



Postharvest quality of tomato fruit (*Solanum lycopersicum* 'Harir') improves with hot water treatment

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Abstract

This study aimed to assess the effects of hot water treatment on the postharvest physicochemical and biochemical characteristics of 'Harir' tomatoes, focusing on shelf life, nutritional quality (including lycopene and TSS), and overall fruit integrity during ambient storage. Treatments were: control (no washing) and hot water immersion at 25°C, 45°C, and 50°C and checking shelf life during 14 days. A completely randomized design was used for this experiment with four replications. Based on the results, maximum weight occurred in samples treated with 25°C; the control retained more firmness, pH significantly increased in fruits treated at 50°C. A significant increase in TSS was observed in the 45°C treatment. The highest weight loss (11.06%) occurred in the control group by day 14, whereas the lowest weight loss (12.41%) was recorded in the 50°C treatment. Lycopene content was also significantly influenced by heat treatment. The highest lycopene concentration was recorded in the 45°C treatment on day 7. Overall, mild hot water treatment at 25°C was effective in maintaining fruit weight and postharvest quality, while higher temperatures improved lycopene content but led to increased pH and softening. These findings suggest that controlled hot water treatment can be an effective postharvest strategy for extending shelf life and improving nutritional quality of 'Harir' tomatoes.

Keywords: Cultivar, Heat stress, HSP, Postharvest, Shelf life, Tomato.

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1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated and consumed vegetable crops worldwide, valued for its nutritional and economic importance. However, tomato fruits are highly perishable and prone to rapid quality deterioration and decay after harvest, which leads to significant postharvest losses (Tilahun et al., 2025). The selection of appropriate tomato cultivars plays a critical role in enhancing postharvest quality and reducing deterioration throughout the supply chain. Different tomato genotypes exhibit diverse physiological and biochemical characteristics that directly influence their susceptibility to spoilage, mechanical damage tolerance, storability, and shelf life. Cultivars with thicker skins, firmer textures, lower respiration rates, and greater resistance to postharvest diseases typically maintain higher quality during storage and exhibit reduced rates of deterioration. Therefore, identifying and cultivating tomato varieties with favourable postharvest traits, whether for fresh market consumption or processing, represents an effective strategy for minimizing postharvest losses, improving profitability, and increasing overall production efficiency (Singh et al., 2020).

Various postharvest treatments have been developed to prolong shelf life and maintain fruit quality, including refrigeration, controlled atmospheres, and chemical treatments (Furukava, 2019). Among these, hot water treatment (HWT) has emerged as an effective, low-cost, and eco-friendly method to reduce decay and delay senescence in many fruits and vegetables. HWT is known to induce the production of heat shock proteins (HSPs), which play a crucial role in enhancing plant stress tolerance by protecting cellular proteins and membranes from damage (Polenta et al., 2020). Despite several studies on the effect of HWT on tomatoes, limited information is available regarding its efficacy on the 'Harir' cultivar under local environmental conditions. Therefore, this study aims to evaluate the effects of hot water treatment on the postharvest quality and shelf life of 'Harir' tomatoes, focusing on morphological and chemical quality of shelf life parameters.

2. Material and methods

2.1. Experimental setup

Tomato fruits *Solanum lycopersicum* 'Harir' were obtained from the research greenhouse of Negin Bazr Company, Isfahan, Iran. The treatments included a control (no washing) and hot water immersions at 25°C, 45°C, and 50°C for 5 minutes. Following the treatments, the samples were stored at ambient room temperature (approximately 20–25°C) for a period of 14 days. Sampling was conducted on days 0, 7, and 14 during the storage period.

2.2. Weight assessment

Tomato fresh weight was measured with a digital scale (± 1 g) and physiological weight loss (PWL) was determined by measuring fruit weight loss over time using the standard percentage formula (Ghasemnezhad et al., 2010):

$$\text{Physiological weight loss (\%)} = \frac{W_t - W_0}{W_0} \times 100$$

W_0 and W_t are initial fruit weight (day 0) and fruit weight at time (day 7 or day 14), receptively.

2.3. Texture analysis

Bud diameter was measured using a caliper, Model 16ER, China (Bohlouli et al., 2019).

2.4. pH measurement

Tomato samples were homogenized and filtered to obtain clear juice. The pH was measured at 25°C using a calibrated digital pH meter (Bohlouli et al., 2019).

2.5. Quantification of TSS

Clear tomato juice was obtained by crushing and filtering the pulp. TSS was measured at 25°C using a calibrated digital refractometer (Model: DR101-60) and expressed as °Brix.

2.6. Analysis of lycopene content

Lycopene content was determined by hexane extraction and measuring absorbance at 503 nm using a spectrophotometer (Bayili et al., 2009).

2.7. Data analysis

The experiment was laid out in a completely randomized design (CRD) with three levels and four replicates. Data were analysed by ANOVA. Mean comparisons were performed using the LSD test.

3. Results and Discussion

3.1. Fruit weight

The results of fresh weight in the studied cultivar were significant ($p < 0.01$). The highest fruit weights at all storage intervals (0, 7, and 14 days) were observed in the 25°C treatment, measuring 135.8 g, 128.5 g, and 131.8 g, respectively (Figure 1).



Figure 1. Effect of hot water treatments on tomato fresh weight. (LSD, $p < 0.01$). Data shown as mean $\pm$ SE.

The relatively high fruit weight in this treatment indicates reduced moisture loss and slower metabolic degradation compared to higher temperature treatments. Moreover, the greater firmness observed in control samples suggests that the absence of heat stress helps maintain cellular integrity and structural stability (Chen et al., 2025).

3.2. Physiological weight loss

The PWL of 'Harir' tomato fruits was significantly influenced by storage duration and hot water treatment ($p < 0.05$). Across all treatments, PWL increased over the 14-day storage period. The highest weight loss occurred in the control group, reaching 11.06% by day 14, while the lowest was observed in fruits treated with 50°C hot water, at 12.41%.

From day 7 onwards, significant differences emerged among treatments, with fruits exposed to higher temperatures (45°C and 50°C) showing consistently lower PWL than the control and 25°C treatments. Statistical analysis (LSD) confirmed the superiority of the 50°C treatment on day 14 (Figure 2).

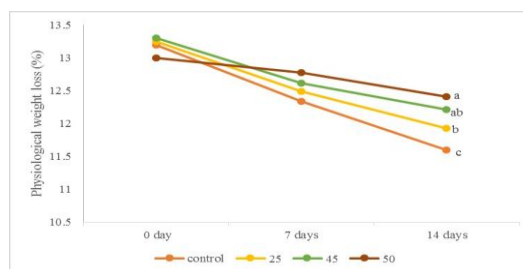


Figure 2. Effect of hot water treatments on tomato physiological weight loss. (LSD, $p < 0.05$). Data shown as mean $\pm$ SE.

These findings suggest that hot water treatment, particularly at 50°C, effectively reduces water loss during storage. This effect may be attributed to reduced transpiration, improved cuticle integrity, or partial stomatal closure, resulting in better moisture retention. These observations align with previous research (Ghasemnezhad et al., 2010), supporting the notion that moderate heat treatments can delay postharvest senescence and minimize water loss in perishable produce.

3.3. Fruit firmness

Fruit firmness was a significant difference among the treatments ($p < 0.01$). It was consistently higher in the control samples compared to other treatments, with values of 18.5 N, 14.3 N, and 9.7 N recorded at days 0, 7, and 14, respectively (Figure 3).



Figure 3. Effect of hot water treatments on tomato fruit firmness. (LSD, $p < 0.01$). Data shown as mean $\pm$ SE.

Fruit firmness was consistently higher in control fruits compared to heat-treated samples, with values declining from 18.5 N at day 0 to 9.7 N at day 14. The decline in firmness over time is a common postharvest phenomenon caused by enzymatic softening and cell wall degradation. However, the

more pronounced firmness in control samples suggests that the absence of heat stress allowed for better preservation of cell structure. In contrast, high-temperature treatments may accelerate pectin breakdown or disrupt cellular membranes, contributing to tissue softening (Polenta et al., 2020). These results highlight a potential trade-off between water loss control and texture retention in heat-treated tomatoes.

3.4. pH levels

According to Figure 4, no significant differences were found in the initial pH values among treatments at day 0, confirming uniformity before storage. However, by days 7 and 14, tomatoes treated at 45°C and 50°C exhibited a significant rise in pH, reaching 4.4 and 4.61, respectively. In contrast, control and 25°C samples showed minimal change.

These results highlight the influence of elevated temperature treatments on the chemical properties of tomato fruit during postharvest storage.

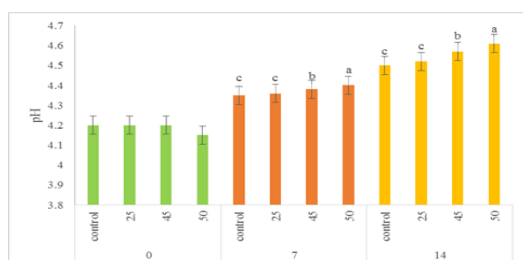


Figure 4. Effect of hot water treatments on tomato pH. (LSD, $p < 0.01$). Data shown as mean $\pm$ SE.

This increase in pH in high-temperature treatments may result from accelerated metabolic activity or enhanced microbial proliferation, both of which can contribute to the breakdown of organic acids (Hatfield and Prueger, 2015). These changes indicate a potential shift toward senescence and quality loss under thermal stress. The pH pattern is consistent with TSS changes, suggesting possible links between sugar metabolism and acid degradation (Hatfield and Prueger, 2015).

3.5. Total soluble solids

Total Soluble Solids (TSS) levels did not differ significantly between the control and 25°C treatments during the first 7 days of storage. Likewise, no major differences were observed among the higher temperature treatments (45°C and 50°C) during this period. However, by day 14, the 45°C treatment showed a significant increase in TSS (6.74 °Brix), surpassing other treatments.



Figure 5. Effect of hot water treatments on tomato TSS. (LSD, $p < 0.01$). Data shown as mean $\pm$ SE.

The stability of TSS between the control treatment and the 25°C treatment during the first 7 days of storage indicates that moderate temperatures at the initial storage period do not significantly affect the soluble solids content. Additionally, the lack of significant differences between the higher temperature treatments (45°C and 50°C) within the same timeframe suggests that short-term exposure to elevated temperatures may not immediately alter TSS levels. However, the significant increase in TSS observed in the 45°C treatment on day 14 reflects physiological changes induced by temperature over prolonged storage. This increase could be attributed to enhanced metabolic activity, including the breakdown of complex carbohydrates into soluble sugars, concentration effects due to moisture loss, or accelerated ripening processes triggered by heat stress (Furukava, 2019). The observation that the 45°C treatment exhibited even higher TSS than the 50°C treatment may indicate an optimal heat stress response that promotes sugar accumulation without causing severe tissue damage. These findings highlight the complexity of the interaction between temperature and fruit physiology and emphasize the necessity of balancing thermal treatments to improve product quality and shelf life.

3.6. Lycopene

The lycopene content on day 0 showed no statistically significant differences between treatments. However, significant differences were observed on days 7 and 14 ($p < 0.01$).

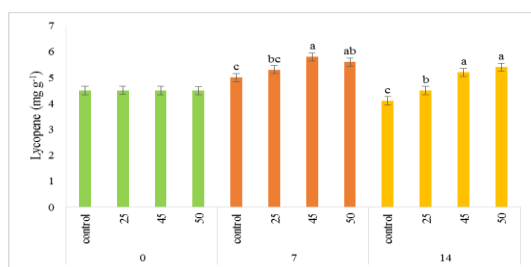


Figure 6.

Effect of hot water treatments on tomato lycopene. (LSD, $p < 0.01$). Data shown as mean $\pm$ SE.

The results indicated that lycopene content was significantly affected by the heat treatment. On day 0, no significant differences were observed among treatments; however, on days 7 and 14 of storage, tomatoes treated with hot water, particularly at 50°C showed significantly higher lycopene content (4.2 and 5.4 mg g⁻¹, respectively), compared to the control. The highest lycopene concentration on day 14 was recorded in the 50°C treatment, which was significantly different from the other treatments.

At day 0, no statistically significant differences in lycopene content were observed among the treatments, indicating that initial thermal conditions did not immediately affect lycopene levels. However, by days 7 and 14, significant differences emerged, suggesting that storage temperature and duration play an important role in the modulation of lycopene accumulation over time.

The increase in lycopene content in certain temperature treatments during storage could be attributed to continued metabolic activity, including the biosynthesis of carotenoids as part of the ripening process. Elevated temperatures may accelerate enzymatic reactions involved in lycopene synthesis, such as the activity of phytoene synthase and lycopene β -cyclase, up to an optimal threshold (Soleimani Aghdam et al., 2013; Polenta et al., 2020). Conversely, excessively high temperatures or prolonged exposure may lead to oxidative degradation of lycopene or impair its synthesis due to cellular damage (Hamalainen et al., 2023).

Interestingly, the differential lycopene accumulation across treatments on days 7 and 14 reflects the complex interaction between heat stress, fruit physiology, and carotenoid metabolism. These findings highlight the importance of optimizing postharvest temperature conditions not only for quality retention but also for enhancing nutritionally valuable compounds such as lycopene.

4. Conclusion

The results of this study demonstrate that hot water treatment significantly influences the postharvest quality of 'Harir' tomato fruits during storage. Among the treatments, immersion at 50°C for a short duration was most effective in reducing physiological weight loss, enhancing lycopene content, and maintaining TSS levels, thereby improving both the nutritional and sensory attributes of the fruit. Although Mild hot water treatment at 25°C can induce the synthesis of heat shock proteins (HSPs), which play a critical role in enhancing postharvest stress tolerance. HSPs protect cellular proteins and membranes from damage caused by stress, thus reducing cellular degradation and improving shelf life and fruit quality. Therefore, the beneficial effects of mild heat treatment are not only physical but also biological, through activation of the fruit's innate defence mechanisms. HSPs play a crucial role in preserving membrane integrity and protein function, thereby slowing down senescence and extending shelf life. Overall, hot water treatment at 25°C emerged as the most effective strategy for enhancing quality attributes such as lycopene and TSS, while 25°C served as a milder treatment that supports structural preservation through biological defense mechanisms. These findings suggest that postharvest thermal treatments, when carefully optimized, can serve as a sustainable and chemical-free method to prolong tomato shelf life and enhance market quality.

References

- Bayili, R., Abdoul-Latif, F., Kone, O., Diao, M., Bassole, I., and Dicko, M. (2011). Phenolic compounds and antioxidant activities in some fruits and vegetables from Burkina Faso.

- African Journal of Biotechnology, 10, 13543-13547.
- Bohloul, M., Dehestani-Ardakani, M., Shirmardi, M., and Razmjoo, J. (2019). Effect of organic and biological fertilizers on some growth characteristics of evening primrose (*Oenothera biennis* L.) under salinity conditions. *Advanced Environmental Sciences*, 12, 263-280.
- Chen, Y., Xu, W., Han, C h., Zhang, M., Chen, Y., Ma, Y., Zhang, X., Liu, H., and Zhang, W. (2025). Synergistic effects of ectoine and biostimulants combinations on tomato seedling growth and heat stress resilience. *Plant Stress*, 16, 100873.
- Furukawa, H. (2019). Chapter 1.2 - Cultivation technology for Vegetable and herb production. *Plant Factory Using Artificial Light*, 15-23.
- Ghasemnezhad, M., Shiri, M A., and Sanavi, M. (2010). Effect of chitosan coatings on some quality indices of apricot (*Prunus armeniaca* L.) during cold postharvest storage. *Food Chemistry*, 99, 724-729.
- Hamalainen, A., Jokinen, K., Kotilainen, T., and Palonen, P. (2023). Tomato quality is influenced by postharvest light and temperature. *Acta Horticulturae*, 1364, 27-34.
- Hatfield, J L., and Prueger, J H. (2015). Temperature extremes: Effect on plant growth and development, *Weather and Climate Extremes*. 10, 4-10.
- Polenta, G, Guidi, S M., Ambrosi, V., and Denoya, G I. (2020). Comparison of different analytical methods to evaluate the heat shock protein (HSP) response in fruits. Application to tomatoes subjected to stress treatments. *Current Research in Food Science*, 3, 229-238.
- Singh, V K., Bhattacharjee A K., Soni, M., and Dikshit, A. (2020). Performance of tomato (*Solanum lycopersicum* Mill) cultivars for quality production under protected cultivation in subtropics. *International Journal of Current Microbiology and Applied Sciences*, 9, 1127-1135.
- Soleimani Aghdam, M., Sevillano, L., Flores, B F. and Bodbodak, S. (2013). Heat shock proteins as biochemical markers for postharvest chilling stress in fruits and vegetables. *Scientia Horticulturae*, 160, 54-64.
- Tilahun, S T., Baek, M W., Tae, S H., Eun Yeo, Ch., Chang, S M., Lee, J H., Park, D., and Jeong, S. (2025). Differential responses of cherry tomato cultivars to preharvest methyl jasmonate across harvest cycles: Impacts on antioxidants, amino acids, and GABA. *Scientia Horticulturae*, 351, 114397.