 at Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh. Well, developed, uniform sized, and healthy tomato fruits were harvested from the field and taken to the Postgraduate Laboratory and were kept under room temperature for observing postharvest changes.

Experimental materials and design

Seventeen tomato cultivars used as treatments in the single factor experiment were Binatomato-6 (Le_1), Bonatomato-7 (Le_2), Binatomato-11 (Le_3), Binatomato-12 (Le_4), Binatomato-13 (Le_5), Ratan (Le_6), Raja Super (Le_7), Beer Super (Le_8), Rubi (Le_9), Roma V. F (Le_{11}), Udayan (Le_{12}), Unnayan (Le_{13}), Jholmol (Le_{14}), Julia (Le_{15}), Deshi patharkuchi (Le_{16}), Chakra (Le_{17}), and Tomato selection-4(Le_{20}). The experiment was conducted in a completely randomized design with 3 replications. Fifteen tomato fruits were taken under each treatment from which 10 fruits were used as destructive sample and 5 were kept for colour changes, weight loss, disease incidence and severity, and shelf life study. Therefore, total number of 765 fruits was used for this experiment for 17 treatments with 3 replications.

Parameters studied

Changes in color

Tomatoes were keenly observed everyday but data was recorded on Color change at 2 days interval (0, 2, 4, 6,8, and 10 days during storage). The change in color of fruit was determined with eye estimation. The peel color of fruit was recorded by matching with a standard color chart. The scales were as follows:
1= Light green, 2= Yellow green, 3= Light yellow green, 4= Yellow, 5= Orange yellow, 6= Orange, 7= Orange red, 8= Red

Total soluble solids (% brix)

Total soluble solids (TSS) were determined from each sample fruit in three replications using a hand-held refractometer at room temperature and expressed as °Brix. (Astuti *et al*., 2015).

Pulp pH

Fresh tomato fruits were cut into small pieces, mashed with mortar and pestle and was filtered through muslin cloth. The filtrate was used for measuring the pH using a Portable pH Meter (HI 2211 p^H /ORP Meter) which was calibrated with buffer solution 4.0, 7.00 and 10.0 at room temperature (Astuti *et al*., 2015).

Firmness (kg cm^{-2})

Firmness was determined by using fruit penetrometer (Model Cat.No.166), the fruits were punctured at two places opposite to each other in radial axis with the plunger and the pressure required was recorded and expressed in kg cm^2.

Weight loss (%)

Weight of five fruits under each treatment and replication were taken at 2 days interval (0, 2, 4, 6, 8- and 10-days during storage) and percentage was calculated by following formula:

$$\% \text{ Weight loss of fruit} = \frac{\text{Initial weight} - \text{Final weight of fruits (g)}}{\text{Initial weight of fruits (g)}} \text{ X } 100$$

Disease incidence (%)

Disease incidence means percentage of samples infected with disease. The tomato fruits were critically examined every day for the appearance of any diseases. This is measured by calculating the percentage of fruits infected under each treatment and replication. Black spot and gray mold were identified by observing the typical symptoms of those diseases, which are caused by *Alternaria alternata and Botrytis cinerea* respectively. The disease incidence was calculated as follows:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits assessed}} \text{X } 100$$

Disease severity (%)

Disease severity represents the percent diseased portion of the infested fruit. In order to measure disease severity level, the fruits were critically observed and percent skin infected fruit was recorded at two days interval starting from the first day of storage up to the last day. All the infected fruits were taken to determine the percent fruit area infected and carefully evaluated. The percent fruit area was measured based on eye estimation. The mean values regarding infected fruit area were calculated.

Moisture content (%)

A known amount of fresh tomato flesh (50 grams) was taken. The fresh weight was recorded in grams. The sample was placed in an oven at 65 °C for 72 hours (until constant weight was achieved). The sample was fully dried. The dried sample was weighed. The dry weight (DW) was recorded in grams. The moisture content (%) was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weeight}} \text{X } 100$$

Dry matter (%)

The dry matter (%) of the fruit was calculated from the data obtained during moisture estimation using following formula:

Dry Matter (%) = 100- Moisture content

Shelf life (days)

Shelf life of tomato fruits (days) was determined by visual observation depending on the appearance and spoilage of fruits. When 50 per cent of fruits showed symptoms of shrinkage or spoilage due to pathogens and temperature injury, that lots of fruit were considered to have reached end of shelf life.

Statistical analysis

The collected data on various parameters were statistically analyzed using MSTATC statistical package. That means for all the treatments were calculated and analysis of variance (ANOVA) for all the parameters was perfected by F-test. The significance difference between pair of means was by least significant difference (LSD) test at 1 and 5% levels of probability (Gomez and Gomez, 1984).

Results

Changes in color

The effect of different cultivars was statistically significant to influence color change during storage (Table 1). At 0 days of storage the cultivar Le_{13} and Le_{20} showed maximum color (4= Yellow) followed by the cultivar Le_{14} and Le_{15} (3=Light yellow green) while maximum number of cultivars showed minimum color which is 1=Light green. Cultivar Le_1 showed minimum color (2= Yellow green), (3=Light yellow green), (4=Yellow), (5= Orange yellow) and (6= Orange) at 2, 4, 6, 8 and 10 days of storage, respectively. Whereas, the cultivars

Le_{13}, Le_{16}(5= Orange yellow) and Le_{20} (6= Orange) showed maximum color development at 2 and 4 days of storage, respectively. The variety Le_{20} showed maximum color (7= Orange red), (8= Red) and (8=Red) at 6, 8, and 10 days of storage. Overall, in terms of appearance cultivars Le_8, Le_9, Le_{11}, Le_{13}, and Le_{20} exhibited bright red color on ripening.

Table 1. Main effect of cultivars on color at different days after storage of tomato

Cultivars	Color at different days after storage					
	0	**2**	**4**	**6**	**8**	**10**
Le_1	1.00	2.00	3.00	4.00	5.00	6.00
Le_2	1.00	3.00	4.00	5.00	5.00	6.00
Le_3	2.00	3.00	4.00	5.00	6.00	7.00
Le_4	1.00	3.00	5.00	6.00	6.00	7.00
Le_5	1.00	3.00	4.00	5.00	6.00	6.00
Le_6	1.00	2.00	3.00	4.00	5.00	6.00
Le_7	1.00	4.00	5.00	6.00	7.00	7.00
Le_8	2.00	4.00	5.00	6.00	7.00	8.00
Le_9	1.00	3.00	5.00	6.00	7.00	8.00
Le_{11}	1.00	2.00	4.00	5.00	7.00	8.00
Le_{12}	2.00	4.00	5.00	6.00	7.00	7.00
Le_{13}	4.00	5.00	6.00	6.00	7.00	8.00
Le_{14}	3.00	4.00	5.00	5.00	5.00	6.00
Le_{15}	3.00	4.00	5.00	6.00	6.00	7.00
Le_{16}	2.00	5.00	6.00	6.00	7.00	7.00
Le_{17}	2.00	4.00	5.00	6.00	6.00	7.00
Le_{20}	4.00	5.00	6.00	7.00	8.00	8.00
$LSD_{0.05}$	0.40	0.81	0.70	0.57	0.70	0.70
$LSD_{0.01}$	0.54	1.09	0.94	0.77	0.94	0.94
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability; Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Total soluble solids (TSS)

The result disclosed a gradual increase in TSS of the tomato fruits during the storage period but at different rates. However, the cultivars significantly influenced TSS (% brix) of the tomato fruits at 1% level of significance (Table 2) for each observed day. The highest TSS 6.27%, 6.73%, 7.20%, 7.83%, 8.33% and 9.17% was attained from the cultivar Le_7 (Raja Super) at 0, 2, 4, 6, 8 days of storage, respectively. The lowest TSS 4.43%, 4.70%, 5.40% and 6.13% was recorded from Le_{15}, Le_5, Le_4 and Le_{12} at 0, 2, 4 and 6 days of storage, respectively. Again, lowest TSS (6.73%) was recorded from the cultivar Le_4 (Binatomato-12) and Le_5 (Binatomato-13) on 8 days of storage and TSS 7.27% was obtained from the cultivar Le_4 (Binatomato-12) at 10 days of storage, respectively. Drastic changed observed in Le_5, Le_8, and Le_{17} whereas Le_1, Le_{12} and Le_{13} exhibited somewhat slower rate.

Table 2. Main effect of cultivars on TSS (%brix) and pH at different days after storage of tomato

Cultivars	TSS (%brix) at different days after storage						pH at different days after storage					
	0	2	4	6	8	10	0	2	4	6	8	10
Le_1	5.37	5.53	5.83	6.53	6.90	7.30	4.17	4.23	4.43	4.57	4.63	4.77
Le_2	4.87	5.47	6.13	6.80	7.47	7.47	4.30	4.37	4.40	4.53	4.63	4.73
Le_3	4.80	5.27	6.33	6.53	7.03	7.50	4.13	4.23	4.33	4.47	4.53	4.67
Le_4	4.53	4.87	5.40	6.40	6.73	7.27	4.23	4.30	4.40	4.50	4.57	4.63
Le_5	4.40	4.70	6.03	6.53	6.73	7.63	4.27	4.43	4.53	4.63	4.70	4.80
Le_6	5.00	5.27	6.33	7.37	7.97	8.37	4.20	4.27	4.47	4.57	4.67	4.73
Le_7	6.27	6.73	7.20	7.83	8.33	9.17	4.33	4.37	4.50	4.60	4.73	4.77
Le_8	4.63	5.80	6.33	7.10	7.30	8.40	4.57	4.60	4.63	4.73	4.77	4.87
Le_9	5.27	5.47	6.00	6.47	7.07	7.60	4.37	4.50	4.53	4.67	4.70	4.83
Le_{11}	5.07	5.23	6.60	7.37	8.17	8.53	4.33	4.43	4.60	4.63	4.73	4.80
Le_{12}	4.63	4.83	5.53	6.13	7.17	7.83	4.47	4.57	4.67	4.73	4.80	4.87
Le_{13}	4.63	5.47	6.60	6.93	7.33	7.97	4.20	4.37	4.50	4.63	4.73	4.80
Le_{14}	4.47	5.00	6.50	7.27	8.17	8.63	4.37	4.37	4.43	4.53	4.63	4.70
Le_{15}	5.40	5.63	6.13	6.40	7.23	8.13	4.40	4.53	4.57	4.67	4.73	4.77
Le_{16}	5.37	5.67	6.60	7.23	8.07	8.57	4.27	4.40	4.50	4.57	4.70	4.73
Le_{17}	4.43	6.00	6.43	6.70	7.17	7.57	4.30	4.47	4.50	4.63	4.73	4.77
Le_{20}	5.00	5.60	6.27	6.73	7.53	8.27	4.43	4.53	4.60	4.70	4.80	4.83
$LSD_{0.05}$	0.36	0.37	0.36	0.44	0.42	0.46	0.25	0.33	0.31	0.30	0.23	0.22
$LSD_{0.01}$	0.48	0.50	0.49	0.59	0.57	0.61	0.33	0.45	0.41	0.41	0.31	0.29
Level of significance	**	**	**	**	**	**	**	*	*	NS	*	*

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Significant; Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Pulp pH

The pulp pH also followed the similar pattern as TSS. A slow but steady rise in tomato pH was noticed throughout the experimental period where cultivars significantly influenced pH of the tomato fruits at 0, 2, 4,8 and 10 days of storage, respectfully but at 6 days of storage the varieties showed non-significant effect on pH of tomato (Table 2). The highest pH 4.57 and 4.60 was attained from the cultivar Le_8 (Beer Super) at 0 and 2 days of storage, respectively. Again, the highest pH 4.67, 4.73, 4.80 and 4.87 was attained from the variety Le_{12} (Udayan) at 4, 6, 8 and 10 days of storage, respectively. Similar result was observed in the cultivar Le_8 (Beer Super) for 6 and 10 days of storage. The lowest pH 4.12, 4.23, 4.33, 4.47 and 4.53 was recorded from Le_3(Binatomato-11) at 0, 2, 4, 6 and 8days of storage, respectively. But lowest pH 4.67 was recorded from the cultivar Le_4 (Binatomato-12) at 10 days of storage.

Weight loss

There was a used significant influence of cultivars on the weight loss percentage of tomato fruits at 1% level of significance (Table 3). The maximum weight loss 6.01%, 7.35%, 8.52%, 9.90% and 10.91% was attained from Le_5(Binatomato-13) followed by Le_6(Ratan) 4.69%, 5.82%, 6.69%, 7.46% and 9.19% at 2, 4, 6, 8, 10 days of storage, respectively. The minimum weight loss 1.42% was recorded in Le_1 and 2.53% in Le_{15} at 2 and 4 days of storage, respectively. Again, the minimum weight loss 3.05%, 3.36%, and 3.59% was recorded from Le_1 (Binatomato-6) followed by Le_2 (Binatomato-7) 3.30%, 3.83%, and 4.29% at 6, 8 and 10 days of storage, respectively.

Firmness

Cultivars also significantly influenced the firmness (kg cm^{-2}) of tomato (Table 3). The maximum firmness 6.00 kg cm^{-2} was attained from the cultivar Le_1(Binatomato-6) and Le_6 (Ratan) at 0 days of storage. The maximum firmness 5.57 kg cm^{-2}, 4.77 kg cm^{-2}, 4.27 kg cm^{-2}, 3.83 kg cm^{-2} and 3.18 kg cm^{-2} was attained from Le_6 (Raja Super) followed by Le_1(Binatomato-6) 5.47 kg cm^{-2}, 4.74 kg cm^{-2}, 4.10 kg cm^{-2},3.50 kg $cm^{-2}$and 3.10 kg cm^{-2} at 2, 4, 6, 8 and 10 days of storage, respectively. The minimum firmness 3.90 kg cm^{-2}, 3.63 kg cm^{-2}, 3.30 kg cm^{-2}, 2.93 kg cm^{-2}, 2.70 kg cm^{-2} and 2.10 kg cm^{-2} was recorded from Le_6(Ratan) at 0, 2, 4, 6, 8 and 10 days of storage, respectively.

Disease incidence

Disease incidence was observed at each two days interval during storage starting from 0 days and continued until 10 days of storage. At 0 days of storage no disease incidence percentage was noticed while at 2 days only the cultivar Le_{14} (Jholmol) showed 20% disease incidence. Cultivars significantly influenced the disease incidence percentage of tomato at 4, 6 and 8 days of storage at 1% level of significance. The maximum disease incidence 33.333%, 53.33%, 60.00% and 60.00% was attained from the cultivar Le_{14}(Jholmol) followed by Le_5(Binatomato-13) 30.33%, 40.00%,60.00% and 60.00% at 4, 6, 8 and 10 days of storage, respectively. The minimum disease incidence 0.00%, 0.00%, 0.00%, 0.00% and 20.00% was recorded from Le_{16}(Deshi patharkuchi) at 2, 4, 6, 8 and 10 days of storage, respectively. While, cultivars Le_6(Ratan), Le_7(Raja super), Le_9(Rubi), Le_{12}(Udayan), Le_{13}(Unnayan) and Le_{17}(Chakra) showed no disease incidence during the storage period. (Figure 1).

Disease severity

Following disease incidence, no disease severity percentage was noticed at 0 days while at 2 days only the cultivar Le_{14}(Jholmol) showed 7.13% disease severity. Varieties significantly influenced the disease severity percentage of tomato at 4,6 and 8 days of storage at 1% level of significance. The maximum disease severity 23.01%, 30.34%, 34.83% and 55.47% was attained from the cultivar Le_{14} (Jholmol) followed by Le_8(Beer Super) 12.89%, 20.57%,24.76% and 31.90% at 4, 6, 8 and 10 days of storage, respectively. The minimum disease severity 0.00%, 0.00%, 0.00%, 0.00% and 23.37% was recorded from Le_{16} (Deshi

patharkuchi) at 2, 4, 6, 8 and 10 days of storage, respectively. While, cultivar Le_6(Ratan), Le_7(Raja super), Le_9 (Rubi), Le_{12} (Udayan), Le_{13} (Unnayan) and Le_{17} (Chakra) showed 0.00% disease severity during the storage period (Figure 2).

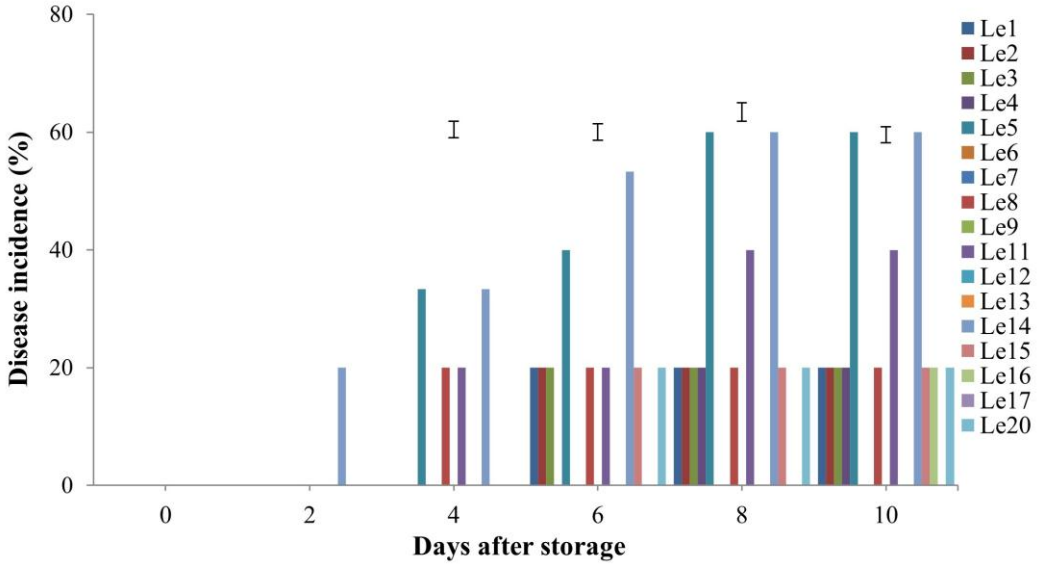

Figure 1. Effects of tomato cultivars on disease incidence at different days after storage. Vertical bars indicate LSD at 1% level of significance. Here, Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

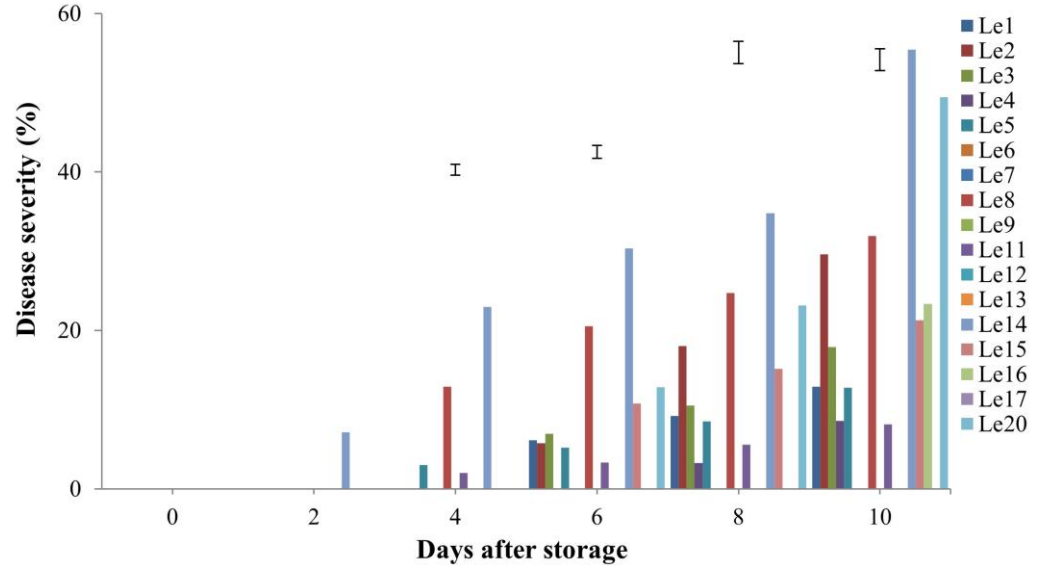

Figure 2. Effects of tomato cultivars on disease severity at different days after storage. Vertical bars indicate LSD at 1% level of significance. Here, Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Table 3. Main effect of cultivars on weight loss (%) and firmness (kg/cm^2) at different days after storage of tomato

Cultivars	Weight loss at different days after storage					Firmness at different days after storage					
	2	4	6	8	10	0	2	4	6	8	10
Le_1	1.42	2.58	3.05	3.36	3.59	6.00	5.47	4.73	4.10	3.50	3.10
Le_2	1.71	2.58	3.30	3.83	4.29	4.27	4.13	3.67	3.37	3.20	2.77
Le_3	2.67	3.41	4.16	5.34	5.89	4.90	4.47	3.83	3.57	2.97	2.53
Le_4	3.92	5.08	6.68	8.39	9.04	5.87	5.37	4.97	4.37	3.87	3.20
Le_5	6.01	7.35	8.52	9.90	10.91	5.07	4.50	3.77	3.80	2.97	2.57
Le_6	4.69	5.82	6.69	7.46	9.19	3.90	3.63	3.30	2.93	2.70	2.17
Le_7	2.87	4.15	5.06	6.39	7.53	6.00	5.57	4.77	4.27	3.83	3.18
Le_8	2.77	4.15	5.82	6.86	7.97	5.30	4.80	4.20	3.93	3.40	2.93
Le_9	4.21	4.66	5.97	7.14	8.47	5.13	4.63	3.77	3.73	2.80	2.30
Le_{11}	1.47	2.64	4.87	6.15	6.96	5.37	3.80	3.53	3.37	3.10	2.60
Le_{12}	2.95	4.00	4.75	6.20	7.36	4.33	4.13	3.83	3.47	2.70	2.03
Le_{13}	2.40	3.11	4.12	5.06	6.42	4.13	3.73	3.50	3.23	2.87	2.20
Le_{14}	3.18	3.98	4.79	5.64	6.95	4.33	3.93	3.67	3.23	3.03	2.47
Le_{15}	2.13	2.53	3.26	4.12	4.83	4.37	3.87	3.57	3.17	2.70	2.27
Le_{16}	2.08	2.46	3.23	4.91	5.85	5.27	4.90	4.40	3.73	3.27	3.00
Le_{17}	2.55	3.11	3.82	4.68	5.62	5.47	4.83	4.07	3.37	3.10	2.47
Le_{20}	3.17	3.46	4.75	5.55	6.56	5.47	4.90	4.33	3.10	2.67	2.23
$LSD_{0.05}$	0.80	0.90	0.87	0.73	0.65	0.35	0.55	0.71	0.79	0.68	0.73
$LSD_{0.01}$	1.08	1.21	1.18	0.98	0.88	0.48	0.74	0.96	1.07	0.91	0.99
Level of significance	**	**	**	**	**	**	**	**	**	**	*

** = Significant at 1% level of probability, * = Significant at 5% level of probability; Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Moisture content

Cultivars significantly influenced moisture content of tomato. Maximum moisture content was observed in Le_2 (95.23%) followed by Le_{12} (95.17%) and Le_5 (95.12%). The minimum moisture content was recorded from the cultivar Le_{16} (90.46%) followed by Le_{17} (91.76%) and Le_{15} (92.22%) (Table 4).

Dry matter

Dry matter content of tomato was statistically significant at 1% level of significance. Maximum dry matter content was recorded from the cultivar Le_{16}(9.54%) followed by Le_{17}(8.24%). The minimum dry matter content was observed in Le_5 (4.77%) followed by Le_{12}(4.83%) and Le_2 (4.88%) (Table 4).

Table 4. Main effect of cultivars on percent moisture and dry matter content of tomato

Cultivars	Moisture content (%)	Dry matter content (%)
Le_1	93.26	6.74
Le_2	95.23	4.77
Le_3	93.09	6.91
Le_4	93.47	6.53
Le_5	95.12	4.88
Le_6	93.85	6.15
Le_7	93.60	6.40
Le_8	93.99	6.01
Le_9	93.11	6.89
Le_{11}	93.12	6.88
Le_{12}	95.17	4.83
Le_{13}	94.63	5.70
Le_{14}	94.73	5.27
Le_{15}	92.22	7.78
Le_{16}	90.46	9.54
Le_{17}	91.76	8.24
Le_{20}	95.42	4.58
$LSD_{0.05}$	1.32	1.30
$LSD_{0.01}$	1.77	1.75
Level of significance	**	**

** = Significant at 1% level of probability; Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Shelf life

Shelf life of tomato was statistically significant for various cultivars at 1% level of significance The highest shelf life (15.17 days) was exhibited by Le_{17}(Chakra), followed by Le_{12}(Udayan) (15.13 days), Le_{16} (Deshi Patharkuchi) (14.83 days) and Le_{7} (Raja Super) (14.33 days), while the minimum shelf life (5.61 days) was found from the cultivar Le_{14} (Jholmol) followed by Le_{2} (Binatomato-7) (7.88 days), Le_{8} (Beer Super) (8.53 days) and Le_{20}(Tomato selection 4) (9.17 days) (Figure 3). The pictorial view of tomato fruits set for the experiment are presented in plate1-5 during the storage period.

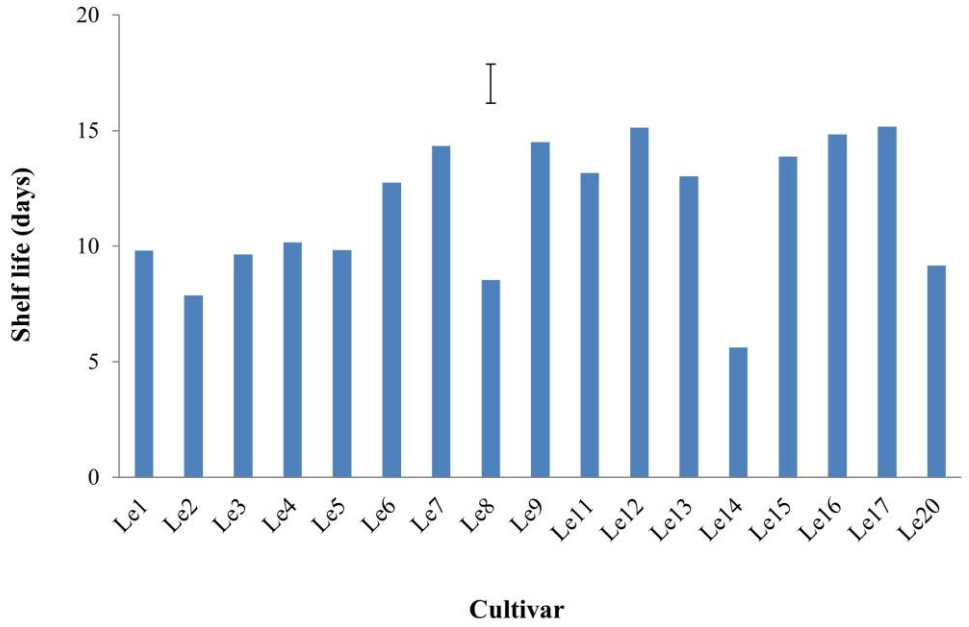

Figure 3. Effects of tomato cultivars on shelf life. Vertical bar indicates LSD at 1% level of significance. Here, Le_{1} =Binatomato-6, Le_{2} =Binatomato-7, Le_{3}=Binatomato-11, Le_{4}=Binatomato-12, Le_{5} = Binatomato-13, Le_{6}= Ratan, Le_{7} = Raja Super, Le_{8}= Beer Super, Le_{9} = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection

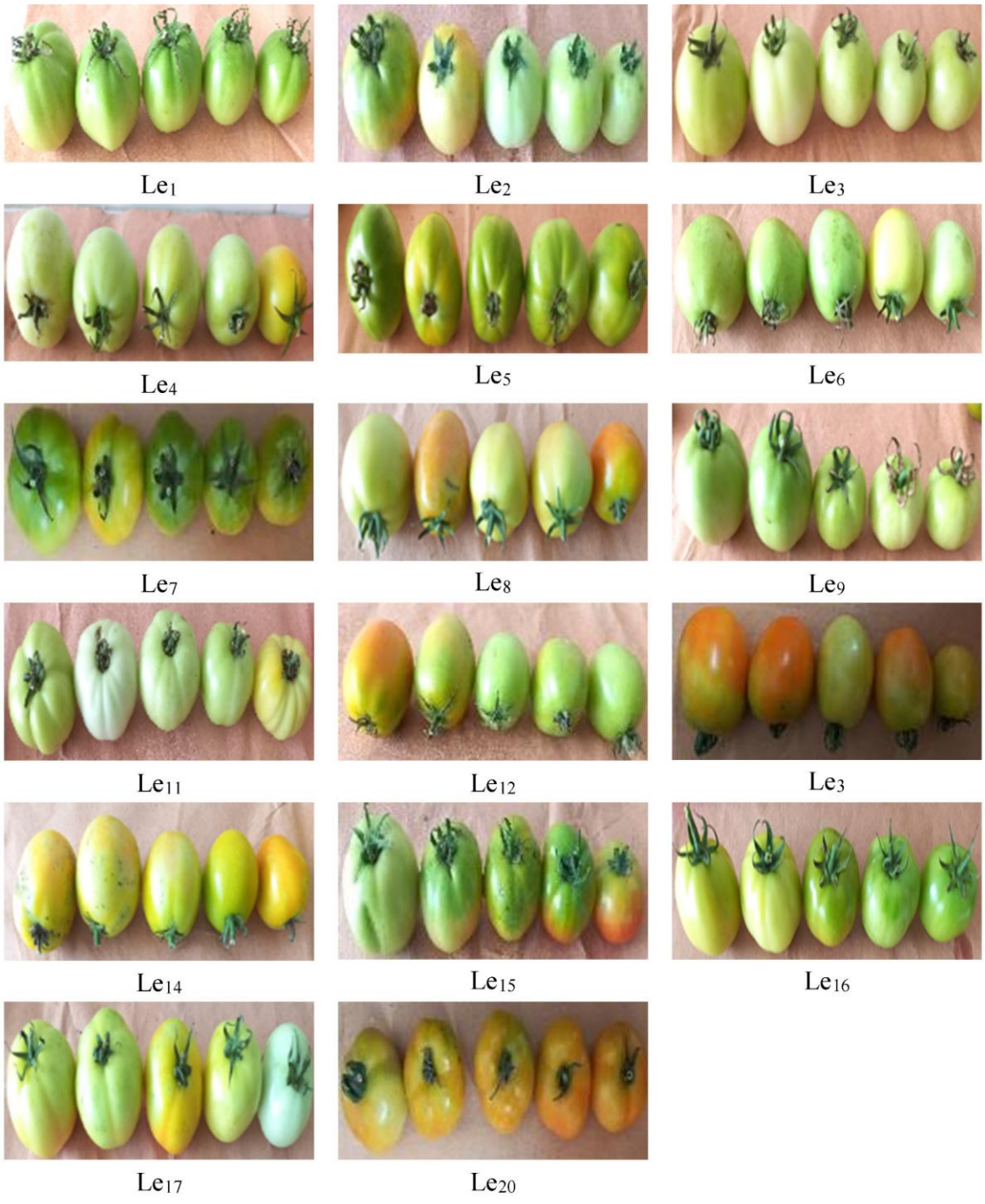

Plate 1. Photograph showing postharvest observation of tomato fruits at 0 days of storage. (Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

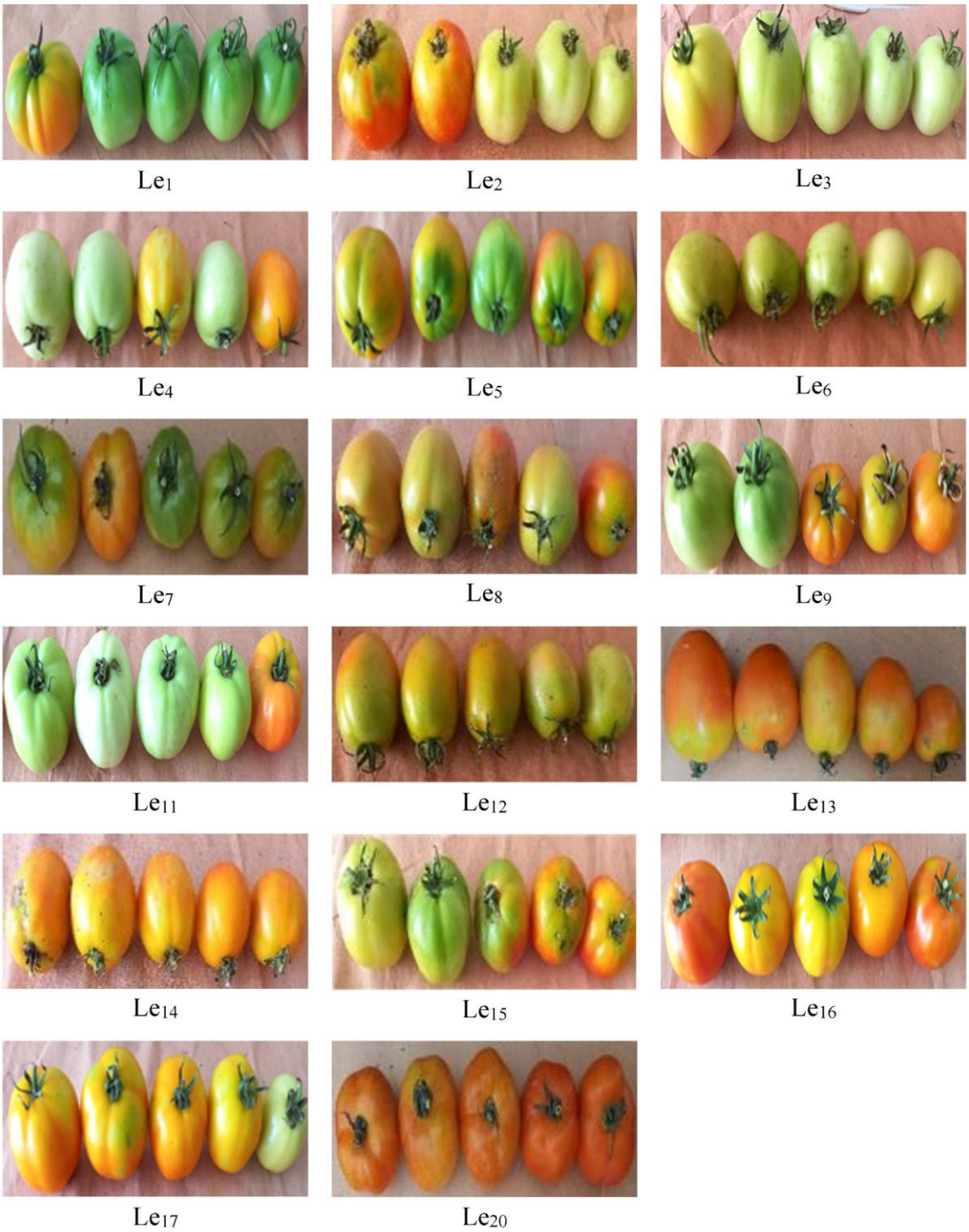

Plate 2. Photograph showing postharvest observation of tomato fruits at 2 days of storage. (Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

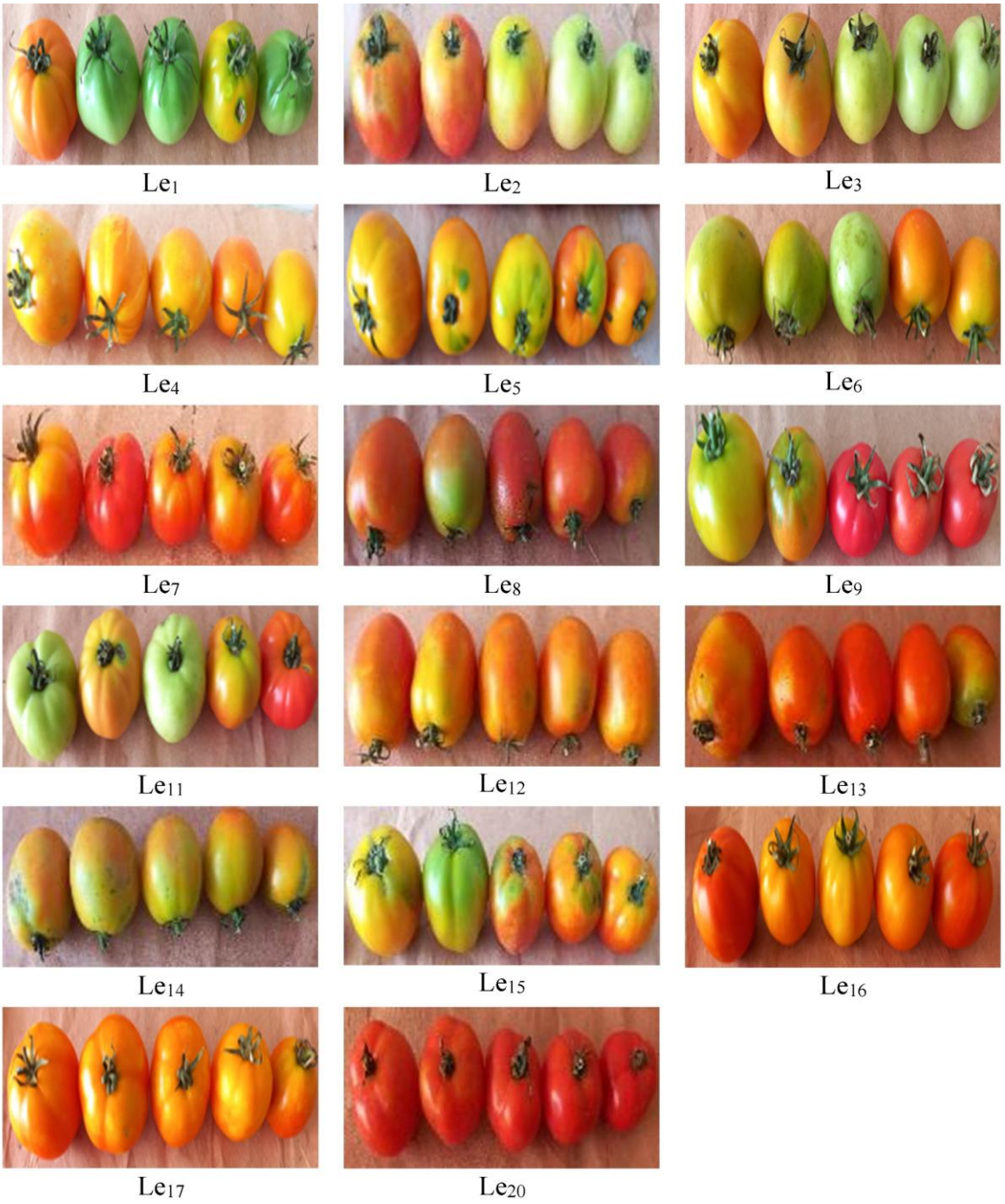

Plate 3. Photograph showing postharvest observation of tomato fruits at 4 days of storage. (Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Plate 4. Photograph showing postharvest observation of tomato fruits at 6 days of storage. (Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Plate 5. Photograph showing postharvest observation of tomato fruits at 8 days of storage. (Le_1 =Binatomato-6, Le_2 =Binatomato-7, Le_3=Binatomato-11, Le_4=Binatomato-12, Le_5 = Binatomato-13, Le_6= Ratan, Le_7 = Raja Super, Le_8= Beer Super, Le_9 = Rubi, Le_{11} = Roma VF, Le_{12} = Udayan, Le_{13} = Unnayan, Le_{14} = Jholmol, Le_{15} = Julia, Le_{16} = Deshi pathorkuchi, Le_{17} = Chakra, Le_{20} = Tomato selection 4

Discussion

Similar to our study, several studies have already observed color change in tomato cultivars. Tomato kept at room temperature can provide an optimal environment resulted in increasing redness compared to cold storage conditions (Munhuewyi, K. 2012). Storage at 22 °C can cause an increase in redness of tomato due to chlorophyll degradation, lycopene accumulation, and ethylene biosynthesis (Hatami *et al*., 2013; Tigist *et al*., 2013). The reduction in yellowness during storage is mostly associated with red color development (Endalew. 2020). As highlighted by Khairi *et al*., (2015) the yellowness of tomato was continually decreased as temperature and time increased. Žnidarčič (2006) found that tomato reached its minimum yellowness after 21 days at 5 and 10 °C.

Early harvested tomatoes usually contain higher soluble solids than later harvested tomatoes and this is consequent with the amount of glucose and fructose that usually declines over time (Cadavid, 2014). El-Dengawy *et al*. (2016) found that the total soluble solids of raw tomato juice are 5, whereas after processing increased to 9. Patwary *et al*. (2013), reported TSS ranging from 4.37 to 5.67% in winter tomato and 3.39 to 4.77% in summer tomato. The variation of TSS among tomato cultivars were also observed by Garcia Gusano *et al*. (2004) and Vishwanath *et al*. (2014). The values between 5.2 and 8.8 ºBrix for round varieties (Figàs *et al*., 2015) and between 5.5 and 7.4 ºBrix for pear varieties (Flores *et al*., 2017) have been described elsewhere. Our results also partially agreed to the aforementioned data. In parallel to our findings, Sinha, S. R *et al*., (2019) also found that pH was increased from 4.33 to4.44 in Roma VF while in Sofol it was 4.15 to 4.33 at 4th and 8thday of storage. Anthon, G. E., 2011 stated that delayed harvesting resulted in juice with a higher pH in all varieties. Average pH ranged from 4.38 to 4.49 at the first harvest, then increased to a range of 4.70 to 4.89 at the final harvest 21 days later. Hanna GC. (1961) found that the average increase in pH was about 0.3 unit over 30 days of vine holding, which is similar to what we found here. Others have also reported increases in pH and declines in TA with increased tomato maturity (Akbudak B.2010; Garcia E and Barrett DM 2006).

Regarding storage, Endalew (2020) stated that storage time and storage temperature had a great effect on the weight loss of tomatoes. Wei *et al*., (2019) reported that fresh produce experienced high weight reduction due to the increment in transport vibration which accelerates water reduction of fresh produce as well as shriveling resulted from intracellular damage. Storage at ambient temperature increased the tomato weight loss due to transpiration, respiration (Abiso *et al*.,2015) and dehydration (Fagundes *et al*.,2015). In terms of storage conditions, ambient temperature can cause a continuous reduction in tomato firmness due to moisture loss through transpiration and enzymatic changes (Abiso *et al*., 2015) which can degrade tomato cell wall (Hatami *et al*., 2013; Zhou *et al*., 2007). In the present study, the firmness of tomato cultivars ranged from 2.10 kg cm^{-2} to 6.00 kg cm^{-2}at 0 to 10 days of storage. The findings agreed with the findings reported by Munhuewyi (2012); Park *et al*., (2018) and Kabir *et al*., (2020) who recorded similar reduction trends of tomato firmness at cold and ambient temperature. Al-Dairi *et al*.,2021 also recorded a 67.80% reduction in tomato firmness at ambient temperature for 12 days.

Cultivars significantly influenced the disease incidence percentage of tomato at 4,6 and 8 days of storage. Sinha *et al*., (2019) also observed this kind of variation as disease incidence and disease severity was higher in Roma VF than Sofol at the 6th and 16th day of storage. Black spot and gray mold were found as two devastating diseases during storage and the severity varied among all studied tomato cultivars. Raynaldo *et al*., (2024) in their review also found *Alternaria alternata* and *Botrytis cinerea* as two devastating pathogen causing black spot and gray mold in tomatoes at storage, respectively. The variation in moisture content was confirmed by Sinha *et al*., (2019) who found that the variety Sofol had higher moisture content (89.43%) at the 12th day of storage than Roma VF (87.3%).

Shelf life is an important issue for tomato, and it varies from cultivar to cultivar. This variation might be due to complex interaction of genetic makeup, especially mutations in ripening-related and ethylene pathway genes (Pavan and Gangaprasad, 2022; Mubarok *et al*., 2024), differences in cell wall composition and metabolites that affect firmness and resistance to decay (Roohanitaziani *et al*., 2022; Osorio *et al*., 2019). Pavan *et al*., 2023 and Guo *et al*., 2023 claimed that higher fruit firmness, thicker pericarp, and altered cell wall metabolism are associated with longer shelf life. Whereas, Conesa *et al*., 2020 and Thole *et al*., 2021 reported that smaller and firmer fruits generally have longer shelf life. Thus, fruit size, shape, and pericarp thickness are important contributors. In parallel to our findings Sinha *et al*., (2019) also found that the longer shelf life was observed in Sofol (17.22 days) than in Roma VF (15.04 days).

Conclusion

In regards of postharvest behaviour, Tomato selection presented overall bright appearance. Maximum TSS and pH were exhibited by Raja Super and Udayan, respectively. Whereas maximum weight loss and firmness were exhibited by Binatomato-13 and Raja Super, respectively at 10 days of storage. Maximum dry matter content exhibited by Deshi pathorkuchi and conversely maximum moisture content identified in Binatomato-7. Jholmol had shown the highest disease incidence and disease severity at 10 days of storage. While, cultivars Le_6(Ratan), Le_7(Raja super), Le_9(Rubi), Le_{12}(Udayan), Le_{13}(Unnayan) and Le_{17}(Chakra) showed no disease incidence and severity during the storage period. And finally, the longest shelf life was observed from Chakra, followed by Udayan, Deshi Pathorkuchi and Raja Super. In conclusion, and Raja super and Deshi pathorkuchi were identified as better cultivars for postharvest quality and storage potential in summer season of Bangladesh. Future research should focus on integrating pre- and postharvest treatments (e.g., packaging materials, temperature management, and biochemical profiling) to further enhance storage potential and marketability of these cultivars. Additionally, emphasis on breeding programs for improved shelf life and fruit quality under heat stress conditions is required.

Acknowledgement

We are thankful to the Standard Chartered Bank (SCB), Bangladesh for funding this work (Project No.2024/13/Other).

Disclosure statement

The authors did this research and wrote the article and there is no conflict of interest with other people.

References

1. Abiso E, Satheesh N and Hailu A, 2015. Effect of storage methods and ripening stages on postharvest quality of tomato (*Lycopersicon esculentum* Mill.) cv. Chali. *Annals of Food Science and Technology*, 6: 127–137.
2. Akbudak B, 2010. Effects of harvest time on the quality attributes of processed and non-processed tomato varieties. *International Journal of Food Science and Technology*, 45: 334–343.
3. Al-Dairi M, Pathare PB and Al-Yahyai R, 2021. Effect of postharvest transport and storage on color and firmness quality of tomato. *Horticulturae*, 7(7): 163.
4. Astuti DS, Salengke S, Laga A, Mariyati, Bilangd M, Mochtar H and Warisf A, 2018. Characteristics of pH, total acid, and total soluble solid on tomato juice by ohmic heating technology. *International Journal of Scientific and Basic Applied Research*, 39(2): 21–28.
5. BBS, 2024. *Yearbook of Agricultural Statistics 2023*. Bangladesh Bureau of Statistics, Statistics and Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh.

6. Cadavid AS, 2014**.** Multicomponent quality control analysis for the tomato industry using portable mid infrared (MIR) spectroscopy. *M.Sc. Thesis*, The Ohio State University, Ohio, USA.
7. Casals J, Rivera A, Sabaté J, Romero del Castillo R and Simó J, 2018. Cherry and fresh market tomatoes: differences in chemical, morphological, and sensory traits and their implications for consumer acceptance. *Agronomy*, 9(1): 9.
8. Cherono K, Sibomana M and Workneh TS, 2018. Effect of in-field handling conditions and time to pre-cooling on the shelf life and quality of tomatoes. *Brazilian Journal of Food Technology*, 21: 1–12.
9. Conesa M, Fullana-Pericàs M, Granell A and Galmés J, 2020. Mediterranean long shelf-life landraces: an untapped genetic resource for tomato improvement. *Frontiers in Plant Science*, 10: 1–13.
10. El-Dengawy RAH, El-Said SMM, El-Kadi SML and Shalata AAM, 2016. Effect of industrial process and storage periods on the nutritional value of tomato juice. *Indian Journal of Nutrition*, 3(1): 1–4.
11. Endalew E, 2020. Postharvest loss assessment of tomato (*Lycopersicon esculentum* Mill) (Galilea cultivar) along the postharvest supply chain, Northwest Ethiopia. ***Master's Thesis***, Bahir Dar University, Bahir Dar, Ethiopia.
12. Fagundes C, Moraes K, Pérez-Gago M, Palou L, Maraschin M and Monteiro A, 2015. Effect of active modified atmosphere and cold storage on the postharvest quality of cherry tomatoes. *Postharvest Biology and Technology*, 109: 73–81.
13. Figàs MR, Prohens J, Raigón MD, Fita A, García-Martínez MD, Casanova C and Soler S, 2015. Characterization of composition traits related to organoleptic and functional quality for differentiation and enhancement of local varieties of tomato. *Food Chemistry*, 187: 517–524.
14. Flores P, Sánchez E, Fenoll J and Hellín P, 2017. Genotypic variability of carotenoids in traditional tomato cultivars. *Food Research International*, 100: 510–516.
15. Garcia E and Barrett DM, 2006. Evaluation of processing tomatoes from two consecutive growing seasons: quality attributes, peelability and yield. *Journal of Food Processing and Preservation*, 30: 20–36.
16. García-Valverde V, Navarro-González I, García-Alonso J and Periago MJ, 2013. Antioxidant bioactive compounds in selected industrial processing and fresh consumption tomato cultivars. *Food and Bioprocess Technology*, 6: 391–402.
17. Gomez KA and Gomez AA, 1984. *Statistical Procedures for Agricultural Research* (2nd Edn.). John Wiley and Sons, New York, pp. 28–92.
18. Guo S, Ji Y, Zheng Y, Watkins C, Wang Q, Liang H, Bai C, Fu A, Li L, Meng D, Liu M and Zuo J, 2023. Transcriptomic, metabolomic, and ATAC-seq analysis reveal the regulatory mechanism of senescence of postharvest tomato fruit. *Frontiers in Plant Science*, 14: 1–15.
19. Hanna GC, 1961. Changes in pH and soluble solids of tomatoes during vine storage of ripe fruit. *Journal of the American Society for Horticultural Science*, 78: 459–463.
20. Hassan K, 2010. Postharvest handling of fruits and vegetables. Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh, pp. 2–3.
21. Hatami M, Kalantari S and Delshad M, 2013. Responses of different maturity stages of tomato fruit to different storage conditions. *Acta Horticulturae*, 14: 857–864.
22. Kabir SN, Rasool K, Lee WH, Cho SI and Chung SO, 2020. Influence of delayed cooling on the quality of tomatoes (*Solanum lycopersicum* L.) stored in a controlled chamber. *AIMS Agriculture and Food*, 5: 272–284.
23. Khairi A, Falah M, Suyantohadi A, Takahashi N and Nishina H, 2015. Effect of storage temperatures on color of tomato fruit (*Solanum lycopersicum* Mill.) cultivated under moderate water stress treatment. *Agriculture and Agricultural Science Procedia*, 3: 178–183.
24. Mubarok S, Nuraini A, Hamdani J, Suminar E, Wiguna G and Ezura H, 2024. The near-isogenic line containing the *Sletr1-2* locus exhibited longer postharvest fruit shelf life under the genetic background of commercial tomato. *Euphytica*, 220: 1–12.

25. Munhuewyi K, 2012. Postharvest losses and changes in quality of vegetables from retail to consumer: a case study of tomato, cabbage and carrot. *Master's Thesis*, Stellenbosch University, Stellenbosch, South Africa.
26. Nwakuba NR, Chukwuezie OC, Asonye GU and Asoegwu SN, 2020. Influence of process parameters on the energy requirements and dried sliced tomato quality. *Engineering Reports*, 2(2): e12123.
27. Osorio S, Carneiro R, Lytovchenko A, McQuinn R, Sørensen I, Vallarino J, Giovannoni J, Fernie A and Rose J, 2019. Genetic and metabolic effects of ripening mutations and vine detachment on tomato fruit quality. *Plant Biotechnology Journal*, 18: 106–118.
28. Park MH, Sangwanangkul P and Baek DR, 2018. Changes in carotenoid and chlorophyll content of black tomatoes (*Lycopersicon esculentum* L.) during storage at various temperatures. *Saudi Journal of Biological Sciences*, 25: 57–65.
29. Patwary MMA, Rahman MM, Ahmad S, Miah MAK and Barua H, 2013. Study of heterosis in heat-tolerant tomato (*Solanum lycopersicum* L.) during summer. *Bangladesh Journal of Agricultural Research*, 38: 531–544.
30. Pavan M and Gangaprasad S, 2022. Studies on mode of gene action for fruit quality characteristics governing shelf life in tomato (*Solanum lycopersicum* L.). *Scientia Horticulturae*, 295: 110856.
31. Pavan M, Gangaprasad S and Adivappar N, 2023. Genetic variability and trait interrelationships governing fruit quality and yield traits for shelf life in tomato (*Solanum lycopersicum* L.). *Plant Genetic Resources: Characterization and Utilization*, 21(3): 321–333.
32. Raynaldo FA, Xu Y, Wang Q, Wu B and Li D, 2024. Biological control and alternatives to chemical fungicides in controlling postharvest disease of fruits caused by *Alternaria alternata* and *Botrytis cinerea*. *Food Innovation and Advances*, 3(2): 135–143.
33. Roohanitaziani R, Lammers M, Molthoff J, Tikunov Y, Meijer-Dekens F, Visser RG and Bovy AG, 2022. Phenotyping of a diverse tomato collection for postharvest shelf life. *Postharvest Biology and Technology*, 188: 111908.
34. Sinha SR, Singha A, Faruquee M, Jiku MAS, Rahaman MA, Alam MA and Kader MA, 2019. Postharvest assessment of fruit quality and shelf life of two elite tomato varieties cultivated in Bangladesh. *Bulletin of the National Research Centre*, 43(1): 185.
35. Thole V, Vain P and Martin C, 2021. Effect of elevated temperature on tomato postharvest properties. *Plants*, 10(5): 981.
36. Tigist M, Workneh TS and Woldetsadik K, 2013. Effects of variety on the quality of tomato stored under ambient conditions. *Journal of Food Science and Technology*, 50: 477–486.
37. Vishwanath K, Rajendra PS, Pallavi HM and Prasanna KPR, 2014. Characterization of tomato cultivars based on morphological traits. *Annals of Plant Science*, 3: 854–862.
38. Wei X, Xie D, Mao L, Xu C, Luo Z, Xia M, Zhao X, Han X and Lu W, 2019. Excess water loss induced by simulated transport vibration in postharvest kiwifruit. *Scientia Horticulturae*, 250: 113–120.
39. Zhou R, Su S, Yan L and Li Y, 2007. Effect of transport vibration levels on mechanical damage and physiological responses of Huanghua pears (*Pyrus pyrifolia* Nakai, cv. Huanghua). *Postharvest Biology and Technology*, 46: 20–28.
40. Žnidarčič D and Požrl T, 2006. Comparative study of quality changes in tomato cv. 'Malike' (*Lycopersicon esculentum* Mill.) whilst stored at different temperatures. *Acta Agriculturae Slovenica*, 87: 235–243.