World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Comparison of technological methods for astringency removal in introduced persimmon (*Diospyros kaki* L.) varieties

Tamar Turmanidze [1, 2, *] and Merab Jgenti [1, 2, 3]

[1] *LEPL Scientific –Research Center of Agriculture, Department of Agricultural Products Storage and Processing, Marshal Gelovani st. 34, 0159, Tbilisi, Georgia.*

[2] *Agricultural University of Georgia, Field of Food Technology, Kakha Bendukidze University Campus, 0159, # 240 David Aghmashenebeli Alley, Tbilisi, Georgia.*

[3] *Georgian Technical University, Biotechnology Center, Abai st. 78, 0197, Tbilisi, Georgia.*

World Journal of Advanced Research and Reviews, 2026, 30(02), 2332-2337

Publication history: Received on 19 April 2026; revised on 25 May 2026; accepted on 27 May 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.2.1463

Abstract

The aim of the research was to select effective and technologically rational methods for removing astringency from the fruits of industrial persimmon varieties common in Georgia immediately after harvest. The study involved the testing of three different methods: warm water treatment (40°C for 4–4.5 hours), freezing (−20°C for 3 and 6 hours), and carbon dioxide treatment (CO_2, 95% at 20°C for 16 and 24 hours). Samples treated by each method were stored at a temperature of 0–1°C with a relative humidity of 90–95%. According to the results, warm water treatment reduces astringency and improves organoleptic indicators; however, it causes fruit softening and deterioration of visual characteristics, with the effect appearing only after 7–10 days. The freezing method ensures rapid astringency removal (20–24 hours) but leads to tissue darkening and reduces shelf life. The best results were achieved with a 24-hour CO_2 treatment, where astringency completely disappears after 3 days, the fruit retains its original color, shape, and firmness, and the shelf life reaches 60–70 days. The conducted research reveals that CO_2 treatment is the most effective method, ensuring the preservation of both taste and visual qualities.

Keywords: Persimmon; Astringency removal; Freezing; CO_2; Storage

1. Introduction

The persimmon (*Diospyros kaki* L.) is a perennial fruit of subtropical and warm-temperate climates. It is primarily cultivated in the warm regions of China, Japan, Brazil, Italy, and the Mediterranean [1]. While persimmons are widely consumed in Asia, their popularity has spread to the West over the past several years. Since then, persimmon production and consumption have steadily expanded, driven by its versatile benefits. According to FAO, global persimmon harvests increased by nearly 2% between 2018–2021, while Geostat data shows a significant increase of almost 37% in Georgia during the same period [2]. Notably, Azerbaijan has the highest average annual growth in world persimmon exports (16.2%), ranking second globally by this indicator [3].

Persimmons are characterized by relatively high antioxidant activity, resulting from a high content of phenols and phytochemical compounds [4,5,6]. Laboratory studies have demonstrated the potential benefits of persimmons in treating conditions such as obesity [7,8], diabetes [9], cardiovascular diseases [10], and cancer [11,12]. These benefits are directly linked to the high concentration of bioactive compounds [13].

* Corresponding author: Tamar Turmanidze

It is noteworthy that in Georgia, persimmons are harvested in October and November. Both astringent and non-astringent varieties are widespread throughout the country. Astringent varieties are characterized by a higher content of bioactive compounds and antioxidant activity compared to non-astringent ones. However, the latter are distinguished by superior organoleptic properties, such as a pleasant aroma and taste. Astringent fruits are primarily used for producing dried fruit (chiri), fruit purees, and candied fruits (tsukati), and are generally not consumed fresh in their firm state because the astringency significantly impairs their organoleptic qualities. This restricts their fresh consumption to the stage of full maturity when the fruit has softened. Post-harvest ripening during storage triggers the natural polymerization of tannins. During this process, soluble tannins (which cause the astringent taste) are converted into an insoluble form. While this ensures the removal of astringency, the fruit softens and loses its original color and shape, presenting a significant challenge for storage, transportation, warehousing, and shelf-display.

Based on modern literature, there are several proven methods for removing astringency from persimmons.

High CO_2 concentrations consistently promote the production of more acetaldehyde, facilitating rapid astringency removal [14]. It has been established that acetaldehyde plays a decisive role in astringency removal both naturally and through CO_2 treatment [15].

Temperature plays a significant role in anaerobic metabolism. At higher temperatures, a greater accumulation of acetaldehyde and ethanol occurs, which serves as an effective means of removing astringency [16]. Research has established the positive effects of various treatments in this regard, including hot water [17], ethanol [18,19], freezing [20], irradiation [21], and others.

It should also be considered that newly harvested astringent persimmon fruits must be stored in cold storage at optimal temperatures, which entails additional costs in terms of space, time, and electricity.

Consequently, the objective of our research is to remove the astringency of newly harvested persimmon fruits using a simple method and to determine the optimal parameters for varieties common in Georgia. The goal is for the fruit to retain its firmness and attractive external appearance. Furthermore, it is essential to ensure that the fruit can be introduced into the marketing chain shortly after harvest and that the research results are economically justified and effective.

2. Object and Methods

The study was conducted on three introduced persimmon varieties Hachiya, Kaki Tipo, and Rojo Brillante—grown in the fruit orchards at the Jighaura base (Mtskheta district, Georgia (41°55′25″ N, 44°46′35″ E)) of the Scientific-Research Center of Agriculture.

The research experiment was conducted according to the following sequence:

Persimmons were harvested at the under-ripe stage, when the fruit exhibited a greenish-yellow coloration.

To remove astringency, the samples were initially treated using safe (non-toxic) methods standard in fruit storage technology. These proven methods were compared across all three persimmon varieties to identify the most efficient option. Specifically

Newly harvested, astringent persimmon fruits were treated in a warm water bath at 40°C for 4–4.5 hours. Following the treatment, the samples were cooled and subsequently stored in a refrigerator at a temperature of 0–1°C, with a relative humidity (φ) of 90–95% (Figure 1).

Figure 1 Treatment of persimmon fruits with warm water

A freezing treatment technology was employed, in which the persimmon fruits were placed in a freezer at a temperature of −20°C for durations of 3 and 6 hours. After treatment, the samples were stored in a refrigerator at 0–1°C, φ - 90–95% (Figure 2).

Figure 2 Treatment of persimmon fruits by freezing

To remove astringency, the persimmon samples were placed in a hermetic desiccator and treated with a high concentration of CO_2 (95%). The treatment was conducted at a temperature of 20°C for durations of 16 and 24 hours. Following treatment, the samples were stored in a refrigerator at 0–1°C, φ - 90–95% (Figure 3).

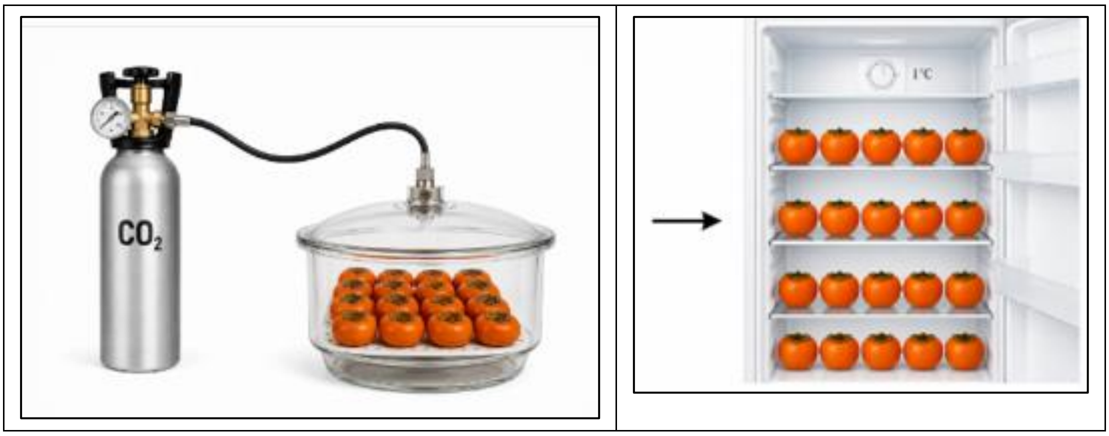

Figure 3 Treatment of persimmon fruits with CO_2

2.1. The following equipment was used for the experiment

- Water bath (LAZNIA Wodna TYP LW-4800W WSL BYTOM BCM);

- Gas analyzer (F-940 Three Gas Analyzer, Felix Instruments, USA, for determining carbon dioxide levels);
- Freezer (FS 225320, Beko Vertical Freezer);
- Cold storage refrigerator (Midea semi-dry, 0–13°C).
- AI was used to generate the images.

3. Results

3.1. Method: Warm Water Treatment

The conducted experiment showed that in the case of all three persimmon varieties, warm water treatment effectively reduces astringency and improves organoleptic indicators. The fruit stores well at low temperatures in the refrigerator and maintains a pleasant taste until the end of the storage period. Despite these positive aspects, the application of this method is characterized by partial darkening of the color and loss of surface gloss; consequently, the fruit is visually less attractive and becomes relatively softened. Furthermore, the result (astringency removal) is achieved only 7–10 days after treatment.

3.2. Method: Freezing Treatment

The freezing treatment yielded interesting results. After removal from the freezer, the persimmon fruits were stored in a refrigerator at a low temperature (0–1°C), where the thawing process took place. The removal of astringency was observed 20–24 hours after treatment in the case of all three persimmon varieties. At room temperature, the samples exhibited improved organoleptic properties, specifically a pleasant taste and aroma. Additionally, astringency was significantly reduced in the fruits; however, the degree of reduction was most pronounced in samples held in the freezer for 6 hours compared to those held for 3 hours. The surface of the persimmon remained glossy and visually appealing. However, in both exposure groups, darkening of the fruit tissue was observed, which may be related to the disruption of redox (oxidation-reduction) processes [22]. At the same time, the test samples maintained their firmness for only 20–30 days.

3.3. Method: CO_2 Treatment

Based on the conducted experiments, a significant positive effect of CO_2 treatment on the removal of astringency in persimmon fruits was observed.

According to the results, astringency was no longer detectable in samples treated with CO_2 for 24 hours after just 3 days of cold storage. In contrast, the 16-hour exposure variant still partially exhibited astringent traits. This indicates the high efficiency of the 24-hour treatment duration. It appears that this timeframe is sufficient to maximally reduce the undesirable taste characteristics caused by soluble tannin compounds. The treated fruits retained their original morphological characteristics, such as shape and color, and were characterized by pleasant organoleptic properties, including a distinct aroma. Notably, under storage conditions (60–70 days), the samples maintained sufficient firmness and the visual characteristics typical of the variety, which serves as an indicator of stable storability.

4. Conclusion

Based on the obtained results, it can be concluded that while the studied treatment methods generally ensure the reduction of astringency and the improvement of organoleptic properties, warm water treatment is less effective in terms of maintaining fruit firmness. The freezing method achieves the goal of astringency removal, but the visual appeal of the fruit is compromised due to tissue darkening. The most effective and technologically rational method is CO_2 treatment with a 24-hour exposure. This approach maximally ensures the removal of astringency and the improvement of organoleptic indicators while simultaneously preserving the initial quality parameters. This method allows persimmon fruits to be harvested early before softening and quickly integrated into the marketing chain, thereby significantly increasing its potential for commercial application.

Compliance with ethical standards

Acknowledgments

The authors gratefully acknowledge the support of the LEPL Scientific-Research Center of Agriculture (SRCA), the Agricultural University of Georgia and the Biotechnology Center for their contribution to this project.

Disclosure of conflict of interest

The authors have declared no conflicts of interest related to this study.

Statement of informed consent

Informed consent was obtained from all participants included in the study.

Funding

The article was carried out within the framework of the project "Study of the storability of astringent persimmon (Diospyros kaki L.) varieties and development of a method for improving organoleptic characteristics (04.01.1.2)" funded by the LEPL Scientific-Research Center of Agriculture.

References

[1] Yonemori, K., Sugiura, A., and Yamada. (2000). Persimmon genetics and breeding. Plant Breeding Reviews, 19, 191–225.

[2] Geostat. (2024). https://www.geostat.ge

[3] FAO. (2024). FAOSTAT statistical database. https://www.fao.org/faostat

[4] Dhawefi, N., Jedidi, S., et al. (2021). Antidiarrheal, antimicrobial, and antioxidant properties of the aqueous extract of Tunisian persimmon (Diospyros kaki Thunb.) fruits. Journal of Medicinal Food, 24(10). https://doi.org/10.1089/jmf.2020.0202

[5] Anđelković, B., Dojčinović, B. P., Mihajlović, I., Živković, J. M., and Pantelić, N. Đ. (2026). Chemical composition, antioxidant properties, and nutritional value of Diospyros kaki L. as a potential functional food. OBM Integrative and Complementary Medicine, 11(1). https://doi.org/10.21926/obm.icm.2601008

[6] Upreti, D., Shootha, D., Joshi, C., et al. (2025). Phytochemical profile, antioxidant, antibacterial, and DNA protection potential of Diospyros kaki L.f. from the Western Himalayas, India. Discover Applied Sciences, 7, 187. https://doi.org/10.1007/s42452-025-06633-x

[7] Pérez-Piñero, S., et al. (2024). Efficacy of a dietary supplement extracted from persimmon (Diospyros kaki L.f.) in overweight healthy adults: A randomized, double-blind, controlled clinical trial. Foods, 13, 4072. https://doi.org/10.3390/foods13244072

[8] Yu, Y., Chen, P., Li, X., Shen, S., and Li, K. (2022). Persimmon proanthocyanidins with different degrees of polymerization possess distinct activities in models of high fat diet induced obesity. Nutrients, 14, 3718. https://doi.org/10.3390/nu14183718

[9] Takemori K, Akaho K, Iwase M, Okano M, Kometani T. (2022). Effects of Persimmon Fruit Polyphenols on Postprandial Plasma Glucose Elevation in Rats and Humans. J Nutr Sci Vitaminol (Tokyo), 68(4):331-341. doi: 10.3177/jnsv.68.331. PMID: 36047105.

[10] Butt, M. S., Sultan, M. T., Aziz, M., Naz, A., Ahmed, W., Kumar, N., and Imran, M. (2015). Persimmon (Diospyros kaki) fruit: Hidden phytochemicals and health claims. EXCLI Journal, 14, 542–561. https://doi.org/10.17179/excli2015-159

[11] Rauf, A., Akram, Z., Hafeez, N., et al. (2024). Anticancer therapeutic potential of genus Diospyros: From phytochemistry to clinical applications—A review. Food Science and Nutrition, 12, 7033–7047. https://doi.org/10.1002/fsn3.4375

[12] Choudhary, R., Singh, A., Upadhyay, A., Singh, R., Thangalakshmi, S., Dar, A. H., Bajpai, V. K., and Shukla, S. (2022). Exotic god fruit, persimmon (Diospyros kaki): Pharmacological importance and human health aspects. eFood, 4, e52. https://doi.org/10.1002/efd2.52

[13] Allouache, R., Ben Haj Koubaier, H., Bouacida, S., et al. (2024). Investigation of chemical composition, antioxidant and alpha-amylase inhibitory properties of pulp and peel of Tunisian Diospyros kaki L. fruit. Chemistry Africa, 7, 2467–2475. https://doi.org/10.1007/s42250-024-00905-6

[14] Edagi, F. K., Sestari, I., Terra, F. A. M., Chiou, D. G., and Kluge, R. A. (2009). Effect of ripening stage on astringency removal of 'Rama Forte' persimmon. Acta Horticulturae, 833.

[15] Amorim, C., Antoniolli, L. R., Orsi, B., and Kluge, R. A. (2023). Advances in metabolism and genetic control of astringency in persimmon (Diospyros kaki Thunb.) fruit: A review. Scientia Horticulturae, 308, 111561.

[16] Ben-Arie, R., and Sonego, L. (1993). Temperature affects astringency removal and recurrence in persimmon. Journal of Food Science, 58, 1397–1400. https://doi.org/10.1111/j.1365-2621.1993.tb06191.x

[17] Ozdemir, A. E., Candir, E., Toplu, C., and Yildiz, E. (2020). Effect of hot water treatment on astringency removal in persimmon cultivars. International Journal of Fruit Science, 20(sup2), S557–S569. https://doi.org/10.1080/15538362.2020.1746729

[18] Kato, K. (1990). Astringency removal and ripening in persimmons treated with ethanol and ethylene. HortScience, 25(2), 205–207.

[19] El-Kady, M. I., Samra, B. N., and Badawy, R. A. A. (2008). Astringency removal and ripening process of persimmons treated with ethephon and ethanol. Journal of Agricultural Science, Mansoura University, 33(5), 3545–3553.

[20] Das, P. R., and Eun, J. B. (2021). Removal of astringency in persimmon fruits (Diospyros kaki) subjected to different freezing temperature treatments. Journal of Food Science and Technology, 58, 3154–3163. https://doi.org/10.1007/s13197-020-04818-3

[21] Zhao, W., M. Zheng, X. Li, K. Song and D. Shi. (2025). Fruit Astringency: Mechanisms, Technologies, and Future Directions. Hortic., 11(6): 699. https://doi.org/10.3390/horticulturae11060699

[22] Singh, B., Suri, K., Shevkani, K., Kaur, A., Kaur, A., Singh, N. (2018). Enzymatic Browning of Fruit and Vegetables: A Review. In: Kuddus, M. (eds) Enzymes in Food Technology. Springer, Singapore. https://doi.org/10.1007/978-981-13-1933-4_4