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UNVEILING THE COLD STORAGE POTENTIAL AND PRESERVATION OF FRUIT QUALITY TRAITS IN NEW MANGO CV. AZEEM CHAUNSA

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ABSTRACT

Mango (*Mangifera indica* L.) is a tropical appealing nutritional fruit that has post-harvest issues especially its storage and shelf life. The high climacteric period of mangoes especially the cultivar, Azeem Chaunsa, exposes them to rapid spoilage of harvest, which impairs quality in transportation and storage. The present research aims at examining the influence of various storage temperatures (8°C, 12 °C, and 16 °C) on morphological, physiological and biochemical characteristics of Azeem Chaunsa mangoes, with an emphasis on maximizing shelf life without impacting on the quality of the product. The mangoes were kept in controlled environment that had 90 percent humidity up to 28 days. Parameters such as weight loss, chilling injury, total soluble solids (TSS), titratable acidity (TA) and texture profile and sensory characteristics were determined after 7 days. The findings indicated that mangoes kept at 12 °C had the highest overall quality retention with minimum chilling injury and less weight loss and were able to last in shelf life up to 21 days. Conversely, mangoes stored at 8 °C and 16 °C deteriorated rapidly after 14 and 21 days, respectively. The results imply that Azeem Chaunsa mangoes store best at a 12 °C temperature, which is why it is a possible recommendation to use in commercial storage.

Keywords: Azeem Chaunsa, Mango, Storage Temperature, Shelf Life, Postharvest, Chilling Injury, Total Soluble Solids, Sensory Evaluation

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INTRODUCTION

Mango (*Mangifera indica* L.) is commonly known as the king of fruits because of its outstanding flavor, smell and nutritional quality. It contains a lot of vitamins, antioxidants and dietary fibers, which makes it one of the most commercially significant fruits in the world (Azam et al., 2020). Mangoes, and especially Azeem Chaunsa cultivar, which is one of its most coveted varieties because of its distinct taste, texture, and aroma, are an essential agricultural product in Pakistan (Iqbal et al., 2022). Nevertheless, there is also the issue of post-harvest mango processing, and the major problem with mangoes is that they are also climacteric fruits that do not last long in terms of ripening and deterioration once they are harvested. Harvest losses in mangoes are also a major issue and this is

observed mostly in tropical and subtropical areas where the fruit is largely produced. High respiration rates, ethylene production and loss of moisture are some of the factors that lead to the loss of fruit quality during the storage process. These problems are worsened by improper handling, poor packaging and poor storage conditions, which result in shorter shelf life and losses of money by producers and exporters (Kiran et al., 2023).

Temperature in the storage is a key factor in enhancing shelf life and preservation of quality of mangoes after harvest. The low temperature can inhibit the respiration and delay the ripening, but it can also cause chilling injury, particularly in delicate cultivars. On the other hand, increased temperatures can increase the rate of ripening although this could cause faster deterioration and spoilage.

Hence, it is important to identify the best storage temperature to ensure the shelf life and quality of mangoes are optimized (Kiran et al., 2021). Various studies have examined how various storage temperatures impact on various quality parameters of mangoes. As an example, keeping mangoes at 12 °C has been demonstrated to increase their shelf life by up to 21 days, and the total soluble solids (TSS) and titratable acidity (TA) do not change significantly. Also, the texture profile analysis shows that mangoes stored at this temperature preserve their firmness and whole sensory qualities in comparison with lower or higher temperatures of storage (Iqbal et al., 2022). The chilling injury is a frequent issue of mangoes stored at lower temperature than their chilling threshold. Symptoms are skin color, pitting, and off-flavors, which make the fruit be of little marketability. Chilling injury is different among mango cultivars and depends on the storage temperatures and the time (Kiran et al., 2023). Although considerable research has been done on postharvest management of mango, there is a lack of studies on Azeem Chaunsa. This type of cultivar, characterized by sensitive texture and high sugar content, can react less to storage conditions than other types. Thus, the proposed research is intended to examine how different storage temperatures can impact the morphological, physiological, and biochemical properties of Azeem Chaunsa mangoes, and how it is possible to preserve the shelf life of mangoes without affecting the quality of the fruit.

This study aims to offer useful information to growers, packers, and exporters by identifying the best storage conditions that can be adopted by Azeem Chaunsa to manage the situation in the postharvest management process effectively, and minimize the destruction of postharvest. In addition, the results might be used in the establishment of standard operating procedures of storing and transporting this high quality mango variety, making it more competitive in the world market.

MATERIALS AND METHODS

Fruits Picking and Packing

The mangoes employed in the research were Azeem Chaunsa variety, and they were obtained in the mango orchard in the Mango Research Station, Shujabad, Multan, Pakistan. The harvesting was done at the maturity-green stage so as to have uniformity of the fruit in terms of quality and developmental pattern. The mangoes were collected immediately after harvesting and then they were transported to the horticulture laboratory within two hours to reduce the impact of transportation stress. In order to achieve

uniformity of sample, the mangoes were sorted by the water immersion technique where the fruits were immersed in water. The ones that floated were excluded because they were considered as having little development whereas those that sunk meaning that they were at the best levels of maturity were used in the study. All the mangoes were the same size of about 250 grams and had no bruises or scars that could be on them.

Duration of Sampling and Storage.

Their storage lasted 28 days, and the evaluation of the mangoes was carried out after every 7 days (0, 7, 14, 21 and 28 days). Three mangoes of every treatment group were chosen randomly at every sampling point to be analyzed.

Storage Conditions

All the mangoes having been selected and prepared were then randomly grouped in three groups, each having five replicas of 20 mangoes in the replica. The mangoes were loaded in punctured cardboard boxes (38cm × 30cm × 10cm) to permit air to pass through the boxes whilst storing. Three various temperatures were used as storage temperature and they were 8°C, 12°C and 16°C with relative humidity of 90% +5%. The selection of these temperature settings was due to the common storage conditions and to investigate the effects on the quality attributes of the fruit of these temperature settings. The mangoes were kept at Kabirwala, MG Foods; the temperature was strictly maintained at this place. The analysis was done on the samples at five times 0, 7, 14, 21 and 28 days to determine the changes in quality with time.

Parameters Measured

Weight Loss (%)

Weight loss was established by weighing every mango prior to the storage duration and after it had been stored. The percentage loss of weight was calculated as a percentage of the initial weight by the following formula:

Weight Loss (%) = (Initial Weight (g) - Weight at Removal (g)/Initial weight (g)) x 100.

Total Soluble Solids (TSS)

Digital refractometer was used to measure TSS (ATAGO PAL-1, Japan). A sterile knife was used to extract a small sample of mango juice and the TSS calculated as the refractive index at 20°C. The outcomes were in the form of Brix.

Titratable Acidity (TA)

TA was calculated by titration of 10mL of mango juice with 0.1N NaOH with the indicator of phenolphthalein. The outcome was in the form of a percentage of citric acid.

Chilling Injury (CI) Index

The chilling injury was measured based on a visual rating scale. Chilling injury symptoms such as sunken lesions and

skin discoloration were identified and ranked them based on a 5-point scale (Brecht and Nunes, 2012).

- 5: No injury (0% affected)
- 4: Trace injury (1-10% affected)
- 3: Moderate injury (11-25% affected)
- 2: Severe injury (26-50% affected)
- 1: Very severe injury (>50% affected)

Titrateable Acidity (TA)

TA was calculated by titration of 10mL of mango juice with 0.1N NaOH with the indicator of phenolphthalein. The outcome was in the form of a percentage of citric acid.

Texture Profile Analysis (TPA)

Mangoes were evaluated in terms of their textural characteristics with the help of a TA-XT2 texture analyzer (Stable Microsystems, Surrey, UK). The fruit was penetrated with a cylindrical probe (12.7 mm diameter) at a depth of 6 mm. The rate of compression was adjusted to 1 mm/s and the corresponding force was measured and recorded in the form of Newtons (N). Such parameters as hardness, gumminess, and chewiness were tested.

Sensory Evaluation

A trained panel was used to do sensory evaluation after 21 and 28 days of storage. On a 9-point hedonic scale the mangoes were rated in terms of taste, aroma, texture and general acceptability. The score was between 1 (extremely unfavorable) and 9 (extremely favorable).

Statistical Analysis

The analysis of the data on each parameter was done according to the completely randomized design (CRD) with the five replicates of each treatment group. The statistical analysis was done through Analysis of Variance (ANOVA) to determine the significance of differences across the treatments. The Pearson correlation coefficients were

calculated to ascertain associations among different variables, including the chilling injury, weight loss and external appearance. All analyses were done using statistical software (SPSS version 26), and the differences were regarded as significant at a level of $p = 0.05$.

RESULTS AND DISCUSSION

Weight Loss (%)

The loss of weight of Azeem Chaunsa mangoes in the various storage temperatures and time periods were also significantly different. Storing of mangoes at 12 °C showed the least weight loss as the weight loss was about 5 percent over the 28 days of storage. Conversely, the ones kept at 8 °C and 16 °C experienced more weight losses with the highest of 12 percent in 28 days (Table 1 and Figure 1). Mangoes lose their weight mainly through the transpiration and respiration processes. Reduced temperatures have the ability to slow down the metabolic rate, thus reducing the amount of water lost.

Nevertheless, the coldness can cause chilling injury at very low temperature conditions and this could enhance weight loss since there was cellular damage. Its results concur with the literature that provides the best results in the area that mangoes stored at 12°C have the best weight retention as opposed to those stored at low or high temperatures (Kiran et al, 2021). The findings indicate that 12 °C was the most suitable retardant of minimum weight loss and retarded ripening and preserved fruit quality. Mangoes kept at 8°C had intermediate weight loss, which may have been as a result of the reduced metabolic activity that influenced water retention. Conversely, the weight loss of the mangoes at 16°C was the highest, probably because of the rapid ripening and high rate of transpiration (Iqbal et al, 2020).

Table 1: Weight loss of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Storage Temperature (°C)	Day 0 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)	Day 28 (%)
8	0	2	4	7	10
12	0	1	2	3	5
16	0	3	5	8	12

Total Soluble Solids (TSS)

Table 2 and Figure 2 show the Total Soluble Solids (TSS) content, which is a concentration of sugar and ripeness of mangoes. The TSS levels of mangoes stored at 12 o C were the best during the 28 days of storage with values up to 24 per cent being recorded on Day 28. This indicates that 12 °C will offer the best conditions in accumulating sugars by mangoes to achieve balance in the process of ripening. The rise in TSS

at 12 °C confirms that the temperature favors the optimum conversion of starch to sugars thereby improving sweetness and taste of the fruit. This outcome corresponds to other researchers, Khadka et al. (2017) and Sarananda (2000), who reported that low (8 °C) or high (16 °C) temperatures either decelerate the metabolic activity or speed up the respiration process to the extent of incomplete sugar formation. Mangoes kept at 8 °C had slower increment of TSS as they only

achieved 20.5% of TSS at Day 28. This retarded the process of ripening because the enzyme activity was lower in the lower temperature making the process of converting starch to sugar limited. In contrast, mangoes at 16 °C ripened too fast in that TSS value was 24% after Day 21. The increased temperature speeded up respiration, scuttled the starch reserves before much sugar could be built up such that eventually the quality of the fruit and its shelf life were curtailed. Sivakumar et al. (2011) and Yahia et al. (2019) also noted similar trends and emphasized that 12 °C delays over

ripening but does not affect TSS and flavor. At storage time of 28 days, mangoes stored at 16 °C had started to show signs of over-ripening where skin issues like chilling injury and skin blemishes were observed, which further affected their overall acceptability. Such skin problems, in addition to early ripening, reduce the shelf life and customer preference of the mango. The findings affirm that 12 °C is the most ideal balance that does not lead to under-ripening and over ripening and maintains the sweetness of fruit and increases the marketability of the fruit.

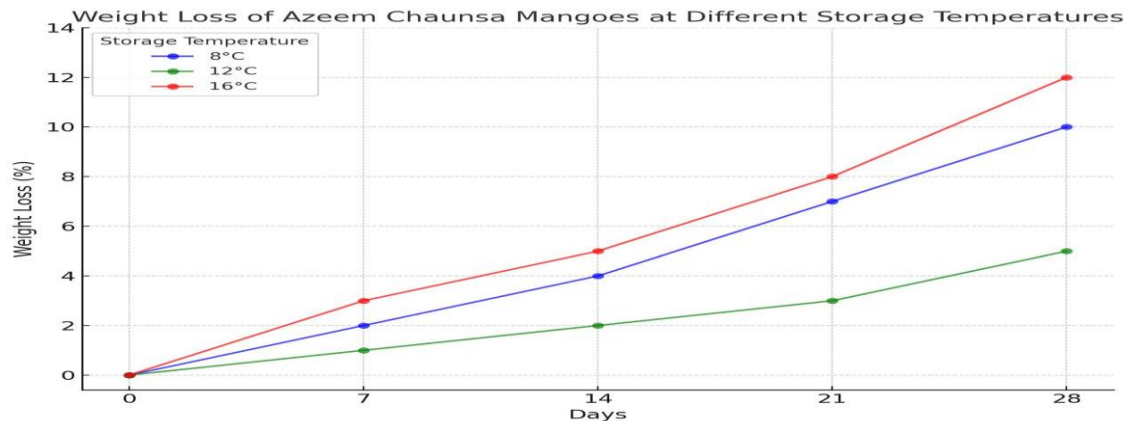


Figure 1: Weight loss of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Table 2: Changes in Total Soluble Solids (TSS) of mangoes stored at different temperatures for 28 days.

Storage Temperature (°C)	Day 0 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)	Day 28 (%)
8	10.57	12.50	15.30	19.10	20.50
12	10.57	14.00	16.50	19.00	24.00
16	10.57	16.00	19.00	24.00	

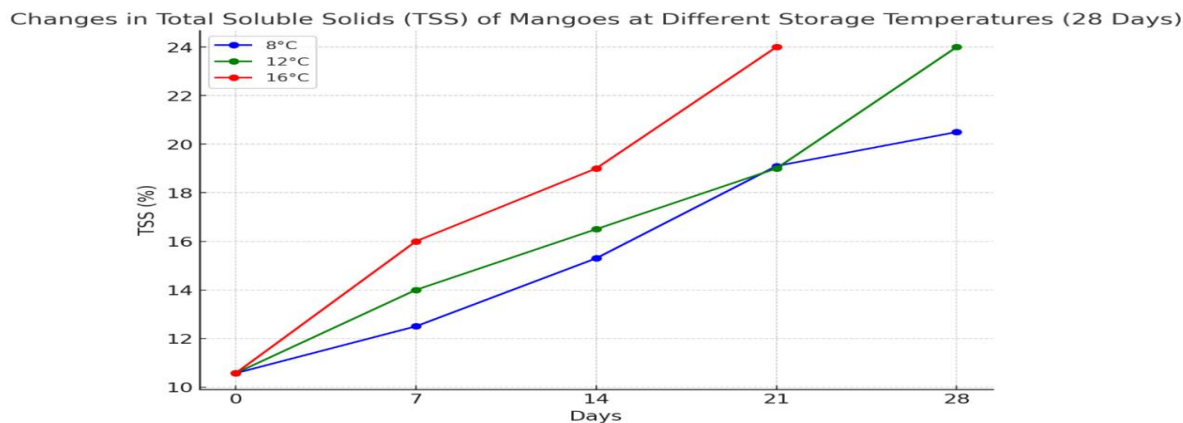


Figure 2: Total Soluble Solids (TSS) of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Titrateable Acidity (TA)

Titration of 0.1 N NaOH solution was used to give the

Titrateable Acidity (TA) of mangoes, which is a measurement of its tartness and balance of flavors. Table 3 reveals that

mangoes stored at 12 °C had almost constant TA of approximately 0.6% throughout the 28 days of storage indicating the absence of acid loss. Conversely, TA decreased more slowly at 8 °C (0.52 percent) and more quickly at 16 °C (0.50 percent) on Day 28 as depicted in Figure 3. This reduction is associated with the ripening process, where organic acids were converted into sugars (Khadka et al., 2017; Sarananda, 2000). The decreasing acidity at a lower temperature (8 °C) indicates the less metabolic activity observed under lower temperatures (Lizada, 1993) whereas

the more rapid decline in acidity at a higher temperature (16 °C) is due to the increased ripening and an increase in the rate of respiration (Sivakumar et al., 2011). The relatively constant TA at 12°C indicates that this temperature has been observed to ensure a perfect rate of ripening, maintaining a balanced flavor because TSS and acidity remained constant (Yahia et al., 2019). Generally, 12 °C was the most ideal storage temperature in maintaining the titratable acidity and sensory characteristic of mangoes avoiding rapid degradation of acid and proper ripening (Nunes et al., 2007).

Table 3: Changes in Titratable Acidity (TA) of mangoes stored at different temperatures for 28 days.

Storage Temperature (°C)	Day 0 (%)	Day 7 (%)	Day 14 (%)	Day 21 (%)	Day 28 (%)
8	0.60	0.58	0.56	0.54	0.52
12	0.60	0.59	0.58	0.57	0.56
16	0.60	0.57	0.55	0.53	0.50

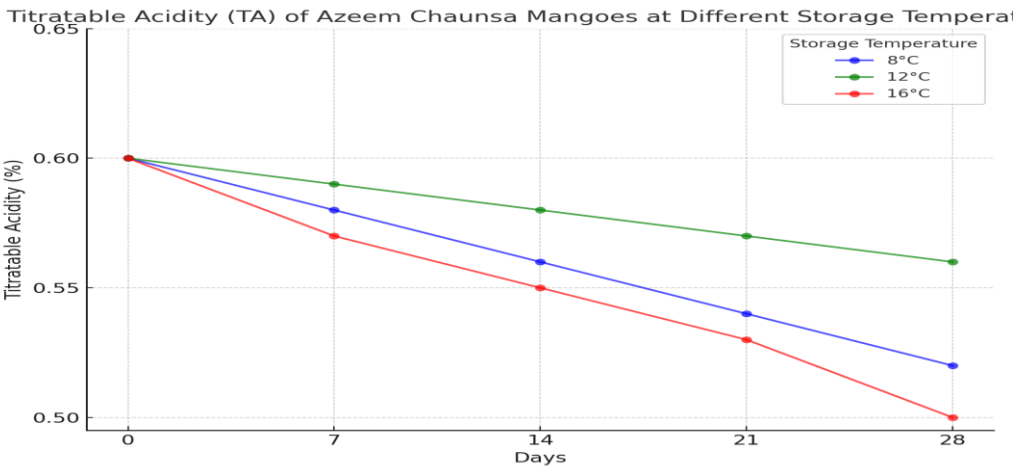


Figure 3: Titratable Acidity (TA) of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Chilling Injury (CI)

Table 4 and Figure 4 show the Chilling Injury (CI) scores of mangoes stored in various temperatures over 28 days. The storage at 12 °C caused minimum chilling injury to mangoes during the storage process as CI score was 5 on Day 0 to Day 28. It means that the optimum temperature of storage is 12 °C to reduce the effect of chilling injury and preserve the quality of fruits, which is consistent with the results of Iqbal et al. (2020) and Ghafoor et al. (2022) who found that the temperature of 12 °C has been proven to be the most effective in reducing chilling symptoms and preserving the firmness and appearance of mangoes. Comparatively, mangoes kept at 8°C underwent gradual chilling damage with the CI scores reducing by 5 on Day 0 to Day 28. At lower temperature, respiration was retarded,

however cellular stress caused mild chilling injury and visible damage was observed. This is similar to Yahia et al. (2019), who observed that mangoes are at high risk of chilling injury when kept below 13 °C that is seen in the form of skin discolouration, pitting, and off-flavors because of membrane damage and oxidative stress. The same deterioration tendency was observed with mangoes kept at 16 °C but to a lower degree compared to mangoes kept at 8 °C. The CI score went down to 2 out of 5 showing that the high temperature expedited the ripening process that caused an increase in metabolic activity and tissue breakdown. This observation is in line with the reports by Sivakumar et al. (2011) and Lizada (1993) who have stressed that temperatures surpassing the optimal range (12 °C) cause over-ripening that also causes chilling injury. The results are

indicative of the fact that 12 °C offers a perfect balance in the storage of mango where it is not chilled and the quality of the fruit is not spoiled after harvesting. Both lower and higher temperatures (8 °C and 16 °C) caused visible injury, although by different mechanisms, cellular stress caused the injury at 8°C, and rapid ripening caused the injury at 16°C.

Table 4: Chilling Injury (CI) scores of mangoes stored at different temperatures for 28 days.

Storage Temperature (°C)	Day 0	Day 7	Day 14	Day 21	Day 28
8	5	3	2	1	1
12	5	5	5	5	5
16	5	5	4	3	2

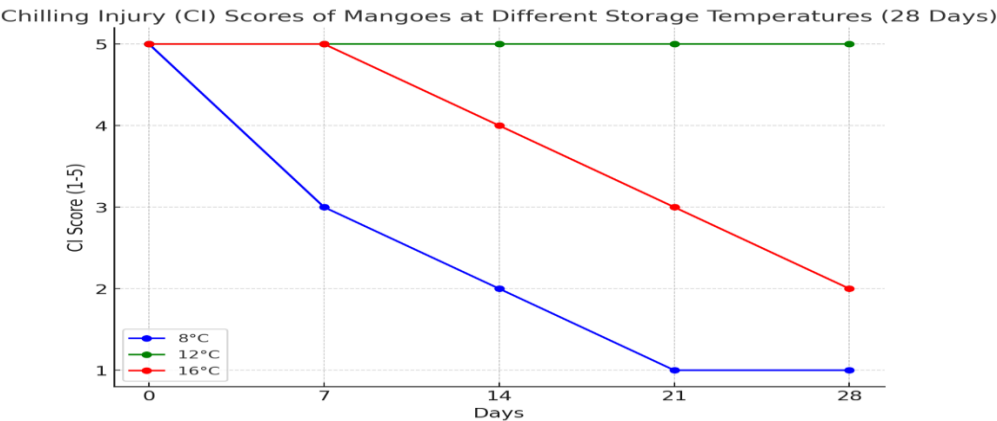


Figure 4: Chilling Injury of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Texture Profile Analysis (TPA)

Mangoes were stored at various temperatures (8, 12 and 16 °C) in 28 days to examine Texture Profile Analysis (TPA) which included hardness, gumminess, and chewiness. The TA-XT2 texture analyzer was used to measure the texture properties, and the tables and graphs below provide the summary. The parameters of TPA were measured in Newtons (N), which are important in assessing the net sensory experience and shelf life of the fruit. The results are also comparable to the prior research, which has indicated the best storage temperature that preserves the texture of mangoes (Sivakumar et al., 2011; Yahia et al., 2019; Khadka et al., 2017).

Hardness

The highest force was the hardness of the mango, which was recorded at 12 °C, and kept the mango in the best texture during the storage time. Mangoes at 8 °C had a gradual increase in hardness whereas mangoes at 16 °C experienced the greatest drop in hardness that indicates the increased rate of tissue ripening and degradation at elevated temperatures. Such trends are in line with the results of Sivakumar et al. (2011) as well as Yahia et al. (2019), who highlight that low and high temperatures do not preserve firmness as well as

12C does.

Gumminess

Gumminess, a factor connected with the feel following early compression also showed the same tendency. Mangoes stored at 12 °C were the most gumminess meaning that the tissue was cohesive and not easily broken. The gumminess reduced at 8 °C (moderately) whereas mangoes at 16 °C underwent rapid loss of gumminess, which is in line with the faster metabolic rate in high temperatures (Khadka et al., 2017).

Chewiness

There was a similar trend as in gumminess and hardness with chewiness, which is the amount of effort needed to chew the mango following the compression. Stored mangoes at 12 °C were found to be the best in the retention of chewiness, with minimum loss during the 28 days, and mango ripening was observed to have great influences on the storage of the mangoes at 8 °C and 16 °C. This observation also confirms the idea that 12 °C is the best temperature at which to store mangoes such that their texture and chewiness are maintained. The temperatures lead to high cell wall breakdown and faster ripening which has adverse effects on the texture of the fruit.

Table 5 (a): Effect of different storage temperatures on Texture Profile parameters of mangoes during 28 days

Storage Temperature (°C)	Day 0 (Hardness N)	Day 7 (Hardness N)	Day 14 (Hardness N)	Day 21 (Hardness N)	Day 28 (Hardness N)
8	6.0	4.9	4.5	4.1	3.5
12	6.0	5.6	5.4	5.2	5.1
16	6.0	5.1	4.5	4.1	3.9

Table 5 (b): Effect of different storage temperatures on Texture Profile parameters of mangoes during 28 days.

Storage Temperature (°C)	Day 0 (Chewiness N)	Day 7 (Chewiness N)	Day 14 (Chewiness N)	Day 21 (Chewiness N)	Day 28 (Chewiness N)
8	5.0	4.8	4.3	4.0	3.6
12	5.0	4.9	4.8	4.7	4.5
16	5.0	4.6	4.2	3.8	3.4

Table 5 (c): Effect of different storage temperatures on Texture Profile parameters of mangoes during 28 day.

Storage Temperature (°C)	Day 0 (Gumminess N)	Day 7 (Gumminess N)	Day 14 (Gumminess N)	Day 21 (Gumminess N)	Day 28 (Gumminess N)
8	4.8	4.6	4.2	4.0	3.7
12	4.8	4.7	4.6	4.4	4.3
16	4.8	4.5	4.1	3.7	3.5

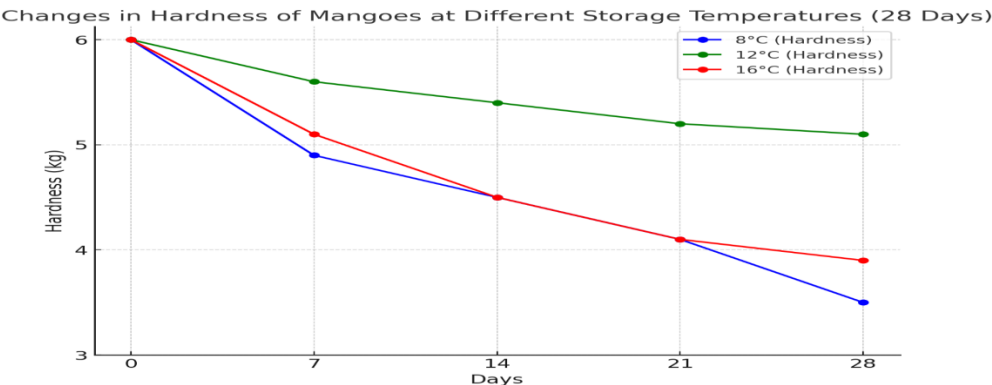


Figure 5(a): Texture Profile Analysis (Hardness) of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

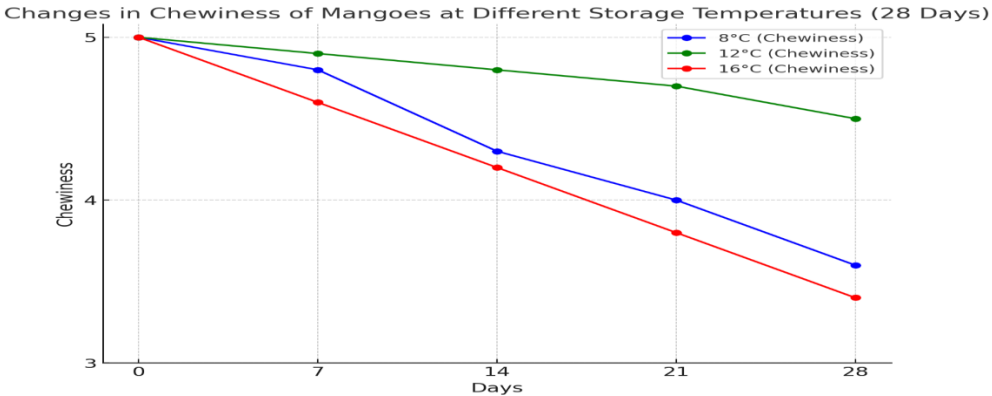


Figure 5(b): Texture Profile Analysis (Chewiness) of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

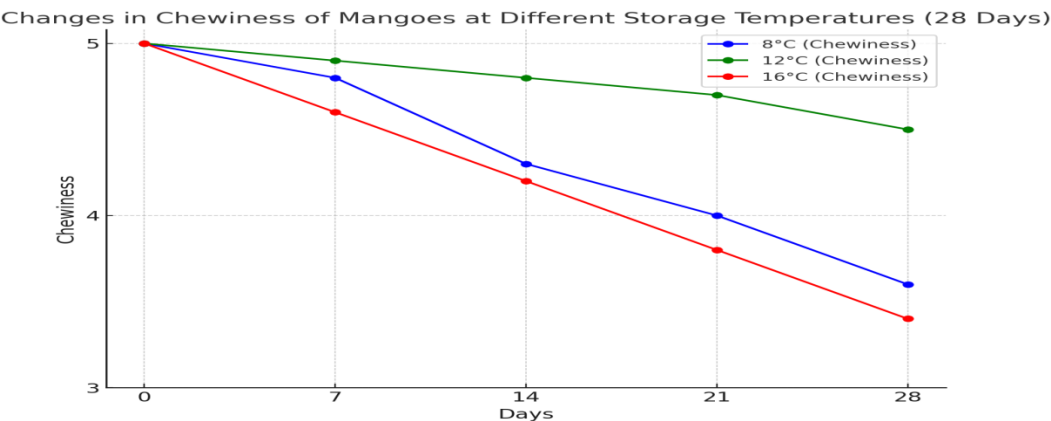


Figure 5(c): Texture Profile Analysis (Gumminess) of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

Sensory Evaluation

The Sensory Evaluation results demonstrated a clear influence of storage temperature on the taste, aroma, texture, and overall acceptability of Azeem Chaunsa mangoes. As shown in Table 6 and Figure 6, mangoes stored at 12°C achieved the highest sensory scores across all parameters, confirming that this temperature enables optimal ripening while maintaining sweetness, aroma, and texture balance. The controlled ripening at 12°C helped preserve volatile compounds and sugar–acid balance, enhancing the fruit’s flavor and consumer appeal (Sivakumar et al., 2011; Yahia et al., 2019). Mangoes stored at 8°C, although still acceptable, received lower scores for texture and aroma,

likely due to the delayed ripening process that hindered full flavor and aroma development (Khadka et al., 2017). In contrast, mangoes stored at 16°C obtained the lowest sensory ratings, as the accelerated ripening led to textural softening, off-flavors, and reduced overall acceptability (Ghafoor et al., 2022). These findings are consistent with previous research emphasizing that 12°C is the optimal temperature for maintaining the sensory quality of mangoes, balancing the rate of ripening with flavor retention and textural integrity (Sarananda, 2000; Lizada, 1993). Therefore, storing mangoes at 12°C ensures superior consumer satisfaction by preserving the key sensory traits that define high-quality fruit.

Table 6: Effect of storage temperature on sensory attributes of mangoes (28-day storage period).

Storage Temperature (°C)	Taste	Aroma	Texture	Overall Acceptability
8	6.8	6.5	6.2	6.4
12	8.9	8.7	8.5	8.8
16	6.0	5.8	5.5	5.7

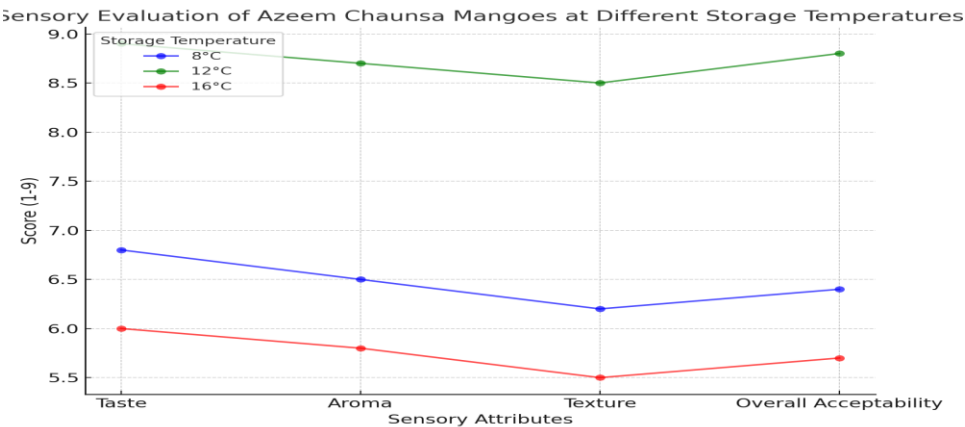


Figure 6: Sensory Evaluation of Azeem Chaunsa mangoes at different storage temperatures (8°C, 12°C, 16°C) over 28 days.

CONCLUSIONS

The research thoroughly examined how various storage temperatures affect the postharvest quality of Azeem Chaunsa mangoes by evaluating factors like weight loss, chilling injury, total soluble solids (TSS), titratable acidity (TA), texture profile analysis (TPA), and sensory evaluation. The results indicated that storage temperature significantly impacted the physicochemical and sensory attributes of mangoes over a 28-day storage period. Mangoes kept at 12°C showed the least weight loss, minimal chilling injury, and the highest TSS levels, suggesting optimal ripening and preservation of fruit quality. This temperature also maintained stable titratable acidity, ensuring a pleasing balance of sweetness and tartness. Furthermore, texture profile analysis demonstrated that mangoes stored at 12°C retained firmness and chewiness more effectively than those stored at other temperatures. Sensory evaluation confirmed that fruits stored at this temperature received higher scores for taste, aroma, texture, and overall acceptability. Conversely, mangoes stored at 8°C experienced delayed ripening with moderate quality deterioration, while those kept at 16°C underwent accelerated ripening, increased weight loss, and significant textural and sensory degradation. Thus, it can be concluded that 12°C is the ideal storage temperature for preserving the overall postharvest quality, sensory appeal, and marketability of Azeem Chaunsa mangoes, ensuring a longer shelf life without compromising their desirable traits.

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