Journal of Natural Science Review

Vol. 4, No. 1, 2026
https://kujnsr.com
e-ISSN: 3006-7804

# Standardizing Recipe for Pomegranate and Apple Blended Nectar

**Atiqullah Muslim[1], Hamid Salari[2], Mohammadullah Amin[✉3],**

[1 2 3 4 5]Kabul University, Horticulture Department, Agriculture Faculty, Kabul, Afghanistan

✉E-mail: mohammadullah.amin74@gmail.com (corresponding author)

**ABSTRACT**

This study was carried out during 2024–2025 at the Laboratory of the Horticulture Department, Faculty of Agriculture, Kabul University, Afghanistan, with the objective of developing a blended pomegranate–apple nectar of acceptable quality and economic feasibility. The experiment was arranged in a split-plot Completely Randomized Design (CRD) with three replications and eleven treatments representing different juice blending ratios. The study assessed chemical properties (TSS, sugars, acidity, and pH), biological stability, sensory attributes, and economic performance of the nectar during storage. The results indicated that increasing storage duration led to a gradual rise in total soluble solids (TSS), reducing sugars, total sugars, and acidity, while pH and non-reducing sugars decreased. The application of sodium benzoate along with proper sterilization and pasteurization effectively prevented microbial spoilage throughout the storage period. Sensory evaluation demonstrated a general decline in appearance, flavor, mouthfeel, and overall acceptability with prolonged storage, with the highest scores recorded at the initial stage and the lowest after 90 days. Blends containing higher proportions of apple juice consistently showed better sensory quality. Among the treatments, T11 (100% apple juice) achieved the highest scores for appearance, color, and aroma, whereas T10 (10% pomegranate and 90% apple juice) ranked highest for flavor, mouthfeel, and overall acceptability. Economic analysis revealed that T10 generated a net return of 1.57 AFN per AFN invested. Therefore, T10 is recommended as the most suitable formulation for blended pomegranate–apple nectar production.

**ARTICLE INFO**

**Article history:**

Received: August 28, 2025
Revised: January 26, 2026
Accepted: February 14, 2026
Published: March 31, 2026

**Keywords:**

*Apple; Blended; Nectar; Pomegranate; Sensory evaluation*

**To cite this article**: Muslim, A., Salari, H., Amin, M., Nasrat, N. A., Rashidi, M. K. (2026 Standardizing Recipe for Pomegranate and Apple Blended Nectar. Journal of Natural Science Review, 4 (1), 93-113. https://doi.org/10.62810/jnsr.v4i1.304

**Link to this article**: https://kujnsr.com/JNSR/article/view/304

Copyright © 2026 Author(s). This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.

## INTRODUCTION

Pomegranate (*Punica granatum* L.), belonging to the Punicaceae family, is recognized as one of the most ancient cultivated fruit tree species known to humanity. Although its origin is traced to Central Asia, particularly Persia and surrounding regions, the crop has achieved global distribution due to its remarkable adaptability to diverse agro-climatic conditions (Teixeira Da Silva et al., 2013; Tinebra et al., 2021). The Punicaceae family consists of a single genus (*Punica*) comprising two species, *P. granatum* and *P. protopunica*, with *P. granatum* being the economically dominant species worldwide. The scientific name is derived from the Latin words *pomum* (apple) and *granatus* (grainy or seeded), collectively referring to a "seeded apple," a term that accurately reflects the fruit's morphology (Teixeira Da Silva et al., 2013).

Genetic and geographical studies classify pomegranate diversity into three mega-centers—primary, secondary, and tertiary—and five macro-centers including the Middle Eastern, Mediterranean, Eastern Asian, American, and South African regions. Among these, the Middle Eastern and Central Asian regions are considered the primary centers of origin and diversity (Kahramanoglu and Usanmaz, 2016; Teixeira Da Silva et al., 2013; Parashuram et al., 2022). Pomegranate is a deciduous, long-lived, and drought-tolerant fruit tree that thrives particularly well in arid and semi-arid environments. Its low respiration rate and minimal ethylene production categorize it as a non-climacteric fruit, making it well suited for extended storage under proper conditions (Tinebra et al., 2021).

Pomegranate cultivation is successful across a wide range of soil types, including clay loam, sandy loam, chestnut, black earth, and alluvial soils. However, fertile, deep, well-drained, humus-rich soils of medium texture are considered optimal for high-quality fruit production (Teixeira Da Silva et al., 2013). Flowering occurs approximately one month after bud break on newly developed shoots, with flowers appearing singly or in clusters. Pomegranate exhibits three floral types—hermaphrodite, male, and intermediate—each influencing fruit set and yield potential. Pollen germination is strongly temperature-dependent, reaching maximum efficiency at 25–35°C, while significantly declining at lower temperatures. Climatic conditions also affect flowering behavior, with near year-round flowering in tropical regions and a single flowering season in subtropical areas (Teixeira Da Silva et al., 2013).

From a nutritional and medicinal perspective, pomegranate is widely regarded as a potent antioxidant-rich fruit. It contains a diverse array of bioactive compounds including flavonoids, anthocyanins, ellagitannins, punicic acid, alkaloids, organic acids, and sugars, which collectively confer anti-inflammatory, antihypertensive, antiatherogenic, and anticancer properties (Saroj et al., 2020; Zarfeshany et al., 2014). Approximately 153 phytochemicals and their derivatives have been identified in different parts of the pomegranate plant, with polyphenols representing the most dominant group, particularly concentrated in the peel (Zarfeshany et al., 2014). These compounds exert beneficial effects through modulation of gene expression and cellular signaling pathways, contributing to the prevention and management of chronic diseases such as cardiovascular disorders, arthritis, cancer, and metabolic syndromes.

Nutritionally, 100 g of raw pomegranate provides approximately 83 kcal of energy, with high water content (77.93 g), moderate carbohydrate levels (18.7 g), dietary fiber (4 g), and essential minerals such as potassium, phosphorus, calcium, and magnesium. It also supplies vitamin C and various trace elements, reinforcing its role as a functional food (Sabale et al., 2020; Higa et al., 2017). Different plant parts exhibit distinct phytochemical profiles: the peel is rich in punicalagin and ellagic acid, the juice contains sugars and organic acids, the seeds are abundant in fatty acids such as punicic and linoleic acid, while roots, bark, leaves, and flowers contain alkaloids, tannins, flavonoids, and triterpenoids (Sabale et al., 2020; Golmakani et al., 2021). Among cultivars, 'Wonderful' has been reported to exhibit superior bioactive properties, although varietal identification is often lacking in clinical studies, limiting reproducibility (Melgarejo-Sánchez et al., 2021).

Pomegranate juice is particularly valued for its balanced composition of natural sugars and organic acids, including citric, malic, and ascorbic acids, as well as essential amino acids. These attributes enhance its antioxidant capacity and therapeutic potential. Moreover, pomegranate extracts have been shown to improve glucose metabolism, reduce atherogenic lipoproteins, and suppress inflammation and angiogenesis, supporting their role in functional beverage development (Anwar et al., 2024).

Apple (*Malus domestica* Borkh.), a member of the Rosaceae family, is among the most widely cultivated and economically important temperate fruits. Nearly the entire fruit is edible, and apples serve as raw material for a wide range of processed products such as juices, cider, jams, dried fruits, and fermented beverages. Apples are recognized for their immune-boosting, antioxidant, and stress-reducing properties, which have been validated through modern evidence-based research (Balık et al., 2023; Patocka et al., 2020; Millán-Laleona et al., 2023). Nutritionally, apples are low in fat and protein but rich in carbohydrates, dietary fiber, minerals, and vitamins, particularly vitamin C and potassium. Variations exist among traditional and exotic cultivars in terms of energy content, sugars, fiber, organic acids, and micronutrients (Arnold and Gramza-Michalowska, 2024; Banjare, 2020).

Apple juice has gained attention as a functional food due to its potential health benefits, including cardiovascular protection, anti-aging effects, weight management, and neuroprotective properties. Cloudy apple juice, in particular, retains higher levels of polyphenols compared to clear juice, enhancing its nutritional value (Vallée Marcotte et al., 2022; Girotto et al., 2025). Additionally, apple pectin plays a crucial role in the food and pharmaceutical industries as a natural gelling and stabilizing agent, with demonstrated detoxifying properties against heavy metals (Zhao et al., 2018; El-Messery et al., 2019).

Blending fruit juices has emerged as an effective strategy to enhance nutritional quality, sensory acceptability, and consumer appeal. Juice blends help balance sugar-to-acid ratios, improve texture, and increase vitamin and mineral content, resulting in superior nectar or ready-to-serve beverages compared to single-fruit juices (Anwar et al., 2024). Combining pomegranate and apple juices offers complementary nutritional and sensory attributes, making such blends highly promising for functional beverage development.

Afghanistan possesses favorable climatic conditions for the production of both pomegranates and apples. Despite challenges related to post-harvest handling, storage, packaging, and processing infrastructure, these fruits remain economically important. However, limited research exists on the formulation, nutritional evaluation, and storage stability of pomegranate–apple blended nectar under local conditions. Furthermore, standardized recipes suitable for commercial production are lacking, and market demand for blended fruit beverages exceeds supply. Therefore, the present study was undertaken to develop value-added pomegranate–apple blended nectar, evaluate its nutritional and chemical properties, assess changes during storage, and determine its organoleptic quality and overall suitability for commercialization.

- How can a value-added blended nectar be developed using pomegranate and apple juice?
- What are the nutritional qualities and storage stability characteristics of the prepared pomegranate–apple blended nectar?
- How does the chemical composition of the pomegranate–apple blended nectar change during different storage periods?
- How does storage duration affect the organoleptic (sensory) qualities of the pomegranate–apple blended nectar?

## METHODS AND MATERIALS

The research was carried out at the laboratory of the horticulture department of the agriculture faculty of Kabul University from 2024 to 2025, utilizing a Split Plot CRD. The detailed methods and materials are described in this chapter.

The materials utilized in this investigation comprised freshly harvested pomegranate (cv. Kandhari) and apple (cv. Red Delicious), along with supplementary ingredients such as refined sugar, citric acid, sodium benzoate, and potable water. Packaging was done using 250 mL glass bottles. All required inputs were procured from nearby commercial sources.

To extract juice from pomegranate and apple, the apple fruits were first thoroughly washed in clean water. They were then cut into pieces using a stainless-steel knife to facilitate pulp extraction. The seeds and other fibrous materials were removed from the central cavity. Juice was extracted using a juicer, then homogenized and filtered through muslin cloth. Similarly, ripened pomegranate fruits were washed, cut open, and the arils were collected. The arils were manually pressed in muslin cloth to extract the juice, which was then homogenized and filtered using muslin cloth.

The blended juice intended for nectar formulation was prepared by combining pomegranate and apple juices in eleven different proportions, as outlined in Table 1.

**Table 1**. Recipe for nectar (according to codex standards - CXS 247-2005).

| Treatment | Juice (%) | TSS (°B) | Acidity (%) |
|---|---|---|---|
| **$T_1$** | 25 % (100 % pomegranate juice) | 13 | 0.3 |
| **$T_2$** | 25 % (90 % pomegranate juice with 10 % apple juice) | 13 | 0.3 |
| **$T_3$** | 25 % (80 % pomegranate juice with 20 % apple juice) | 13 | 0.3 |
| **$T_4$** | 25 % (70 % pomegranate juice with 30 % apple juice) | 13 | 0.3 |
| **$T_5$** | 25 % (60 % pomegranate juice with 40 % apple juice) | 13 | 0.3 |
| **$T_6$** | 25 % (50 % pomegranate juice with 50 % apple juice) | 13 | 0.3 |
| **$T_7$** | 25 % (40 % pomegranate juice with 60 % apple juice) | 13 | 0.3 |
| **$T_8$** | 25 % (30 % pomegranate juice with 70 % apple juice) | 13 | 0.3 |
| **$T_9$** | 25 % (20 % pomegranate juice with 80 % apple juice) | 13 | 0.3 |

| | | | |
|---|---|---|---|
| **$T_{10}$** | 25 % (10 % pomegranate juice with 90 % apple juice) | 13 | 0.3 |
| **$T_{11}$** | 25 % (100 % apple juice) | 13 | 0.3 |

According to Table 1, the blended apple–pomegranate nectar contained 75% sugar syrup and 25% mixed fruit juice (apple and pomegranate). The treatments for the 25% blended apple and pomegranate juice were prepared using predetermined proportions. TSS of each blend was then measured and adjusted to 13°Brix by adding a sugar syrup prepared by dissolving sugar in warm water. The acidity level was also analyzed and adjusted to the desired level (0.3%) using citric acid. Sodium benzoate (120 ppm), dissolved in a small volume of warm water, was added as a preservative. The final product was filled into 250 mL bottles and sealed with metal caps using a capping machine. The sealed bottles were pasteurized by immersing them in near-boiling water for 25 minutes and then stored at room temperature.

In physical parameters of fruits, a total of five pomegranates and five apples were randomly chosen for evaluation. Each fruit was assessed based on three physical characteristics: size, weight, and juice yield percentage. The data collected from these measurements were averaged to document the final results. The physical parameters of the fruits included fruit size, fruit weight, and juice recovery percentage.

***Juice Recovery $_{(\%)}$ = [Volume of Fruit Juice $_{(mL)}$ / Total Fruit Weight $_{(g)}$] ×100***

In chemical parameters, the pomegranate and apple nectar were analyzed for pH, TSS, reducing sugars, non-reducing sugars, total sugars, and acidity at monthly intervals up to three months during storage at ambient temperature. In biological parameters of the nectar spoilage was studied.

In nectar sensory evaluation, A sensory panel of 10 untrained individuals with basic expertise in organoleptic evaluation conducted the sensory assessment of the nectar. The attributes evaluated included appearance, aroma, flavor, color, mouthfeel, and overall acceptability. All juice samples from the treatments were rated using a 9-point Hedonic scale, where 9: like extremely, 8: like very much, 7: like moderately, 6: like slightly, 5: neither like nor dislike, 4: dislike slightly, 3: dislike moderately, 2: dislike very much, and 1: dislike extremely.

In economic evaluation of nectar, A comprehensive economic analysis was conducted to assess the most effective treatment for product cost-efficiency. The net profit was determined based on the formula below:

***Net Income = Total Income – Total Cost***

Given that the benefit-cost ratio serves as a reliable metric for evaluating the commercial viability of the product, it was likewise computed using the following equation:

***Benefit-Cost Ratio = Total Income / Total Cost***

The experiment was laid out using a Split Plot design within a CRD framework, incorporating three replications. Data obtained from the study were analyzed using the STAR software, and treatment means were compared employing the LSD test at a 1 and 5% level of significance.

## FINDINGS

The results of the data collected from various research parameters, which were analyzed using STAR software, and are displayed in different tables.

### *Physical Parameters of Fruits*

In this study, the Kandhari pomegranate exhibited the following characteristics: an average diameter of 8.3 cm, an average length of 8.5 cm, and an average fruit weight of 395 g. TSS measured 11.5° Brix, the titratable acidity was 0.83 %, and the average juice recovery was 42 %. Similarly, the Red Delicious apple used in this study had an average diameter of 7.1 cm, an average length of 7.5 cm, juice recovery was 73 %, and an average weight of 174 g. Its total soluble solids measured 11 ° Brix, and its titratable acidity was 0.2 %.

### *TSS*

The TSS changes for each treatment across three storage intervals are presented in Table 2. At the initial stage, all treatments had a uniform TSS of 13°Brix.

**Table 2:** Effect of juice blending ratio and storage period on TSS of blended nectar (° Brix).

| | **Storage Period** | | | |
|---|---|---|---|---|
| | **Initial** | **30 Days** | **60 Days** | **90 Days** |
| **$T_1$** | 13.00 a | 14.93 de | 15.80 de | 16.75 de |
| **$T_2$** | 13.00 a | 15.10 cd | 15.96 cd | 16.91 cd |
| **$T_3$** | 13.00 a | 15.07 cd | 15.93 cd | 16.88 cd |
| **$T_4$** | 13.00 a | 15.33 ab | 16.18 ab | 17.13 ab |
| **$T_5$** | 13.00 a | 14.53 f | 15.43 f | 16.37 f |
| **$T_6$** | 13.00 a | 14.20 g | 15.12 g | 16.05 g |
| **$T_7$** | 13.00 a | 15.23 abc | 16.09 abc | 17.03 abc |
| **$T_8$** | 13.00 a | 15.43 a | 16.27 a | 17.22 a |
| **$T_9$** | 13.00 a | 15.10 cd | 15.96 cd | 16.91 cd |
| **$T_{10}$** | 13.00 a | 15.17 bc | 16.02 bc | 16.97 bc |
| **$T_{11}$** | 13.00 a | 14.83 e | 15.71 e | 16.65 e |
| **Factor** | **F-test** | **LSD (5%)** | **CV (%)** | |
| Storage Period (A) | * | - | 0.86 | |
| PmJ & ApJ % (B) | * | - | 0.84 | |
| A X B | * | 0.20 | - | |

**PmJ**: Pomegranate Juice, **ApJ**: Apple juice, **CV:** Coefficient of Variation**, LSD:** Least Significant Difference. ***:** 5% Significance. **Within** each column, means followed by different lowercase letters (a, b, c, ...) indicate significant differences according to the LSD test.

After 30 days of storage, the highest TSS was recorded in T8, while T6 showed the lowest value. Similarly, at both 60- and 90-day intervals, T8 consistently maintained the highest TSS, whereas T6 recorded the lowest values throughout the storage period.

### *pH*

The results of the study, at the 5% probability level, indicated that storage duration had a significant effect on the pH of the blended nectar (Table 3). Over time, the pH of the nectar decreased, with the highest value recorded at the initial storage stage and the lowest after 90 days.

***Table 3.*** *Effect of juice blending ratio and storage period on pH of pomegranate and apple blended nectar*

| Factor B | Factor A | | | | Factor B Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **T1** | 4.27 | 4.07 | 3.90 | 3.77 | **4.00 g** |
| **T2** | 4.47 | 4.27 | 4.07 | 3.97 | **4.19 f** |
| **T3** | 4.57 | 4.37 | 4.17 | 4.03 | **4.28 f** |
| **T4** | 4.83 | 4.63 | 4.43 | 4.23 | **4.53 e** |
| **T5** | 4.97 | 4.77 | 4.57 | 4.37 | **4.67 d** |
| **T6** | 5.10 | 4.90 | 4.70 | 4.50 | **4.80 c** |
| **T7** | 5.20 | 5.00 | 4.77 | 4.60 | **4.89 c** |
| **T8** | 5.47 | 5.27 | 5.00 | 4.80 | **5.13 b** |
| **T9** | 5.50 | 5.30 | 5.03 | 4.83 | **5.17 b** |
| **T10** | 5.73 | 5.50 | 5.23 | 5.03 | **5.38 a** |
| **T11** | 5.77 | 5.50 | 5.27 | 5.07 | **5.40 a** |
| **Factor A Means** | **5.08 A** | **4.87 B** | **4.65 C** | **4.47 D** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | * | 0.1 | | 3.9 | |
| PmJ & ApJ % (B) | * | 0.13 | | 3.37 | |
| A X B | Ns | - | | - | |

Within each row, means followed by different uppercase letters (A, B, C, ...) indicate significant differences according to the LSD test.

Additionally, different blending ratios of pomegranate and apple juice significantly influenced the pH of the nectar at the 5% probability level. Treatment T11 recorded the highest pH, whereas T1 showed the lowest. According to the LSD test, means sharing the same letters were not significantly different from each other.

### *Reducing Sugar*

The results of the study indicated that storage duration had a statistically significant effect on the reducing sugar content of the nectar at the 5% probability level Table 4. The highest reducing sugar content was recorded after 90 days of storage, while the lowest was observed at the initial stage. According to the LSD test, means sharing the same letters were not significantly different from each other.

**Table 4.** *Effect of juice blending ratio and storage period on reducing sugar of blended nectar (%)*

| Factor B | Factor A | | | | Factor B Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **T1** | 5.05 | 6.84 | 7.78 | 8.95 | **6.55 c** |
| **T2** | 4.93 | 6.82 | 7.73 | 8.89 | **6.47 cd** |
| **T3** | 5.18 | 7.16 | 8.13 | 9.35 | **6.80 bc** |
| **T4** | 5.11 | 7.28 | 8.24 | 9.47 | **6.84 bc** |
| **T5** | 4.71 | 6.17 | 7.14 | 8.20 | **5.99 e** |
| **T6** | 4.97 | 6.05 | 6.95 | 8.00 | **6.03 de** |
| **T7** | 5.18 | 7.15 | 8.04 | 9.25 | **6.79 bc** |

| | | | | | |
|---|---|---|---|---|---|
| **$T_8$** | 5.66 | 7.72 | 8.57 | 9.86 | **7.37 a** |
| **$T_9$** | 5.63 | 7.39 | 8.23 | 9.46 | **7.14 ab** |
| **$T_{10}$** | 5.18 | 7.06 | 7.94 | 9.13 | **6.74 bc** |
| **$T_{11}$** | 5.29 | 6.81 | 7.69 | 8.84 | **6.81 bc** |
| **Factor A Means** | **5.17 D** | **6.95 C** | **7.86 B** | **9.04 A** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | * | 0.2 | | 5.01 | |
| PmJ & ApJ % (B) | * | 0.24 | | 4.17 | |
| A X B | Ns | - | | - | |

Similarly, different blending ratios of pomegranate and apple juice significantly influenced the reducing sugar content of the blended nectar. Treatment T8 recorded the highest value, whereas T5 showed the lowest. Based on the LSD test, means sharing the same letters were not significantly different.

### *Non-Reducing Sugar*

The results of the study indicated that storage duration and different blending ratios of pomegranate and apple juices had a significant effect on the non-reducing sugar content of the blended nectar Table 5.

**Table 5.** *Effect of juice blending ratio and storage period on none-reducing sugar of blended nectar (%)*

| Factor B | Factor A | | | | Factor B Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **$T_1$** | 5.05 | 6.84 | 7.78 | 8.95 | **5.93 bc** |
| **$T_2$** | 4.93 | 6.82 | 7.73 | 8.89 | **5.73 c** |
| **$T_3$** | 5.18 | 7.16 | 8.13 | 9.35 | **6.12 b** |
| **$T_4$** | 5.11 | 7.28 | 8.24 | 9.47 | **5.93 bc** |
| **$T_5$** | 4.71 | 6.17 | 7.14 | 8.20 | **6.54 a** |
| **$T_6$** | 4.97 | 6.05 | 6.95 | 8.00 | **5.76 c** |
| **$T_7$** | 5.18 | 7.15 | 8.04 | 9.25 | **5.33 d** |
| **$T_8$** | 5.66 | 7.72 | 8.57 | 9.86 | **4.50 e** |
| **$T_9$** | 5.63 | 7.39 | 8.23 | 9.46 | **4.49 e** |
| **$T_{10}$** | 5.18 | 7.06 | 7.94 | 9.13 | **5.19 d** |
| **$T_{11}$** | 5.29 | 6.81 | 7.69 | 8.84 | **4.67 e** |
| **Factor A Means** | **5.70 A** | **5.59 A** | **5.41 B** | **5.19 C** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | * | 0.17 | | 5.55 | |
| PmJ & ApJ % (B) | * | 0.3 | | 6.91 | |
| A X B | Ns | - | | - | |

Storage duration significantly influenced non-reducing sugar content, with the highest value recorded at the initial stage and the lowest observed after 90 days, indicating a decreasing trend over time. According to the LSD test at the 5% significance level, means sharing the same letters were not significantly different from each other. Similarly, blending treatments significantly affected non-reducing sugar content at the 5% probability level. Treatment T5 recorded the highest value, whereas T9 showed the lowest. Based on the LSD test (5% level), means with common letters did not differ significantly.

### *Total Sugars*

The results indicated that, at the 5% significance level, storage duration and different blending ratios of pomegranate and apple juices significantly affected the total sugar content of the blended nectar Table 6.

**Table 6.** *Effect of juice blending ratio and storage period on total sugar of blended nectar (%)*

| Factor B | Factor A | | | | Factor A Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **$T_1$** | 11.23 | 12.90 | 13.65 | 14.47 | **13.06 bc** |
| **$T_2$** | 10.91 | 12.67 | 13.39 | 14.19 | **12.79 cd** |
| **$T_3$** | 11.57 | 13.41 | 14.17 | 15.02 | **13.54 a** |
| **$T_4$** | 11.31 | 13.34 | 14.08 | 14.91 | **13.41 a** |
| **$T_5$** | 11.48 | 12.83 | 13.62 | 14.46 | **13.10 b** |
| **$T_6$** | 10.91 | 11.92 | 12.69 | 13.48 | **12.25 fg** |
| **$T_7$** | 10.75 | 12.59 | 13.30 | 14.08 | **12.68 de** |
| **$T_8$** | 10.38 | 12.33 | 13.00 | 13.76 | **12.37 fg** |
| **$T_9$** | 10.31 | 11.97 | 12.66 | 13.41 | **12.09 g** |
| **$T_{10}$** | 10.60 | 12.36 | 13.06 | 13.84 | **12.47 ef** |
| **$T_{11}$** | 10.17 | 11.60 | 12.29 | 13.02 | **11.77 h** |
| **Factor B Means** | **10.87 D** | **12.54 C** | **13.27 B** | **14.06 A** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | * | 0.15 | | 2.09 | |
| PmJ & ApJ % (B) | * | 0.3 | | 2.91 | |
| A X B | Ns | - | | - | |

At the same significance level, the highest total sugar content was recorded after 90 days of storage, whereas the lowest value was observed at the initial stage. According to the LSD test (5% level), means sharing the same letters were not significantly different from each other. Similarly, juice combinations had a significant effect on total sugar content at the 5% probability level. Treatment T3 recorded the highest total sugar content, while T11 showed the lowest. Based on the LSD test (5% level), means with common letters did not differ significantly.

### *Titratable Acidity*

The results indicated that, at the 1% probability level, storage duration and different blending ratios of pomegranate and apple juices had a significant effect on the titratable acidity of the blended nectar Table 7.

**Table 7.** *Effect of juice blending ratio and storage period on titratable acidity of blended nectar (%)*

| Treatment | Storage Period | | | |
|---|---|---|---|---|
| | Initial | 30 Days | 60 Days | 90 Days |
| **$T_1$** | 0.300 a | 0.361 a | 0.463 bcd | 0.540 cd |
| **$T_2$** | 0.300 a | 0.358 a | 0.453 cde | 0.515 de |
| **$T_3$** | 0.300 a | 0.359 a | 0.455 cde | 0.520 de |
| **$T_4$** | 0.300 a | 0.355 a | 0.439 de | 0.482 fg |
| **$T_5$** | 0.300 a | 0.368 a | 0.487 ab | 0.602 b |
| **$T_6$** | 0.300 a | 0.375 a | 0.509 a | 0.658 a |
| **$T_7$** | 0.300 a | 0.356 a | 0.445 cde | 0.495 ef |
| **$T_8$** | 0.300 a | 0.353 a | 0.434 e | 0.468 g |

| Treatment | Storage Period | | | |
|---|---|---|---|---|
| | Initial | 30 Days | 60 Days | 90 Days |
| **$T_9$** | 0.300 a | 0.358 a | 0.453 cde | 0.515 de |
| **$T_{10}$** | 0.300 a | 0.357 a | 0.449 cde | 0.506 ef |
| **$T_{11}$** | 0.300 a | 0.363 a | 0.469 bc | 0.555 c |
| **Factor** | **F-test** | **LSD $_{(1\%)}$** | **CV $_{(\%)}$** | |
| Storage Period (A) | ** | - | 3.09 | |
| PmJ & ApJ % (B) | ** | - | 2.92 | |
| A X B | ** | 0.04 | - | |

***: 1% Significance.*

### *Nectar Spoilage*

During the three-month storage period, no signs of juice spoilage were observed or recorded in any of the eleven different combinations of pomegranate and apple juice in the blended nectar.

### *Appearance*

The results indicated that storage duration and different blending ratios of pomegranate and apple juices significantly affected the appearance of the blended nectar Table 8.

**Table 8.** *Effect of juice blending ratio and storage period on appearance of blended nectar*

| Factor B | Factor A | | | | Factor A Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **$T_1$** | 7.5 | 6.6 | 6.5 | 6.6 | **6.80 f** |
| **$T_2$** | 7.7 | 6.9 | 6.7 | 5.7 | **6.75 f** |
| **$T_3$** | 7.8 | 7.1 | 6.8 | 5.8 | **6.88 f** |
| **$T_4$** | 8.1 | 7.6 | 7.1 | 6.1 | **7.22 ef** |
| **$T_5$** | 8.3 | 7.9 | 7.4 | 6.4 | **7.50 de** |
| **$T_6$** | 8.7 | 8.5 | 7.8 | 6.8 | **7.95 cd** |
| **$T_7$** | 8.8 | 8.6 | 8.1 | 7.1 | **8.15 bc** |
| **$T_8$** | 8.9 | 8.8 | 8.4 | 7.4 | **8.38 abc** |
| **$T_9$** | 9.0 | 9.0 | 8.6 | 7.6 | **8.55 ab** |
| **$T_{10}$** | 8.9 | 8.8 | 8.6 | 7.9 | **8.55 ab** |
| **$T_{11}$** | 9.0 | 9.0 | 8.7 | 8.0 | **8.68 a** |
| **Factor B Means** | **8.43 A** | **8.7 B** | **7.70 C** | **6.85 D** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | ** | 0.33 | | 11.47 | |
| PmJ & ApJ % (B) | ** | 0.5 | | 11.04 | |
| A X B | Ns | - | | - | |

At the 1% probability level, storage duration had a significant effect on appearance, with the highest scores recorded at the initial stage and the lowest observed after 90 days of storage, indicating a gradual decline in visual quality over time. According to the LSD test, means sharing the same letters were not significantly different from each other. Similarly, increasing the proportion of apple juice improved the appearance scores of the blended nectar. Treatment T11 recorded the highest score, whereas T2 showed the lowest. Based on the LSD test at the 1% significance level, treatments with common letters did not differ significantly.

### *Color*

The results indicated that storage duration and different blending ratios of pomegranate and apple juices had a significant effect on the color of the blended nectar.

***Table 9.*** *Effect of juice blending ratio and storage period on color of blended nectar*

| Factor B | Factor A<br>Initial | 15 Days | 30 Days | 45 Days | Factor B Means |
|---|---|---|---|---|---|
| $T_1$ | 8.4 | 8.1 | 7.9 | 7.0 | **7.85 bc** |
| $T_2$ | 7.9 | 7.4 | 7.0 | 6.1 | **7.10 e** |
| $T_3$ | 8.0 | 7.5 | 7.0 | 6.0 | **7.12 e** |
| $T_4$ | 8.1 | 7.6 | 7.1 | 6.1 | **7.22 de** |
| $T_5$ | 8.4 | 8.0 | 7.4 | 6.4 | **7.55 cde** |
| $T_6$ | 8.5 | 8.1 | 7.6 | 6.6 | **7.70 cd** |
| $T_7$ | 8.6 | 8.2 | 7.8 | 6.8 | **7.85 bc** |
| $T_8$ | 8.9 | 8.8 | 8.4 | 7.4 | **8.38 ab** |
| $T_9$ | 9.0 | 9.0 | 8.6 | 7.6 | **8.55 a** |
| $T_{10}$ | 9.0 | 9.0 | 8.6 | 7.9 | **8.62 a** |
| $T_{11}$ | 9.0 | 9.0 | 8.7 | 8.2 | **8.72 a** |
| **Factor A Means** | **8.53 A** | **8.25 AB** | **7.83 B** | **6.92 D** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | ** | 0.45 | | 15.62 | |
| PmJ & ApJ % (B) | ** | 0.55 | | 12.06 | |
| A X B | Ns | - | | - | |

At the 1% probability level, the highest color scores were recorded at the initial stage, whereas the lowest values were observed at the third stage of storage. Means sharing the same letters were not significantly different according to the LSD test. Regarding blending treatments, T11 achieved the highest color score, while T2 recorded the lowest. Based on the LSD test at the 1% significance level, treatments with common letters did not differ significantly from each other.

### *Aroma*

The results indicated that storage duration and different blending ratios of pomegranate and apple juices had a highly significant effect on the aroma of the blended nectar Table 10.

**Table 10.** *Effect of juice blending ratio and storage period on aroma of blended nectar*

| Factor B | Factor A<br>Initial | 15 Days | 30 Days | 45 Days | Factor B Means |
|---|---|---|---|---|---|
| $T_1$ | 7.6 | 6.9 | 6.6 | 6.5 | **6.90 de** |
| $T_2$ | 7.7 | 7.1 | 6.7 | 5.7 | **6.80 e** |
| $T_3$ | 7.9 | 7.3 | 6.9 | 5.9 | **7.00 de** |
| $T_4$ | 8.2 | 7.5 | 7.1 | 6.1 | **7.22 de** |
| $T_5$ | 8.3 | 7.9 | 7.3 | 6.3 | **7.45 cd** |
| $T_6$ | 8.6 | 8.3 | 7.7 | 6.7 | **7.83 c** |
| $T_7$ | 8.8 | 8.4 | 7.8 | 6.8 | **7.95 bc** |
| $T_8$ | 8.5 | 8.1 | 7.9 | 6.9 | **7.85 c** |
| $T_9$ | 9.0 | 9.0 | 8.4 | 7.4 | **8.45 ab** |
| $T_{10}$ | 9.0 | 9.0 | 8.7 | 8.0 | **8.68 a** |
| $T_{11}$ | 9.0 | 9.0 | 8.7 | 8.3 | **8.75 a** |
| **Factor A Means** | **8.42 A** | **8.05 B** | **7.62 C** | **6.78 D** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | ** | 0.36 | | 12.68 | |
| PmJ & ApJ % (B) | ** | 0.57 | | 12.83 | |

| | | | |
|---|---|---|---|
| A X B | Ns | - | - |

At the 1% probability level, aroma scores were highest at the initial stage and lowest after 90 days of storage, demonstrating a gradual decline in aroma with increasing storage duration. Similarly, blending ratio significantly affected aroma at the 1% significance level. Increasing the proportion of apple juice in the blend resulted in higher aroma scores. Treatment T11 recorded the highest value, whereas T2 showed the lowest. According to the LSD test (1% level), treatments T9, T10, and T11 did not differ significantly from each other. Likewise, treatments sharing the same letters in the mean comparison were not statistically different Table 10.

### *Flavor*

The results indicated that storage duration and different blending ratios of pomegranate and apple juices significantly affected the flavor of the blended nectar Table 11.

**Table 11.** *Effect of juice blending ratio and storage period on flavor of blended nectar*

| Factor B | Factor A | | | | Factor B Means |
|---|---|---|---|---|---|
| | Initial | 15 Days | 30 Days | 45 Days | |
| **$T_1$** | 7.3 | 6.5 | 6.3 | 6.1 | **6.55 f** |
| **$T_2$** | 7.5 | 6.7 | 6.5 | 5.5 | **6.55 f** |
| **$T_3$** | 7.9 | 7.3 | 6.9 | 5.9 | **7.00 ef** |
| **$T_4$** | 8.0 | 7.6 | 7.2 | 6.4 | **7.30 de** |
| **$T_5$** | 8.6 | 8.3 | 7.7 | 6.7 | **7.83 cd** |
| **$T_6$** | 8.7 | 8.4 | 7.9 | 6.9 | **7.97 bc** |
| **$T_7$** | 8.9 | 8.8 | 8.2 | 7.2 | **8.28 abc** |
| **$T_8$** | 9.0 | 9.0 | 8.5 | 7.5 | **8.50 ab** |
| **$T_9$** | 9.0 | 9.0 | 8.6 | 7.6 | **8.55 a** |
| **$T_{10}$** | 9.0 | 9.0 | 8.7 | 8.0 | **8.68 a** |
| **$T_{11}$** | 9.0 | 9.0 | 8.6 | 7.8 | **8.60 a** |
| **Factor A Means** | **8.45 A** | **8.15 A** | **7.74 B** | **6.87 C** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | ** | 0.35 | | 12.13 | |
| PmJ & ApJ % (B) | ** | 0.53 | | 11.68 | |
| A X B | Ns | - | | - | |

At the 1% probability level, storage duration had a significant effect on flavor, with the highest scores recorded at the initial stage and the lowest after 90 days of storage. These findings demonstrate that prolonged storage led to a decline in flavor quality. Similarly, juice combinations significantly influenced flavor at the 1% significance level. Increasing the proportion of apple juice in the blend resulted in higher flavor scores. Treatment T10 achieved the highest score, whereas T1 and T2 recorded the lowest values. According to the LSD test (1% level), T1 and T2 did not differ significantly from each other, and treatments T7, T8, T9, T10, and T11 were also statistically similar.

### *Mouth-Feel*

The results indicated that different blending ratios of pomegranate and apple juices, as well as storage duration, significantly affected the mouthfeel of the blended nectar Table12.

**Table 12.** *Effect of juice blending ratio and storage period on mouth-feel of blended nectar*

| Factor B | Factor A<br>Initial | 15 Days | 30 Days | 45 Days | Factor B Means |
|---|---|---|---|---|---|
| $T_1$ | 7.3 | 6.6 | 6.3 | 6.5 | **6.67 f** |
| $T_2$ | 7.5 | 6.7 | 6.5 | 5.5 | **6.55 f** |
| $T_3$ | 7.9 | 7.2 | 6.9 | 5.9 | **6.97 ef** |
| $T_4$ | 8.2 | 7.7 | 7.3 | 6.3 | **7.38 de** |
| $T_5$ | 8.5 | 8.2 | 7.5 | 6.5 | **7.67 cd** |
| $T_6$ | 8.7 | 8.5 | 7.8 | 6.8 | **7.95 c** |
| $T_7$ | 8.7 | 8.5 | 8.1 | 7.1 | **8.10 bc** |
| $T_8$ | 9.0 | 9.0 | 8.5 | 7.5 | **8.50 ab** |
| $T_9$ | 8.9 | 8.8 | 8.7 | 7.9 | **8.57 ab** |
| $T_{10}$ | 9.0 | 9.0 | 8.8 | 8.3 | **8.78 a** |
| $T_{11}$ | 9.0 | 9.0 | 8.7 | 8.1 | **8.70 a** |
| **Factor A Means** | **8.43 A** | **8.11 AB** | **7.74 B** | **6.95 C** | |
| **Factors** | **F- test** | **LSD (5%)** | | **CV** | |
| Storage Period (A) | ** | 0.45 | | 15.86 | |
| PmJ & ApJ % (B) | ** | 0.50 | | 11.18 | |
| A X B | Ns | - | | - | |

At the 1% probability level, mouthfeel scores were highest at the initial stage and lowest after three months of storage, demonstrating a decline in mouthfeel with increasing storage time. According to the LSD test at the 1% significance level, means sharing the same letters were not significantly different from each other. Similarly, increasing the proportion of apple juice significantly improved mouthfeel scores. Treatment 10 recorded the highest value, whereas T2 showed the lowest. Based on the LSD test (1% level), treatments T8, T9, T10, and T11 did not differ significantly from one another, and other treatments sharing common letters were also statistically similar.

### *Overall Acceptance*

The results indicated that storage duration and different blending ratios of pomegranate and apple juices had a significant effect on the overall acceptability of the blended nectar Table 13.

**Table 13.** *Effect of juice blending ratio and storage period on overall acceptance of blended nectar*

| Factor B | Factor A<br>Initial | 15 Days | 30 Days | 45 Days | Factor B Means |
|---|---|---|---|---|---|
| $T_1$ | 7.5 | 6.6 | 6.5 | 6.2 | **6.70 f** |
| $T_2$ | 7.8 | 7.0 | 6.8 | 5.8 | **6.85 f** |
| $T_3$ | 7.9 | 7.2 | 7.0 | 6.0 | **7.03 ef** |
| $T_4$ | 8.2 | 7.6 | 7.2 | 6.2 | **7.30 de** |
| $T_5$ | 8.5 | 8.0 | 7.5 | 6.5 | **7.62 cd** |
| $T_6$ | 8.6 | 8.2 | 7.7 | 6.7 | **7.80 c** |
| $T_7$ | 8.9 | 8.8 | 8.3 | 7.3 | **8.32 b** |
| $T_8$ | 9.0 | 9.0 | 8.7 | 7.7 | **8.60 ab** |
| $T_9$ | 9.0 | 9.0 | 8.7 | 8.0 | **8.68 ab** |
| $T_{10}$ | 9.0 | 9.0 | 8.9 | 8.3 | **8.80 a** |
| $T_{11}$ | 9.0 | 9.0 | 8.9 | 8.2 | **8.78 a** |
| **Factor A Means** | **8.49 A** | **8.13 AB** | **7.84 B** | **6.99 C** | |
| **Factors** | **F- test** | **LSD (1%)** | | **CV** | |
| Storage Period (A) | ** | 0.45 | | 15.7 | |

| | | | |
|---|---|---|---|
| PmJ & ApJ % (B) | ** | 0.38 | 8.29 |
| A X B | Ns | - | - |

Overall acceptability decreased progressively with increasing storage time. The highest scores were observed at the initial stage of storage, whereas the lowest values were recorded after 90 days. An increase in the proportion of apple juice in the blend resulted in higher overall acceptability scores. Treatment T10 achieved the highest score, while T1 recorded the lowest. According to the LSD test at the 1% significance level, treatments T8, T9, T10, and T11 did not differ significantly from each other.

### *Economic Evaluation of Nectar*

Table 14 presents the details of the ingredients, along with their quantities and prices, for preparing blended pomegranate–apple nectar containing 10% pomegranate juice and 90% apple juice. The quantities of ingredients required for producing 750 mL of nectar are calculated and provided in detail in the mentioned table.

**Table 14.** *The 3-replication cost details of $T_{10}$ (10 % PmJ+90 % ApJ)*

| No | Materials | Amounts | Cost per Unit (AFN) | Grand Total Cost |
|---|---|---|---|---|
| 1 | Pomegranate Fruit (g) | 35 | 0.028 | 0.98 |
| 2 | Apple Fruit (g) | 216 | 0.014 | 3.02 |
| 3 | Sugar (g) | 45 | 0.055 | 2.47 |
| 4 | Sodium benzoate (ppm) | 120 | 0.040 | 4.80 |
| 5 | Water(mL) | 517.5 | 0.001 | 0.45 |
| 6 | Citric Acid (g) | 1 | 1 | 1 |
| 7 | Bottles and corks | 3 | 10 | 30 |
| 8 | Labors | 1 | 2 | 2 |
| 9 | Other Expense | 1 | 3 | 3 |
| **Total Cost** | | | **47.73** | |
| **Cost per Bottle** | | | **15.91** | |

## DISCUSSION

The TSS levels in blended nectar increased consistently during storage, with the lowest values at the initial measurement and the highest at 90 days. This rise is primarily due to the hydrolysis of complex carbohydrates, such as starch, pectin, and oligosaccharides, into simpler sugars, as well as the degradation of organic acids, reducing titratable acidity relative to TSS. Similar trends have been reported in blended juices by Salari et al. (2012), Grobelna et al. (2019), Sharma et al. (2020), Kumar et al. (2023), and Gautam et al. (2021), They reported that the juice TSS increases with time. TSS of the blended nectar varied with juice ratios: higher apple or pomegranate proportions increased TSS, reflecting the intrinsic sugar content of each fruit. Both storage duration and blend composition significantly influenced soluble solids. Gautam et al. (2021) reported that TSS increased with higher apple juice concentrations, while Assadi et al. (2019) found that higher pomegranate juice proportions also significantly raised TSS levels.

The pH of blended nectar decreased steadily during storage, with the highest pH recorded at the initial interval and the lowest at 90 days. This decline is primarily attributed to the formation of organic acids resulting from the hydrolysis of ascorbic acid and pectin.

The results supportedby Gautam et al. (2021), Nour et al. (2022), and Kumar et al. (2023), who observed a gradual decrease in juice pH over time. Increasing the proportion of pomegranate juice lowers the pH, whereas higher apple juice content raises it, reflecting the intrinsic acidity and pH of each fruit. These findings are supported by Gautam et al. (2021), who reported that decreasing the apple juice proportion increased overall acidity and, consequently, lowered the pH. Similarly, Salari et al. (2012), studying a melon–pomegranate squash blend, found that higher levels of pomegranate juice were associated with lower pH and greater acidity.

The reducing sugar levels in blended nectar increased with storage duration, attributed to the hydrolysis of non-reducing sugars. Comparable results have been documented by Kumar et al. (2023) and Gautam et al. (2021) in different blended juice formulation, indicating a progressive increase in reducing sugars over the storage period. Increasing apple juice proportion raised reducing sugar content, whereas higher pomegranate juice proportion reduced it, likely due to apple's higher sugar content compared to pomegranate. Ranjha et al. (2020) similarly reported that apple juice contains more reducing sugars than pomegranate juice. Consistent findings were noted by Gautam et al. (2021), who observed that reducing the apple juice concentration in a blend with mandarin and lemon lowered reducing sugar levels, attributed to the overall reduction in sugar content.

The storage duration (three months) significantly reduced the non-reducing sugar content of pomegranate–apple nectar, attributed to their conversion into reducing sugars. Similar trends have been reported in blended juices, where non-reducing sugars decreased during storage due to hydrolysis. In agreement with the present results, Gautam et al. (2021) and Kumar et al. (2023) also observed a time-depended reduction in non-reducing sugars throughout the storage period. Higher pomegranate juice increased non-reducing sugars, while more apple juice decreased them, likely due to pomegranate's greater non-reducing sugar content. Comparable results were reported by Ranjha et al. (2020).

The total sugars in blended nectar increased with storage, from the lowest at the initial stage to the highest at 90 days. This rise is attributed to the hydrolysis of starch and pectin, along with the conversion of non-reducing sugars into reducing sugars. Comparable results were reported by Gautam et al. (2021) and Kumar et al. (2023), both noting that prolonged storage elevated total sugars in blended juices through polysaccharide breakdown and sugar conversion. The total sugar content of the blended nectar varied with juice proportions, with the highest in T3 and the lowest in T11. Nectars containing more pomegranate juice had greater total sugars, attributed to its higher TSS and sugar content compared to apple.

The titratable acidity of blended nectar increased with storage, attributed to the production of organic acids. Treatments with higher pomegranate content exhibited greater acidity, reflecting its naturally higher acid levels compared to apple. Comparable trends were observed by Kumar et al. (2023) in pomegranate–aloe vera–ginger juice and by Gautam et al. (2021) in apple–strawberry–mandarin–lemon blends, both attributing the rise in acidity to organic acid formation, ascorbic acid degradation, and pectic substance breakdown during storage. Since sodium benzoate was used to prevent fungal growth and the sterilization and pasteurization processes were properly performed, no spoilage was observed in the nectar.

The blended nectar appearance declined with storage, highest initially and lowest after 90 days, due to phenolic degradation and acid–sugar interactions. Comparable findings were reported by Sharma et al. (2023). Nectars with higher apple juice proportions received better appearance scores. Muhammadi et al. (2020) reported that increasing pomegranate juice enhanced appearance in apple–aloe vera–pomegranate–banana blends, likely due to its attractive color. Similarly, Mahanandia et al. (2022) found that apple–carrot–ginger blends achieved the highest appearance scores in 100% juice treatments, emphasizing the role of fruit proportion and juice purity in visual quality. Color of blended nectar declined with prolonged storage, attributed to phenolic oxidation and Maillard (browning) reactions. Consistent with the present study, Gautam et al. (2021) in apple–strawberry–mandarin–lemon juice, Sharma et al. (2023) in pomegranate–anola–mandarin–ginger blends, and Muhammadi et al. (2020) in pomegranate–apple–aloe vera–banana juice. All studies concluded that extended storage causes color weakening due to phenolic degradation and non-enzymatic interactions between sugars and organic acids.

The aroma scores of blended nectars declined with storage, lowest at 90 days, due to temperature, enzymatic, and biochemical changes. Similar findings were reported by Gautam et al. (2021) and Sharma et al. (2023), they observed a gradual decline in juice aroma during storage. Table 26 shows that higher apple juice proportions in the mixed nectar resulted in better aroma scores, likely due to apple's more pleasant scent. Anwar et al. (2023) reported comparable findings with lower pomegranate content enhancing aroma. Flavor scores of blended nectars declined over three months, attributed to citrus flavor loss, low pH, and high storage temperatures. These findings are supported by the studies of Muhammadi et al. (2020) and Sharma et al. (2023), They observed a gradual weakening of juice flavor during storage. Higher apple juice proportions in the mixed nectar improved flavor scores, likely due to apple's dominant taste. Similar findings were reported by Muhammadi et al. (2020) and Anwar et al. (2023).

The mouthfeel scores of blended nectars declined over three months, lowest at 90 days, likely due to biochemical changes. These observations are consistent with the results reported by Muhammadi et al. (2020), They noted that the mouthfeel of the juice progressively declined over the storage period. Higher apple juice proportions improved the texture of mixed nectar, likely due to apple's better texture. Comparable trends were reported by Ranjha et al. (2020) and Anwar et al. (2023). The overall acceptance of blended nectar declined with storage, due to changes in taste, texture, aroma, and colour. These observations are consistent with the findings of Gautam (2021) and Sharma et al. (2023), who noted a decline in the general acceptability of the juice over time. Higher apple juice proportions improved overall acceptance of the mixed nectar, likely due to better sensory characteristics. Comparable findings were reported by Ranjha et al. (2020) and Gautam et al.

(2021), who reported that higher apple juice content enhanced the sensory quality of mixed juice formulations.

The economic analysis of blended nectar (25% fruit, 75% sugar syrup). Producing three 250 mL bottles cost 47.73 AFN (15.91 AFN per bottle), with a wholesale return of 1.57 AFN per 1 AFN spent. Using paper or plastic bottles could reduce costs. The BCR for T10 is 1:1.57.

## CONCLUSION

This study on blended pomegranate–apple nectar showed that during storage, TSS, reducing sugars, and total sugars increased, while pH and non-reducing sugars decreased; acidity also rose over time. Effective use of sodium benzoate, along with proper sterilization and pasteurization, prevented spoilage. Sensory evaluation indicated that longer storage reduced scores, with the highest ratings initially and the lowest at 90 days. Increasing apple juice proportion enhanced sensory attributes, with T10 (10% pomegranate + 90% apple) receiving the best scores. Economic analysis revealed a return of 1.57 AFN per 1 AFN invested, confirming T10 as the optimal formulation based on sensory and economic parameters.

### Recommendation

Based on the sensory results of the study, it is recommended that Treatment No. 10 (10% pomegranate and 90% apple juice) be used for the production of high-quality pomegranate and apple blended nectar.

## ACKNOWLEDGEMENTS

The authors thank the Department of Horticulture, Faculty of Agriculture, Kabul University, for their technical support.

## AUTHORS CONTRIBUTIONS

- Hamid Salari conceptualized and supervised the study.
- Atiqullah Muslim conducted the study in the field and collected the raw data.
- Atiqulla Muslim, Mohammadullah, and HamidSalari processed and analyzed data (equally).
- Mohammadullah Amin wrote the manuscript with input from all authors.
- All authors reviewed and approved the final version.

## FUNDING INFORMATION

No funding is available for the manuscript.

## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

## DATA AVAILABILITY STATEMENT

Data are available upon request from the corresponding author, subject to the approval of the relevant ethics committee

## REFERENCES

Anwar, A., Ali, E., Nisar, W., Ashraf, S., Javed, N., Anwar, L., Zulfiqar, A., Nazir, M.A., Tahir, F., 2024. Development and Quality Evaluation of Functional Carbonated Pomegranate Orange Nectar. *Agrobiol*. Rec. 15, 52–58. https://doi.org/10.47278/journal.abr/2023.048

Arnold, M., Gramza-Michalowska, A., 2024. Recent Development on the Chemical Composition and Phenolic Extraction Methods of Apple (Malus domestica)—A Review. *Food Bioprocess Technol* 17, 2519–2560. https://doi.org/10.1007/s11947-023-03208-9

Assadi, I., Elfalleh, W., Benabderrahim, M.A., Hannachi, H., Chaalen, W., Ferchichi, A., 2019. Nutritional Quality and Antioxidant Capacity of a Combination of Pomegranate and Date Juices. *International Journal of Fruit Science* 19, 300–314. https://doi.org/10.1080/15538362.2018.1512438

Balık, S., Kaya, T., Aslantaş, R., 2023. Fruit Quality Parameters, Sugars, Vitamin C, Antioxidant Activity, Organic Acids, and Phenolic Compounds for a New Endemic Apple Variety, "Long Apple." *Horticulturae* 9, 1171. https://doi.org/10.3390/horticulturae9111171

Banjare, A., 2020. Studies on Preparation and Standardization of Apple Cider (PhD Thesis). Indira Gandhi Krishi Vishwavidyalaya, *Raipur*.Link.

El-Messery, T.M., El-Said, M.M., Demircan, E., Ozçelik, B., 2019. Microencapsulation of natural polyphenolic compounds extracted from apple peel and its application in yoghurt. *Acta Scientiarum Polonorum Technologia Alimentaria* 18, 25–34. https://doi.org/10.17306/J.AFS.2019.0597

Gautam, D., Jain, S.K., Bhatnagar, P., Meena, N., Chippa, H., 2021. Utilization of custard apple pulp for preparation of blended nectar. *Indian Journal of Horticulture* 78, 229–235. https://doi.org/10.5958/0974-0112.2021.00033.5

Girotto, O.S., Furlan, O.O., Moretti Junior, R.C., Goulart, R. de A., Baldi Junior, E., Barbalho-Lamas, C., Fornari Laurindo, L., Barbalho, S.M., 2025. Effects of apples (Malus domestica) and their derivatives on metabolic conditions related to inflammation and oxidative stress and an overview of by-products use in food processing. *Critical Reviews in Food Science and Nutrition* 65, 3785–3816. https://doi.org/10.1080/10408398.2024.2372690

Golmakani, M.-T., Eskandari, M.H., Kooshesh, S., Pishan, M., 2021. Investigation of the effects of pomegranate juice addition on physicochemical, microbiological, and functional properties of set and stirred yogurts. *Food Science & Nutrition* 9, 6662–6671. https://doi.org/10.1002/fsn3.2615

Grobelna, A., Kalisz, S., Kieliszek, M., 2019. The Effect of the Addition of Blue Honeysuckle Berry Juice to Apple Juice on the Selected Quality Characteristics, Anthocyanin Stability, and Antioxidant Properties. *Biomolecules* 9, 744. https://doi.org/10.3390/biom9110744

Higa, F., Koppel, K., Chambers, E., 2017. Effect of Additional Information on Consumer Acceptance: An Example with Pomegranate Juice and Green Tea Blends. *Beverages* 3, 30. https://doi.org/10.3390/beverages3030030

Kahramanoglu, I., Usanmaz, S., 2016. Pomegranate Production and Marketing. CRC Press.

Kumar, D., Bhati, D., Harendra, Debnath, S., 2023. Evaluation of Quality Attributes and Storability of Pomegranate-Based Blended Drink. *Plant Archive*s 23, 323–329. https://doi.org/10.51470/PLANTARCHIVES.2023.v23.no1.053

Mahanandia, B.K., Singh, S.S., Saini, N., 2022. Development and quality assessment of health beverage from apple juice blended with carrot and ginger. *Pharma Innovation* 11, 1563–1567. https://doi.org/10.22271/tpi.2022.v11.i9s.15578

Melgarejo-Sánchez, P., Núñez-Gómez, D., Martínez-Nicolás, J.J., Hernández, F., Legua, P., Melgarejo, P., 2021. Pomegranate variety and pomegranate plant part, relevance from bioactive point of view: a review. *Bioresour. Bioprocess*. 8, 2. https://doi.org/10.1186/s40643-020-00351-5

Millán-Laleona, A., Bielsa, F.J., Aranda-Cañada, E., Gómez-Rincón, C., Errea, P., López, V., 2023. Antioxidant, Antidiabetic, and Anti-Obesity Properties of Apple Pulp Extracts (Malus domestica Bork): A Comparative Study of 15 Local and Commercial Cultivars from Spain. *Biology* 12, 891. https://doi.org/10.3390/biology12070891

Muhammadi, M.R., Desai, C.S., Patil, S.J., 2020. Effect of banana pseudostem sap with apple, pomegranate and Aloe vera juice on organoleptic properties of blended nectar. *Pharma Innovation* 9, 272–276. Link.

Nour, V., 2022. Quality Characteristics, Anthocyanin Stability and Antioxidant Activity of Apple (Malus domestica) and Black Chokeberry (Aronia melanocarpa) Juice Blends. *Plants* 11, 2027. https://doi.org/10.3390/plants11152027

Parashuram, S., Singh, N.V., Gaikwad, N.N., Corrado, G., Roopa Sowjanya, P., Basile, B., Devaraja, N.S., Chandra, R., Babu, K.D., Patil, P.G., Kumar, P., Singh, A., Marathe, R.A., 2022. Morphological, Biochemical, and Molecular Diversity of an Indian Ex Situ Collection of Pomegranate (Punica granatum L.). *Plants* 11, 3518. https://doi.org/10.3390/plants11243518

Patocka, J., Bhardwaj, K., Klimova, B., Nepovimova, E., Wu, Q., Landi, M., Kuca, K., Valis, M., Wu, W., 2020. Malus domestica: A Review on Nutritional Features, Chemical Composition, Traditional and Medicinal Value. *Plants* 9, 1408. https://doi.org/10.3390/plants9111408

Raj, D., Sharma, P.C., Vaidya, D., 2011. Effect of blending and storage on quality characteristics of blended sand pear-apple juice beverage. *J Food Sci Technol* 48, 102–105. https://doi.org/10.1007/s13197-010-0098-x

Ranjha, M. M. A. N., Amjad, S., Ashraf, S., Khawar, L., Safdar, M. N., Jabbar, S., Nadeem, M., Mahmood, S., & Murtaza, M. A. (2020). Extraction of Polyphenols from Apple and Pomegranate Peels Employing Different Extraction Techniques for the Development of Functional Date Bars. *International Journal of Fruit Science*, *20*(sup3), S1201–S1221. https://doi.org/10.1080/15538362.2020.1782804

Sabale, S., Rao, P., Jadhav, R., 2020. Nutritional value of pomegranate: a review. *World Journal of Pharmaceutical Research* 9, 733–744. https://doi.org/10.20959/wjpr20205-17361

Salari, H., Sreenivas, K.N., Shankarappa, T.H., Krishna, H.C., Gowda, A.M., 2012. Physico-chemical and sensory parameters of muskmelon blended pomegranate squash and syrup. *Environment & Ecology* 30, 1052–1057. Link.

Saroj, R., Kushwaha, R., Puranik, V., Kaur, D., 2020. Pomegranate Peel: Nutritional Values and Its Emerging Potential for Use in Food Systems, in: Mishra, P., Mishra, R.R., Adetunji, C.O. (Eds.), *Innovations in Food Technology: Current Perspectives and Future Goals. Springer, Singapore*, pp. 231–241. https://doi.org/10.1007/978-981-15-6121-4_16

Sharma, R., Choudhary, R., Thakur, N.S., Bishist, R., Thakur, A., 2020. Optimization of Fructooligosaccharide Fortified Low Calorie Apple-Whey Based RTS Beverage and Its Quality Evaluation during Storage. *Current Journal of Applied Science and Technology* 30, 17–28. https://doi.org/10.9734/cjast/2020/v39i1030625

Sharma, S., Panigrahi, H.K., Patel, D., 2023. Recipe standardization and sensory evaluation of fortified Aonla nectar. *Pharma Innovation* 12, 1858–1862. Link.

Teixeira Da Silva, J.A., Rana, T.S., Narzary, D., Verma, N., Meshram, D.T., Ranade, S.A., 2013. Pomegranate biology and biotechnology: A review. *Scientia Horticulturae* 160, 85–107. https://doi.org/10.1016/j.scienta.2013.05.017

Tinebra, I., Scuderi, D., Sortino, G., Mazzaglia, A., Farina, V., 2021. Pomegranate Cultivation in Mediterranean Climate: Plant Adaptation and Fruit Quality of 'Mollar de Elche' and 'Wonderful' Cultivars. *Agronomy* 11, 156. https://doi.org/10.3390/agronomy11010156

Vallée Marcotte, B., Verheyde, M., Pomerleau, S., Doyen, A., Couillard, C., 2022. Health Benefits of Apple Juice Consumption: A Review of Interventional Trials on Humans. *Nutrients* 14, 821. https://doi.org/10.3390/nu14040821

Zarfeshany, A., Asgary, S., Javanmard, S.H., 2014. Potent health effects of pomegranate.

*Advanced Biomedical Research* 3, 100. https://doi.org/10.4103/2277-9175.129371

Zhao, S., Yang, F., Liu, Y., Ma, X., Zhang, Y., 2018. Study of chemical characteristics, gelation properties and biological application of calcium pectate prepared using apple or citrus pectin. *International Journal of Biological Macromolecules* 109, 180–187. https://doi.org/10.1016/j.ijbiomac.2017.12.082