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Original Research Article

THE IMPACT OF STORAGE TEMPERATURE ON MORPHO-PHYSIOLOGICAL CHANGES AND SHELF LIFE OF MANGO CV. SINDRI

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Abstract *The preservation of mango quality during storage is crucial for extending shelf life, reducing post-harvest losses, and ensuring consumer satisfaction. This study explored the potential of cold storage of mango cv. Sindhri fruit at various temperatures as well as the quality attributes over a duration of 0, 7, 14, 21, and 28 days. Mangoes were stored at 8°C, 12°C, and 16°C. The study evaluated pH, titratable acidity, total soluble solids, vitamin C content, total phenolic content, total flavonoid content, color changes and sensory qualities. The results revealed that pH and acidity of the juice has decreased while the total soluble solids exhibit an increased trend over storage duration. The juice pH and titratable acidity has decreased with higher storage temperatures, while total soluble solids and Vitamin C contents has increased with the storage duration. Notably, the decline in vitamin C, phenolic, and flavonoid contents was least at 8°C. Color changes were minimal at 8°C but more pronounced at 16°C. Sensory evaluations revealed optimal texture, flavor, aroma, appearance, and overall acceptability at 8°C. The study demonstrates that storing mangoes at 8°C effectively preserves their quality attributes throughout the storage period, with significant declines in quality observed particularly after 21 and 28 days.*

Keywords*:* *Mango; storage temperature; storage duration; shelf life; quality*

Introduction

The mango (*Mangifera indica* L.) is a member of the botanical family Anacardiaceae and possess chromosome number 2n=40 and small genome size 439Mb (Rashid et al., 2024). The world mango production is 59 million ton out of which Asia contributes 43 million ton with 66% share. The mango area under cultivation in Pakistan is 0.2 million hectares which generate annual production 2.7 million ton with 111 thousand ton exported to various countries of the world (FAO, 2022). The mango season in Sindh and Punjab provinces commences from May and extends /till early October. Mango cultivar Sindhri occupies 18% area under its cultivation in Punjab while 70% occupies in Sindh. Mango occupies an area under its cultivation in Punjab is 244 thousand acres while Sindhri has its area 44011 acres (FAO, 2024). The exportable mango cultivars of Pakistan area Sindhri, Sammar Bahisht Chaunsa, Sufaid Chaunsa, Chenab Gold and Azeem Chaunsa while domestic cultivars include Malda, Siroli, Dusehri, Anwar Retaul, Langra, Fajri, Late Retaul, Sensation etc. The mango export is 136 thousand ton and out of which 90% is concentrated into the adjacent and gulf countries. The export routes are 70% via road transportation, 23% via sea shipments and approximately 1% by air freight (Memon, 2016). Pakistan is the sixth-largest producer of mangoes in the globe, contributing approximately 5% to the global production (Ghafoor et al., 2010). Mango cultivars such as Sindhri, SB Chaunsa, Sufaid Chaunsa, Chenab Gold and Azeem Chaunsa have export potential while local cultivars as Langra, Anwar Ratol, Fajri, Dusehri, Malda, Siroli, Ghulab Khas, Swarnarekha, Neelum and Kala Chaunsa are among the most frequently cultivated commercial mango varieties in Pakistan (Usman et al., 2003). Bioactive components, including vitamin C, β-carotene, and polyphenols, are present in mango fruit, which contribute to its nutritional and antioxidant properties (Campbell et al., 2009). β- carotene is present in mangoes, which contributes to the improvement of nutritional security in tropical and subtropical regions (Qureshi et al., 2014). The primary source of vitamin A is β-carotene, a carotenoid. It enhances reproductive, ocular, and immune functions. In light of the heightened demand for mangoes in rural communities, it is imperative to identify high-nutrient cultivars and assess cost-effective postharvest procedures in order to preserve the quality of mango fruit. The nutritional value of

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mangoes is contingent upon the cultivar, maturation stage, storage conditions, and postharvest procedure employed. Mangoes are nutrient-dense and possess a unique flavor and aroma. As a result of its consistent increase in market popularity, it has become the second most extensively grown and consumed tropical fruit in the world (Masood et al., 2011). The majority of mango-producing regions are situated in tropical regions with elevated humidity and temperatures (Ayyaz et al., 2019). Mango consumption has shifted from local and peripheral sales to off-site and export sales as the consumer market expands. Nevertheless, the quality of mangoes can be diminished by postharvest maturity and maturation during storage and transportation, which can lead to significant economic losses during long-distance cold-chain transportation.

The market and consumption value of fruit are increased by postharvest maturation, which delays its harvest ripeness and transforms it into an edible form. The mango industry has experienced a surge in consumer demand for premium commodities (Naz et al., 2014), and marketing strategies for raw mangos are in a state of perpetual evolution (Raza et al., 2017). The current method for the preservation and maturation of mangoes is based on the traditional 13°C low-temperature transportation and preservation technique, which substantially reduces the ripening time. The product is sprayed with ethephon to expedite the ripening process and subsequently deposited in a compact storage container (car). This methodology has the potential to decrease the duration of mango post-ripening. Nevertheless, mangoes in the storehouse (or automobile) are susceptible to rotting as a result of their rapid ripening and aging, which results in substantial financial losses and biological contamination. The objective of the present study was to evaluate the changes in biochemical and quality parameters during storage at different temperatures.

Materials and methods

Experimental material

The mangoes used in this investigation, cv. Sindri, were procured from the Mango Research Station's orchard in Shujabad, Multan, Pakistan. The mangoes were transported to the horticulture laboratory within two hours of their collection. To guarantee uniformity, the mangoes were separated using the water immersion procedure, which was determined by their specific gravity. The mangoes that floated, which indicated poor development, were removed by submerging them in a bucket of water. Only mangoes with a completely green surface, no flaws, and a uniform dimension were included in this experiment.

Storage Conditions

The mangoes were divided into five groups, each of which contained five duplicates. The recommended treatment technique resulted in the fruits being neatly packaged in plastic boxes that measured 37 cm x 55.5 cm x 30.5 cm. Mangoes were stored at the MG Food, Kabirwala facility in three distinct temperature ranges until the conclusion of the storage period: 1) at a constant temperature of 8°C, 2) at 12°C, and 3) at 16°C with 90% relative humidity. The integrity of the stored mangoes was evaluated at 0, 7, 14, 21, and 28 days following storage.

Total soluble solids

Total soluble solids (TSS) was measured by taking a small quantity of fruit juice utilizing a digital refractometer calibrated within a scale range of 0 degrees Brix with distilled water.

Titratable Acidity

The titratable acidity was determined by utilizing the quantity of citric acid present in 100 milliliters of mango juice.

Vitamin C Content

Vitamin C content of mango pulp tissue was determined as described by (Tahir *et al.*, 2012), and expressed as mg 100 ml−1 FW.

Total phenolic content

Total phenolic content of mango pulp tissue was determined as described by (Comparative Response of Mango Fruit towards Pre- and Post-Storage Quarantine Heat Treatments), and expressed as mg GAE/100mL.

Total Flavonoid Content

Total phenolic content of mango pulp tissue was determined as described by (Zahid *et al.*, 2022) and expressed mg QE/100mL.

Color analysis

For color analysis, L, a* and b* values of mango pulp were measured by using colorimeter.

Sensory evaluation

We conducted a sensory evaluation of the fruit at 21 and 28 days of storage t. The mango's flavor, aroma, and overall acceptability were evaluated by trained panelists using a nine-point hedonic scale. The rating scale was a scale of 1 to 9, with 9 representing "extremely favorable," 1 representing "extremely unfavorable," and intermediate values representing differing degrees of likeness or hatred. The samples were assessed on a scale of one to nine.

Results and discussion`

pH

Our results indicated that the pH of mango samples was gradually increased by increasing storage temperature from 8ºC to 16 ºC (figure 1). While decreasing trend in pH values was observed as the storage time increased from 0 to 28 days of storage. Minimum values of pH were observed at 8 ºC for 28 days of storge.

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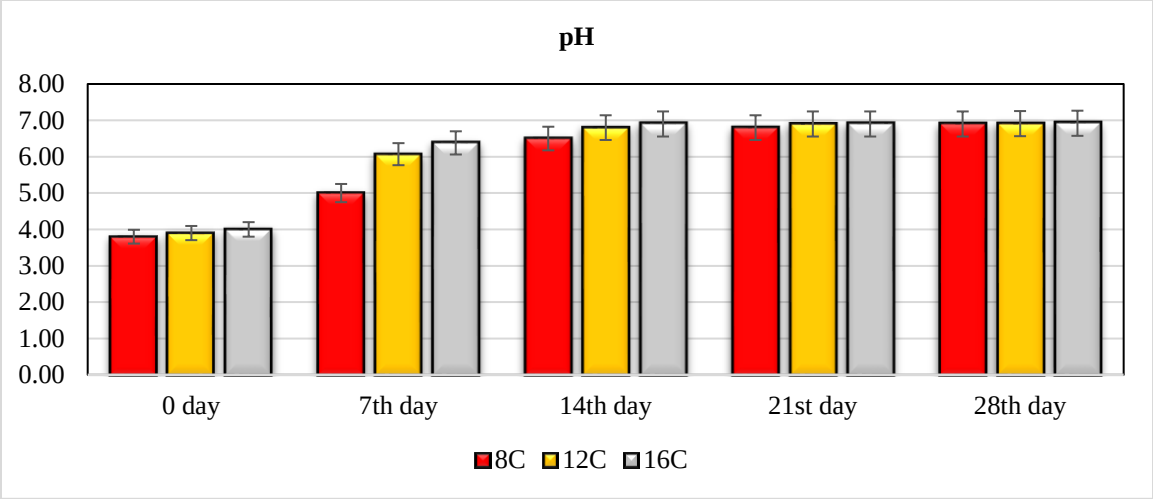

Figure 1: Impact of different storage temperatures on the pH of the mango cv sindri for different storage durations

Titratable Acidity (%)

TA is also a reliable indicator of fruit quality, as it is responsible for the unique aromas and smells of the majority of fruits [38]. Due to the rapid metabolism and conversion of organic molecules into carbohydrates, fruit frequently exhibits a diminished acid content [39]. In our investigation, a decrease in TA contents was observed during cold storage. Storage duration also significantly reduced the TA of the mangoes (figure 2).

Our results are consistent with those of (Khan et al., 2008), who found that mango cultivars stored at temperatures varying from 18 to 34 °C experienced a decrease in titratable acidity (0.04-2.71%). The fruit's store life can be substantially extended by maintaining a flexible pH level (Badar et al., 2019). TA and juice pH are influenced by the levels of ascorbic acid, malic acid, and citric acid. Our results indicate that the pH of the juice increased as a result of the increased transformation of organic acids into other metabolites as fruit maturation improved. (Khushk & Smith, 1996) discovered that the pH of the liquid was increased (2.85-4.38%) when mango cultivars were maintained at 18 to 34 °C.

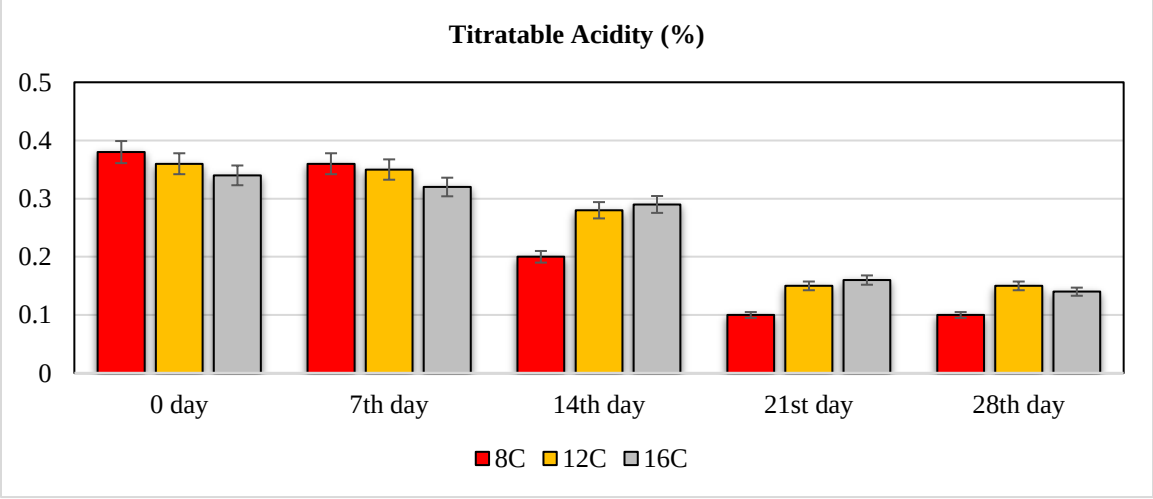

Figure 2: Impact of different storage temperatures on the titratable acidity of the mango cv sindri for different storage durations

Total Soluble Solids (°Brix)

In the fruit maturation process, total soluble solids are a critical component that affects the financial benefits of the fruit trade and the acceptance of abundant nutrients. TSS were increased during storage at different cold temperature conditions and the least values were observed at at 8°C (figure 3).

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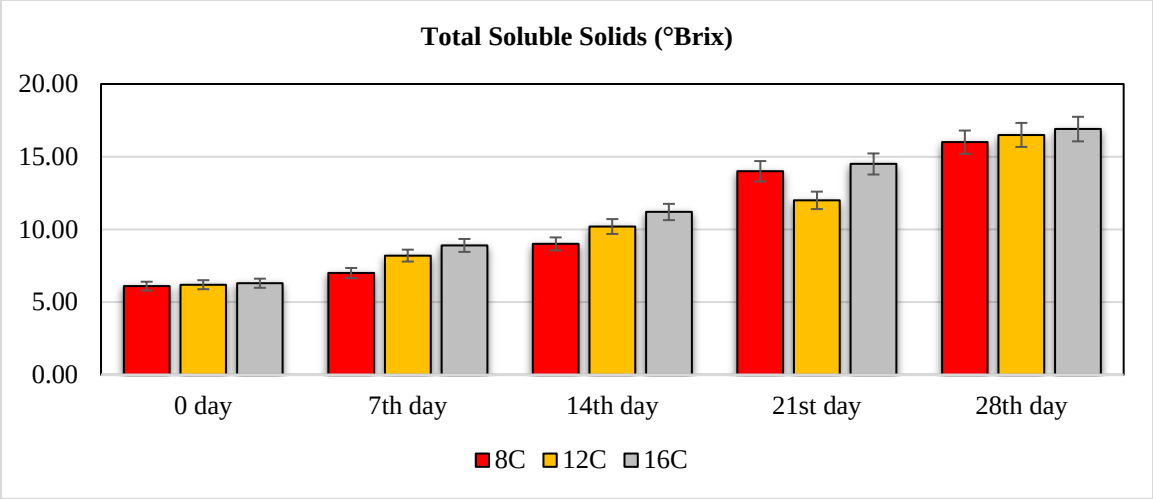

Figure 3: Impact of different storage temperatures on the total soluble solids of the mango cv sindri for different storage durations

Vitamin C Content (mg/100mL)

Bioactive compounds, such as vitamin C, are present in horticultural crops. It possesses biological properties that are advantageous to human health (Mitra, 2014). Mango fruits are generally rich in vitamin C, although the amount differs depending on the cultivar (Badar et al., 2014). We found that the levels of vitamin C decreased in both ambient and vitamin C are likely to be reduced by both ambient temperature and elevated temperatures during heat treatments, as it is a water-soluble and temperature-sensitive vitamin (Alam et al., 2017). In current study, minimum decrease in vitamin C was observed at 8°C for a storage duration of 28 days.

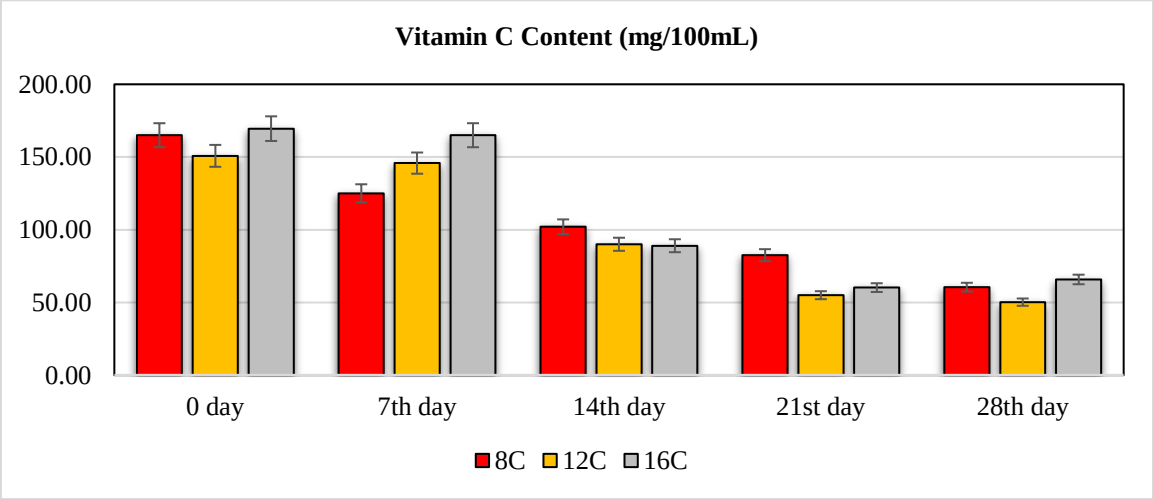

Figure 4: Impact of different storage temperatures on the vitamin C contents of the mango cv sindri for different storage durations

Total Phenolic Content (mg GAE/100mL)

Phenolic compounds due to their biological properties can exhibit antioxidant, anti- inflammatory, antiviral, and anticancer activities (Alam et al., 2017). Total phenols and flavonoids form an active oxygen scavenging system of defense and guarantee the normal activities of plant macromolecules (Maqbool et al., 2007). Most probably, the decrease in these phenols might be due to the enhanced activity of polyphenol oxidase, which led to the breakdown of the cell structure polyphenols within the fruit tissues (Rajwana et al., 2010). Mangos are a rich source of bioactive compounds (β-carotene, ascorbic acid, and total phenolics) and possess a high antioxidant capacity. The decrease in antioxidant activity during storage can be attributed to a decreased level of vitamin C, total phenolics, phenolic acids, and other compounds, such as flavonoids, carotenoids, and anthocyanins when the fruit and vegetables are stored (Ghafoor et al., 2009). In our study, maximum values

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of phenolic contents were observed at storage temperature of 8°C (figure 5).

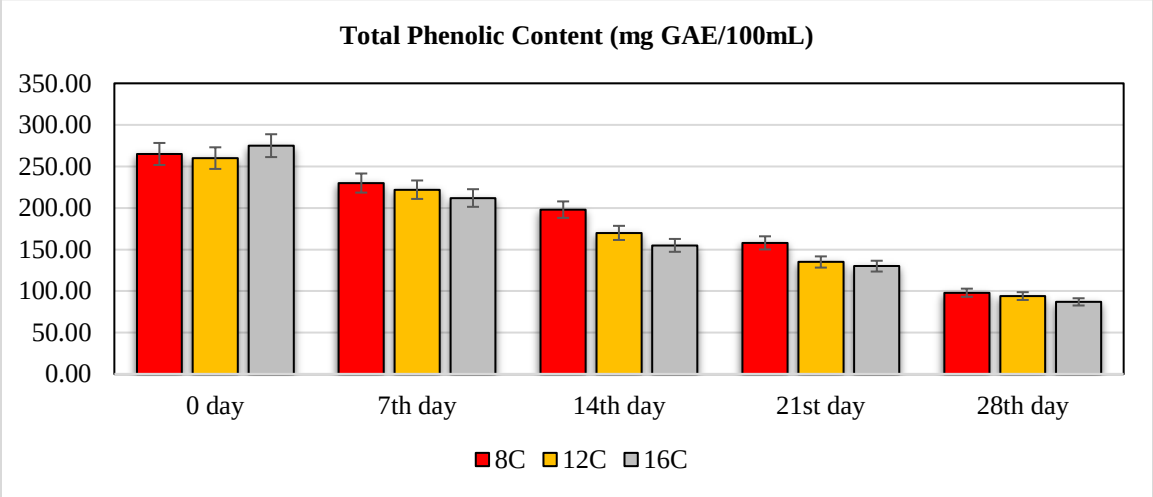

Figure 5: Impact of different storage temperatures on the total phenolic content of the mango cv sindri for different storage durations

Total Flavonoid Content (mg QE/100mL)

Total flavonoid contents were also decreased significantly during storage duration of 28 days but the reduction was least observed at 8°C (24.20) followed by 12°C (16.80). Maximum reduction in was observed at 16°C for 28 days of storage (7.90) as represented in figure 6.

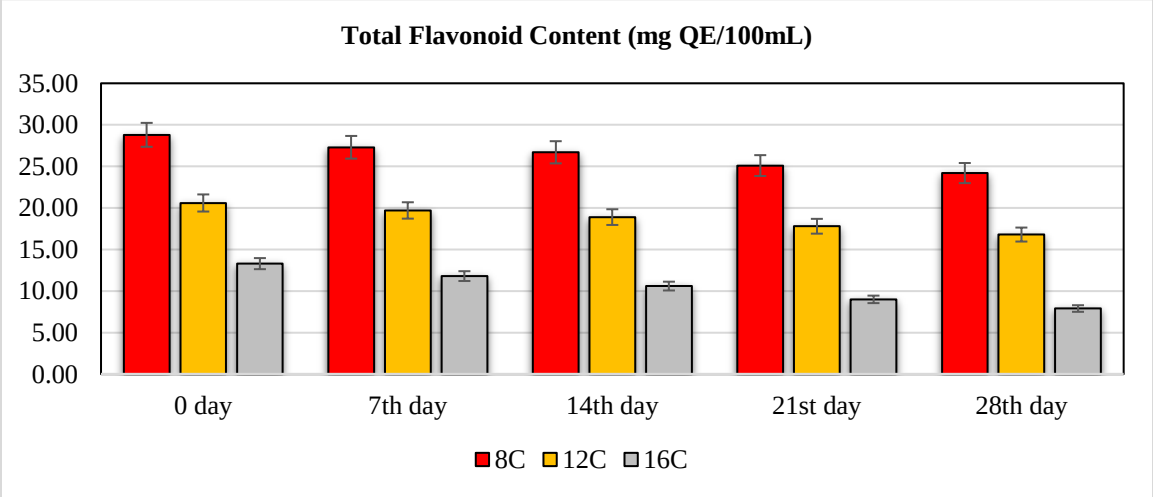

Figure 6: Impact of different storage temperatures on flavonoid contents of the mango cv sindri for different storage durations

Colour analysis

When purchasing fruits, individuals are mostly influenced by two factors: appearance and vibrant colors. A mango fruit's sensory quality can be assessed based on the color of its flesh and epidermis, which is closely related to the fruit's developmental stage (Memon, 2015). The three primary color coordinates that influence mango color variations are a (value coordinate from green to red), b (value coordinate from yellow to blue), and L (fruit luminosity).

In our experiment, minor changes in L, a* and b* values were observed at 8°C (figure 7, 8 and 9). While maximum impacts were observed at 16 °C for 28 days of storage. The color value of a* was altered during cold storage, whereas the a value increased over time in ambient storage. This suggests that the a value transitions from green to red-purple as maturation intensifies. A similar pattern of change was observed in cold storage and shelf investigations (Iqbal et al., 2007). Some pigment is lost from mango skins during the ripening and storage process. A breakdown in the production of carotenoid and chlorophyll is indicated by a decrease in hue values during cool storage or after ripening (Masood et al., 2010). Higher hue values are indicative of greater maturity than lower hue levels.

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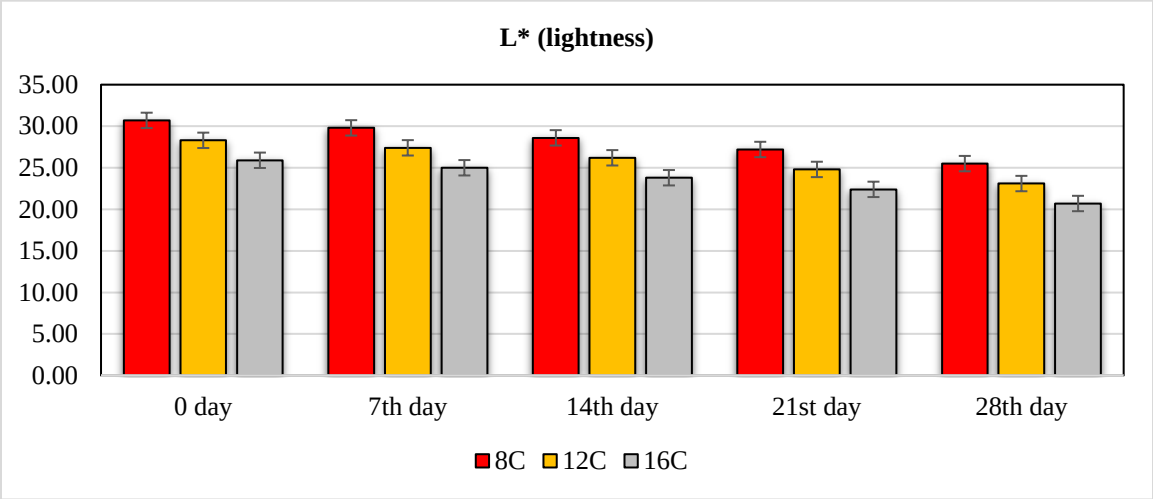

Figure 7: Impact of different storage temperatures on L* of the mango cv sindri for different storage durations

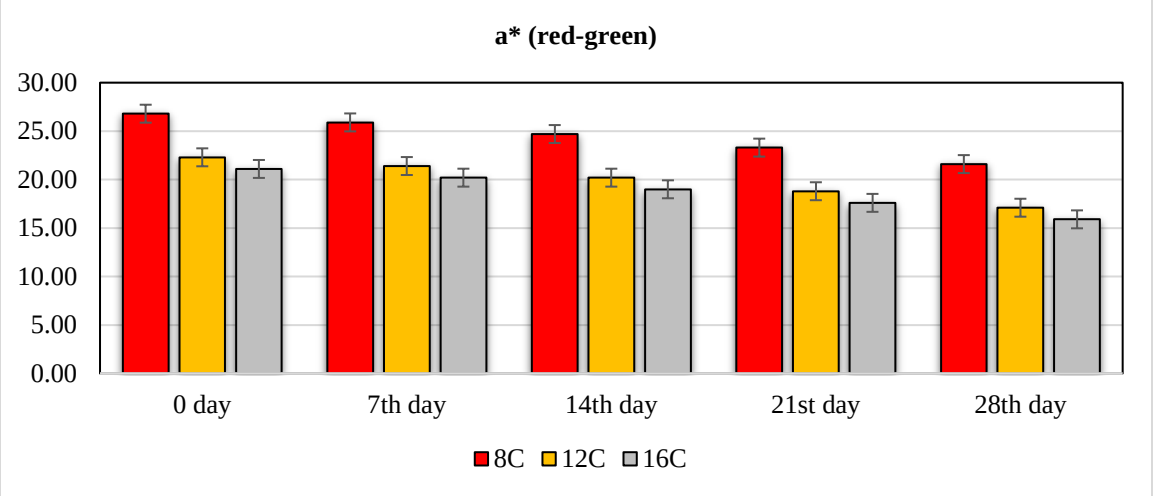

Figure 8: Impact of different storage temperatures on a*of the mango cv sindri for different storage durations

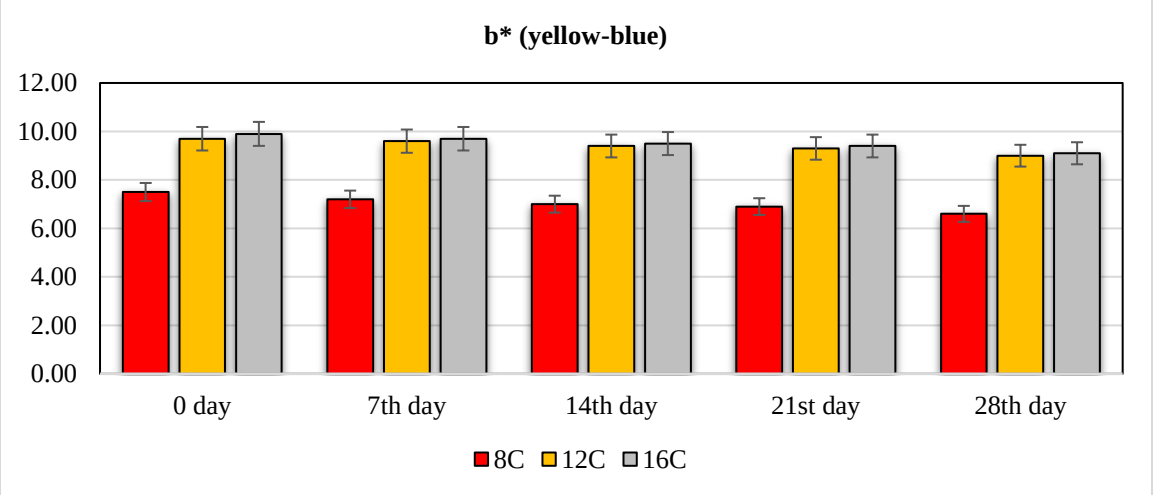

Figure 9: Impact of different storage temperatures on b* of the mango cv sindri for different storage durations

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Sensory evaluation

When consumers are picking a product, one of the most crucial qualitative factors to consider is texture throughout the sensory evaluation process. Fruit softens as a result of structural polysaccharides, also known as pectic substances, which separate from cell walls throughout the maturity process. Pectic chemicals give pears their grainy texture. Hardness can therefore be used to estimate the ideal maturity stage for harvesting. In our study, least values for this parameter were observed at 16°C for 28 days of storage (figure 10). Flavor and aroma are detected during the ingestion of food. This is referred to as flavor. The taste receptors of the palate identify flavors, while the epithelium of the olfactory organ detects aromatic substances. In our study, maximum points for aroma, flavour, appearance and overall acceptability were observed at 8°C of storage temperature (figure 11,12,13 and 14).

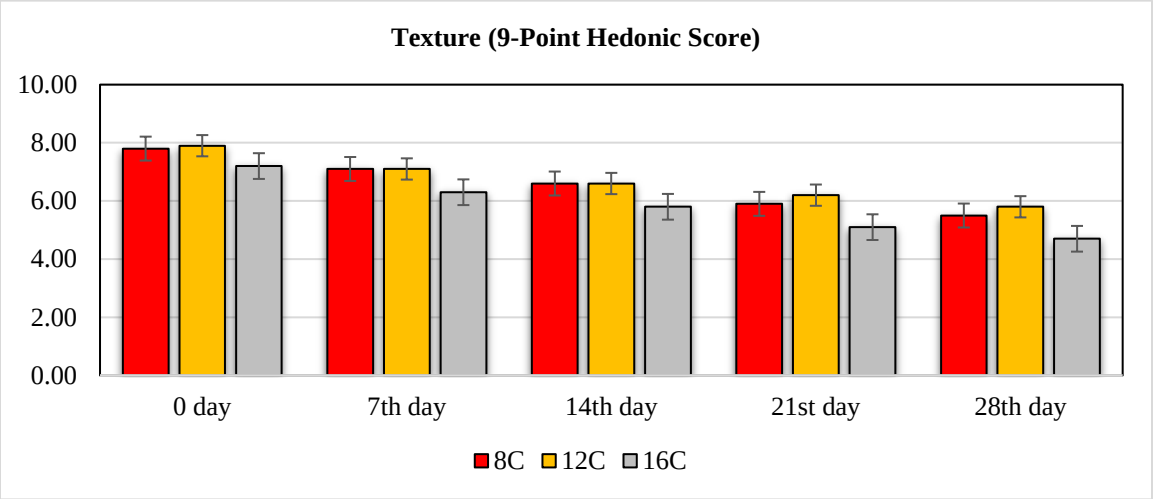

Figure 10: Impact of different storage temperatures on texture of the mango cv sindri for different storage durations

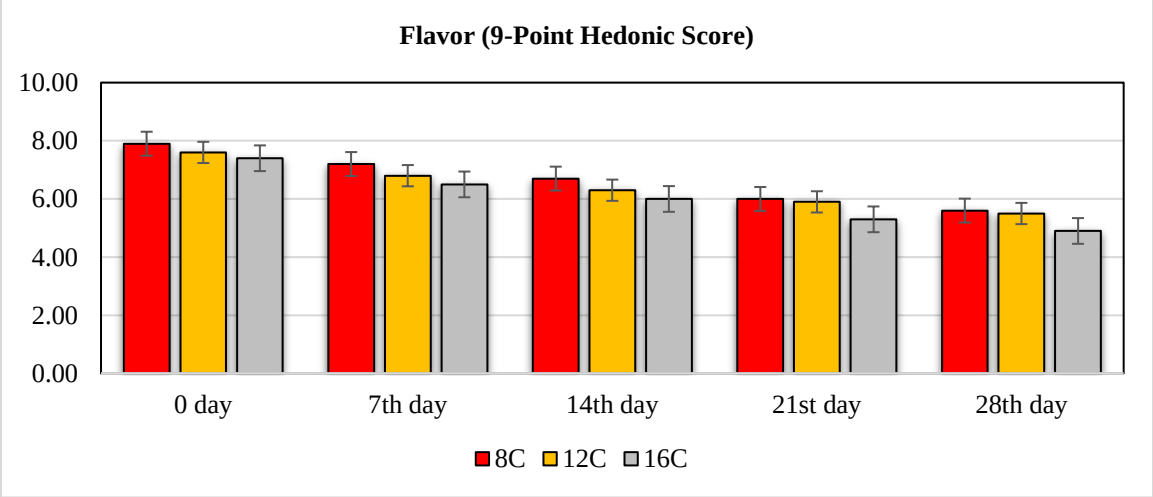

Figure 11: Impact of different storage temperatures on flavor of the mango cv sindri for different storage durations

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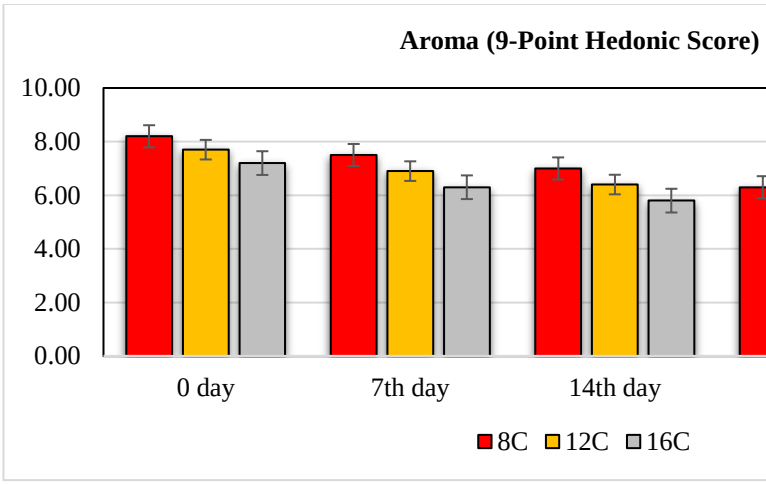

Figure 12: Impact of different storage temperatures on aroma of the mango cv sindri for different storage durations

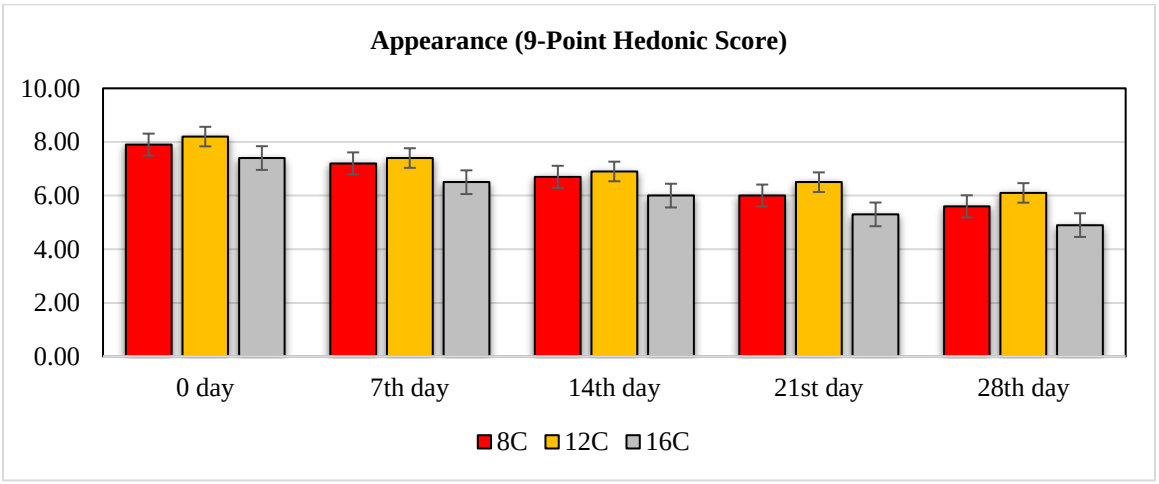

Figure 13: Impact of different storage temperatures on appearance of the mango cv sindri for different storage durations

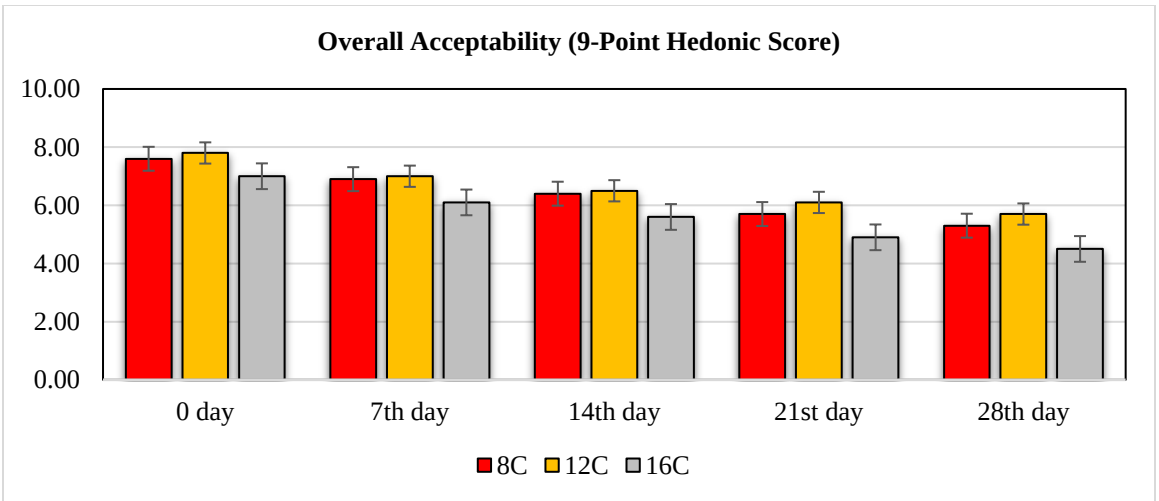

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Figure 14: Impact of different storage temperatures on overall acceptability of the mango cv sindri for different storage durations

Conclusion

In conclusion, at 8°C temperature, reductions in total soluble solids, vitamin C content, total phenolic and flavonoid contents were minimal, and color changes were minor. Sensory evaluations indicated that mangoes stored at 8°C retained the best texture, flavor, aroma, appearance, and overall acceptability. The impact of storage duration was evident, with a marked decline in quality observed after 21 and 28 days. Therefore, 8°C is recommended as the optimal storage temperature for preserving the quality of mangoes during extended storage.

References

Alam, M. W., Rehman, A., Sahi, S. T., & Malik, A. U. (2017). Exploitation of natural products as an alternative strategy to control stem end rot disease of mango fruit in Pakistan. *Pakistan Journal of Agricultural Sciences **54***.

Ayyaz, S., Bonney, L., & Akmal, N. (2019). Competitiveness in mango trade: a comparative analysis between pakistan andother mango exporting nations. *International Journal of Food and Agricultural Economics (IJFAEC) **7***, 341-349.

Badar, H., Ariyawardana, A., & Collins, R. (2014). *Mango value preferences of consumers in Pakistan*. Paper presented at the XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes (IHC2014): 1120.

Badar, H., Ariyawardana, A., & Collins, R. (2019). Dynamics of mango value chains in Pakistan. *Pak. J. Agric. Sci **56***, 523-530.

Campbell, J., Malik, A., Johnson, P., Dunne, A., Sun, X., Amin, M., . . . Collins, R. (2009). *Managing mango fruit quality through the supply chain: a Pakistan case study*. Paper presented at the International Symposium Postharvest Pacifica 2009-Pathways to Quality: mV International Symposium on Managing Quality in 880.

Ghafoor, A., Mustafa, K., & Mushtaq, K. (2009). Cointegration and causality: An application to major mango markets in Pakistan. *The Lahore Journal of Economics **14***, 85.

Ghafoor, A., Mustafa, K., Zafar, I., & Mushtaq, K. (2010). DETERMINANTS OF MANGO EXPORT FROM PAKISTAN. *Journal of Agricultural Research (03681157) **48***.

Iqbal, Z., Valeem, E. E., Shahbaz, M., Ahmad, K., Khan, Z. I., Malik, M. T., & Danish, M. (2007). Determination of different decline disorders in mango orchards of the Punjab, Pakistan. *Pakistan Journal of Botany **39***, 1313.

Khan, M., Mustafa, K., Shah, M., Khan, N., & Khan, J. Z. (2008). Forecasting mango production in Pakistan an econometric model approach. *Sarhad J. Agri **24***, 363-370.

Khushk, A. M., & Smith, L. E. (1996). A preliminary analysis of the marketing of mango in Sindh Province, Pakistan. *The Pakistan Development Review*241-255.

Maqbool, M., Malik, A. U., & Jabbar, A. (2007). Sap dynamics and its management in commercial mango cultivars of Pakistan. *Pak. J. Bot **39***, 1565-1574.

Masood, A., Saeed, S., Iqbal, N., Malik, M. T., & Kazmi, M. R. (2010). Methodology for the evaluation of symptoms severity of mango sudden death syndrome in Pakistan. *Pakistan Journal of Botany **42***, 1289-1299.

Masood, A., Saeed, S., Silveira, S., Akem, C. N., Hussain, N., & Farooq, M. (2011). Quick decline of mango in Pakistan: survey and pathogenicity of fungi isolated from mango tree and bark beetle. *Pakistan Journal of Botany **43***, 1793-1798.

Memon, N. A. (2015). Pakistan to export 100,000 tonnes of mangoes this season. *Pakistan Food Journal (PFJ) **4***, 24-27.

Memon, N. A. (2016). Mango: Pakistan 4th largest producer in the world. *Paistan Food Journal*24-26.

Mitra, S. (2014). *Mango production in the world–present situation and future prospect*. Paper presented at the XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes (IHC2014): IV 1111.

Naz, S., Anjum, M. A., Chohan, S., Akhtar, S., & Siddique, B. (2014). Physico-chemical and sensory profiling of promising mango cultivars grown in peri-urban areas of Multan, Pakistan. *Pak. J. Bot **46***, 191-198.

Qureshi, M. N., Bilal, M., Ayyub, R., & Ayyub, S. (2014). Modelling on Mango Production in Pakistan. *Sci. Int.,(Lahore) **26***, 1227-1231.

Rajwana, I. A., Malik, A. U., Khan, A. S., Saleem, B. A., & Malik, S. A. (2010). A new mango hybrid shows better shelf life and fruit quality. *Pak. J. Bot **42***, 2503-2512.

Rashid, S., Ali, L., Saleem, A., Ummer, K., Nisar, I., Ahmed, F., & Zubair, M. (2024). Fatima 1, 2024. Studies on the seasonal variation of major elements during fruit development stages and evaluation of post-harvest changes in mango germplasm. Agrobiological Records 15: 75-90. In.

[Citation: Kiran, S., Khan, A.H., Iqbal, M., Hussain, R., Iqbal, J., Iqbal, A., Khadija, F., Bashir, M.A (2024). The Impact of Storage Temperature on Morpho-physiological Changes and Shelf Life of Mango CV. Sindri. *Biol. Clin. Sci. Res. J.*, **2024***:* 980. doi: https://doi.org/10.54112/bcsrj.v2024i1.980]

Raza, S. A., Khan, A. S., Khan, I. A., Rajwana, I. A., Ali, S., Khan, A. A., & Rehman, A. (2017). Morphological and physico-chemical diversity in some indigenous mango (Mangifera indica L.) germplasm of Pakistan. *Pakistan Journal of Agricultural Sciences **54***.

Tahir, W. A., Ahmad, M., & Iftikhar, M. (2012). An analysis of the effectiveness of extension work conducted by public sector with special reference to mango in the southern Punjab, Pakistan. *Pak. J. Agri. Sci **49***, 229-232.

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Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

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Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

All authors contributed equally.

Usman, M., Fatima, B., Khan, M. M., & Chaudhry, M. I. (2003). Mango in Pakistan: A chronological review. *Pakistan Journal of Agricultural Sciences **40***, 151-154.

Zahid, G., Aka Kaçar, Y., Shimira, F., Iftikhar, S., & Nadeem, M. A. (2022). Recent progress in omics and biotechnological approaches for improved mango cultivars in Pakistan. *Genetic Resources and Crop Evolution **69***, 2047-2065.