

Development of Ginger-Flavored Peach Nectar

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ABSTRACT

Peach nectar is a nutritious and widely consumed beverage; however, its chemical stability and sensory quality decline during storage. Limited studies have been conducted on the use of ginger extract to improve the quality and storage stability of peach nectar, particularly regarding its physicochemical and sensory properties. Therefore, this study was conducted in 2025 at the Laboratory of the Horticulture Department, Faculty of Agriculture, Kabul University, Afghanistan, to evaluate the effects of ginger extract on the physicochemical characteristics, sensory quality, and storage stability of peach nectar. Seven treatments were prepared using 60% sugar syrup and 40% fruit pulp, containing 1–6% ginger extract. The experiment was arranged in a Factorial Completely Randomized Design (F-CRD) with three replications. Parameters evaluated included total soluble solids (TSS), pH, titratable acidity, reducing sugars, non-reducing sugars, total sugars, and sensory attributes. The results showed that ginger concentration and storage duration significantly influenced the quality of peach nectar. During storage, TSS and total sugars increased, whereas pH and non-reducing sugars decreased. Treatments containing 1–3% ginger extract maintained better sensory quality and storage stability. Among all treatments, the formulation containing 2% ginger extract (T3) was found to be the most suitable due to its superior chemical stability and higher sensory acceptability. Future studies should focus on the microbial stability, antioxidant properties, and nutritional value of ginger-flavored peach nectar.

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INTRODUCTION

Peach (*Prunus persica* (L.) Batsch) is a deciduous fruit-bearing tree belonging to the family Rosaceae. It is believed to have originated in China, where cultivation dates back more than 4,000 years (Dip & Aggarwal, 2023). Peaches are recognized as a valuable source of nutrients and biologically active compounds, including organic acids, soluble carbohydrates, vitamin C, essential minerals such as potassium, dietary fiber, and proteins. In addition, peaches are rich in polyphenols, flavonoids, and carotenoids, which are known for their strong antioxidant properties. These bioactive compounds contribute to various health benefits, including improved digestive function and enhanced immune response (Qin et al., 2025). As a result,

peach possesses considerable nutritional value and economic importance in the global fruit industry. From a commercial and pomological perspective, peaches are classified into five major groups: yellow-fleshed peaches, white-fleshed peaches, yellow-fleshed nectarines, white-fleshed nectarines, and percoche types (Khadiv et al., 2025).

In 2022, worldwide production of peaches and nectarines amounted to approximately 43.17 million tons. China remained the dominant producer with an output of about 16.8 million tons, followed by Italy (1.15 million tons) and Türkiye (1.01 million tons). Other major producing countries included Greece (0.89 million tons), Spain (0.87 million tons), the United States (0.67 million tons), and Iran (0.58 million tons). These seven countries collectively accounted for the leading global producers of peaches and nectarines that year (FAOSTAT, 2024).

Ginger (*Zingiber officinale*) is a flowering herbaceous plant whose rhizome is widely used as a culinary spice and medicinal herb. Since ancient times, it has been incorporated into traditional diets and folk medicine because of its recognized health-promoting properties. Numerous *in vitro* and *in vivo* studies have demonstrated that ginger possesses antioxidant, anti-inflammatory, antimicrobial, and anticarcinogenic activities, attributed to its diverse bioactive compounds (Shaukat et al., 2023). With increasing consumer awareness and growing industrial demand for natural antioxidants and functional food ingredients, ginger and its derivatives have been widely used in various food systems. Ginger provides antioxidant and nutraceutical benefits in bakery products; improves flavor, consumer acceptability, and techno-functional properties in dairy products; enhances sensory quality and antimicrobial activity in beverages; improves oxidative stability, tenderness, and sensory characteristics in meat products; and extends shelf life while improving the quality of edible films, coatings, and packaging materials (Pali et al., 2020). Fresh ginger is composed mainly of moisture, along with important nutritional constituents such as carbohydrates, protein, fiber, and minerals, as well as small amounts of fat. It contains approximately 80.9% moisture, 12.3% carbohydrates, 2.3% protein, 2.4% fiber, 1.2% minerals, and 0.9% fat. In addition, ginger contains about 1.80% total soluble solids (TSS), 0.08% acidity, and 1.90 mg/100 g vitamin C, which contribute to its nutritional and functional value (Verma & Deen, 2024)

Ginger is a plant-derived medicinal substance with strong therapeutic potential for treating various diseases. Extensive scientific research has demonstrated that ginger possesses multiple biological activities, among which its anti-inflammatory effect is particularly significant. Inflammation itself is a complex physiological and pathological response involving numerous biological pathways (Bekkouch et al., 2023). The chemical profile of ginger has been thoroughly investigated in numerous studies, all of which have successfully characterized its composition. These investigations revealed that ginger contains a diverse array of chemical constituents and bioactive compounds that contribute to its medicinal and functional properties (Pali et al., 2020). Among these compounds, 6-gingerol has been identified as the predominant bioactive constituent, alongside other

important components such as 4-gingerol and 8-gingerol, which are largely responsible for the pharmacological and health-promoting effects of ginger (Verma & Deen, 2024).

Peach nectar is a nutritious, natural beverage made from peach juice, water, and sweetening agents, and is widely appreciated by consumers for its pleasant taste, natural color, and aroma. Peach nectar is a rich source of vitamin C, vitamin A, potassium, dietary fiber, flavonoids, and phenolic compounds, which help strengthen the immune system and reduce the harmful effects of free radicals through antioxidant activity (Verma et al., 2025). The preparation of peach nectar involves juice extraction, filtration, and pasteurization, followed by blending with water and sugar, and carbonation may also be added when required. Studies have shown that peach nectar possesses desirable sensory characteristics, including attractive color, good flavor, and an acceptable mouthfeel. Furthermore, the presence of carbon dioxide helps preserve the nutritional components, especially vitamin C and other bioactive compounds, while also extending the beverage's shelf life (Gagan & Aggarwal, 2023).

Afghanistan has favorable climatic conditions for peach production. Despite weak post-harvest management systems and inadequate packaging, transportation, storage, and processing facilities, peaches remain one of the important fruit crops cultivated in the country. In Afghanistan, the potential peach production exceeds market demand. Peaches require careful handling to minimize damage, and due to inadequate post-harvest infrastructure, fruit supply often increases during the harvest season, resulting in reduced market prices (El Maazouzi et al., 2025). Peach is a climacteric fruit characterized by high respiration and ethylene production rates after harvest. Consequently, the fruits soften rapidly and deteriorate under ambient conditions. The thin skin and soft texture of peaches make them highly susceptible to bruising during harvesting, packaging, and transportation. Such mechanical injuries provide entry points for pathogens and accelerate fruit deterioration. Therefore, to preserve fruit quality, enhance economic value, and reduce post-harvest losses, it is essential to process peaches into various value-added products (Cao et al., 2025).

The present study is designed to develop a value-added ginger-flavored peach nectar and evaluate its overall quality. It aims to assess the nutritional characteristics and storage stability of the prepared product, and to monitor changes in its chemical composition during storage. In addition, the study seeks to examine variations in the organoleptic properties of the nectar over time to determine its acceptability and quality retention during storage.

To achieve these objectives, this study addresses the following key questions:

- What is the optimal formulation ratio of ginger flavor to peach nectar that ensures maximum consumer acceptability?
- How do the total soluble solids (TSS), pH, and antioxidant activity of the blended nectar change under different storage temperatures?

- What is the impact of the storage period on the microbiological safety and sensory attributes of the final product?

METHODS AND MATERIALS

Research site

The research was carried out at the Horticulture Department Laboratory, Faculty of Agriculture, Kabul University, Kabul, Afghanistan, in 2025.

The raw materials used in this study included fresh peach fruits, fresh ginger, sugar, citric acid, sodium benzoate, water, and 250 mL glass bottles. All materials were sourced from the local market.

Extraction of Juice

To extract juice from peaches, the peaches were first washed thoroughly. Water was then boiled in a pot, and 20 grams of sodium hydroxide were added per liter of water to remove the peach skin. The peaches were placed into this solution and heated on a gas stove for two minutes. Afterward, the peaches were removed from the pot using a perforated ladle and washed with cold water to remove any remaining peel. The stones (pits) were removed manually, and only the pulp was separated. The pulp was then transferred to a mixer, and pure peach pulp was extracted. Similarly, to extract juice from ginger, the ginger was first thoroughly washed. Its peel was removed with a sharp knife and cut into small pieces. The pieces were placed into a mixer and blended until finely ground. The mixture was then filtered using a muslin cloth to extract the liquid, which was collected in a container.

The blended juice intended for nectar formulation was prepared by combining peach and ginger juices in seven different proportions, as shown in Table 1

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

Treatment	Blinding Ratio	TSS (°B)	Acidity (%)
T1	(Pure peach pulp)	13	0.3
T2	(Peach pulp + 1 % ginger extract)	13	0.3
T3	(Peach pulp + 2 % ginger extract)	13	0.3
T4	(Peach pulp + 3 % ginger extract)	13	0.3
T5	(Peach pulp + 4 % ginger extract)	13	0.3
T6	(Peach pulp + 5 % ginger extract)	13	0.3
T7	(Peach pulp + 6 % ginger extract)	13	0.3

In this study, different treatments of peach and ginger nectar were prepared based on predetermined percentages, where pure peach pulp containing 40% peach and 60% sugar syrup was used as the control, and other treatments were formulated by blending peach pulp with ginger extract at 1%, 2%, 3%, 4%, 5%, and 6% levels to evaluate the chemical properties,

flavor, and overall quality of the nectar. The total soluble solids (TSS) of each blend were measured and adjusted to 13°Brix by adding sugar syrup, while the acidity was standardized to 0.3% using citric acid. Sodium benzoate (120 ppm) was also added as a preservative. The final product was hot-filled into 250 mL bottles, tightly sealed with metal caps, pasteurized in near-boiling water for 25 minutes, and stored at room temperature. During storage for up to three months, the ginger-flavored peach nectar was analyzed monthly for pH, TSS, reducing sugars, non-reducing sugars, total sugars, and acidity. The experiment was conducted using a Factorial Completely Randomized Design (Factorial CRD) with three replications, and the collected data were analyzed using STAR software, with treatment differences evaluated at the 5% level of significance using LSD.

Data collection tools and data collection procedure

TSS: A Hand Refractometer was used to measure the TSS of nectar. TSS data for all samples were recorded and expressed in °Brix.

PH: A digital pH meter was used to measure the pH of nectar. The temperature was kept constant during observations for all samples.

Reducing sugar

To determine the reducing sugar content, 25 mL of the product was blended with 100 mL of distilled water and neutralized with 1 N NaOH using phenolphthalein as an indicator. Subsequently, 2 mL of 45% lead acetate was added, followed by 2 mL of 22% potassium oxalate. The volume was adjusted to 250 mL, and the solution was filtered. The filtrate was titrated against 10 mL of Fehling's solution. The titer value obtained was used to calculate the percentage of reducing sugars.

Non-reducing sugars

The content of non-reducing sugars was calculated using the following formula:

$$\text{Non-reducing sugars (\%)} = \text{Total sugars (\%)} - \text{Reducing sugars (\%)}$$

Total sugars

To determine the total sugars, 100 mL of the filtrate was hydrolyzed by mixing with 10 g of citric acid and kept overnight. It was then neutralized with sodium hydroxide using phenolphthalein as an indicator. The volume was brought to 250 mL, and the filtrate was titrated with 10 mL of Fehling's mixture. The titer value obtained was used to calculate the percentage of total sugars.

Titrateable acidity

To determine the titrateable acidity, the nectar sample was diluted and titrated against a standard 0.1 N sodium hydroxide solution using phenolphthalein as an indicator. The results were expressed as a percentage of citric acid.

The prepared nectar was observed visually for mold growth at monthly intervals throughout the storage period.

Sensory evaluation

Sensory evaluation was conducted by a panel of 10 individuals with basic knowledge and training in the organoleptic assessment of nectar. The sensory attributes evaluated included appearance, color, flavor, taste, odor, texture, and overall acceptability. Juice from all treatments was assessed 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.

The product's cost-effectiveness was analyzed to determine the best treatment. Net income was calculated using the following formula:

$$\text{Net Income} = \text{Total Income} - \text{Total Cost}$$

Since the benefit-cost ratio is an effective indicator of the commercial feasibility of product preparation, it was also calculated using the formula:

$$\text{Benefit-Cost Ratio} = \text{Total Income} / \text{Total Cost}$$

Data analysis

The study was designed in a Factorial CRD with three replicates. The generated data were analyzed using the Statistical Tool for Agricultural Research (STAR) software, and treatments were compared using the Least Significant Difference (LSD) at the 5% level of significance.

FINDINGS

The present study found that both ginger concentration and storage duration significantly affected the quality of ginger-flavored peach nectar. Samples containing low to moderate levels of ginger (1–3%) maintained good consumer acceptance and retained their sensory characteristics throughout storage. In contrast, samples with higher ginger concentrations (4–6%) showed a gradual decline in overall acceptability, particularly after 30 and 60 days of storage, indicating that excessive ginger negatively affected the taste, aroma, and overall sensory quality of the nectar. Statistical analysis confirmed significant differences among treatments, highlighting the importance of optimizing ginger concentration. Among all treatments, the 2% ginger sample (T₃) demonstrated the best overall performance, maintaining good chemical stability and the highest sensory scores during storage. Therefore, the study suggests that ginger can successfully be used as a functional ingredient in peach nectar; however, its concentration must be carefully optimized to ensure product stability and consumer satisfaction.

Chemical Parameters

The chemical evaluation results showed that, with increasing storage duration, total soluble solids (TSS), total sugars, reducing sugars, and titratable acidity gradually increased, whereas pH and non-reducing sugars decreased. These changes are mainly attributed to biochemical reactions occurring during storage, including the hydrolysis of complex carbohydrates into simpler sugars and the conversion of sugars into organic acids. The increase in TSS and total

sugars indicates increased sweetness due to the breakdown of complex compounds, while the increase in titratable acidity and decrease in pH reflect the accumulation of organic acids, which influence the product's flavor and stability. Furthermore, the decrease in non-reducing sugars suggests that complex sugars were progressively converted into simple sugars during storage. The results also indicated that moderate levels of ginger provided better chemical stability. In contrast, higher concentrations accelerated changes in acidity and sugar composition, underscoring the importance of using an optimal level of ginger in peach nectar formulation.

Total Soluble Solids (TSS)

The results of the study showed that the type of treatment, storage duration, and their interaction had a significant effect on the total soluble solids of peach nectar. The second treatment recorded the highest total soluble solids content (14.10 °Brix) during storage, attributed to the addition of 1% ginger juice. During the same period, the lowest total soluble solids value (13.50 °Brix) was observed in the third treatment. In the fifth treatment, the total soluble solids content increased slightly over time; however, after 90 days of storage, this treatment exhibited the lowest total soluble solids level (13.76 °Brix) among all treatments. (Table-2)

Table 2. Effect of different levels of ginger extract on Total Soluble Solids (TSS °Brix) of peach nectar during storage at different intervals (0, 30, 60 and 90 days)

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	13.00 ^a _C	13.60 ^{ab} _B	14.00 ^a _A	14.00 ^a _A
T2(Peach pulp + 1 % ginger extract)	13.00 ^a _C	13.73 ^a _B	14.10 ^a _A	14.00 ^a _A
T3(Peach pulp + 2 % ginger extract)	13.00 ^a _C	13.40 ^b _B	13.50 ^b _B	14.00 ^a _A
T4(Peach pulp + 3 % ginger extract)	13.00 ^a _C	13.50 ^a _B	14.00 ^a _A	14.00 ^a _A
T5(Peach pulp + 4 % ginger extract)	13.00 ^a _D	13.56 ^{ab} _C	14.00 ^a _A	13.76 ^b _B
T6(Peach pulp + 5 % ginger extract)	13.00 ^a _C	13.46 ^b _B	14.00 ^a _A	14.00 ^a _A
T7(Peach pulp + 6 % ginger extract)	13.00 ^a _C	13.40 ^b _B	13.86 ^a _A	14.00 ^a _A
Factors	F-test	LSD _{0.05}		CV (%)
Storage period (A)	**	0.15		
Treatment (B)	**	0.24		0.71
Interaction of A & B	**	-		

** : P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation;

According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

During storage, the total soluble solids content increased by 1 °Brix in all treatments except the fifth. In the fifth treatment, in which 4% ginger juice was added to the nectar, a decrease of 0.24 °Brix was observed after 90 days of storage compared to 60 days. The results indicate that, with increasing storage duration, total soluble solids content increased in most

treatments. This increase may be attributed to the breakdown of polysaccharides and their conversion into mono- and disaccharides.

Titratable Acidity

The results of the study showed that the type of treatment, storage duration, and their interaction had a significant effect on the titratable acidity of peach nectar. The fifth treatment recorded the highest acidity level (0.26%) during storage, attributed to the addition of 4% ginger juice. During the same period, the lowest acidity level (0.13%) was observed in the control peach nectar treatment (Table 3).

Table 3. Effect of different levels of ginger extract on acidity (%) of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	0.26 ^a _A	0.32 ^{ab} _A	0.26 ^b _A	0.13 ^b _B
T2(Peach pulp + 1 % ginger extract)	0.26 ^a _{BC}	0.30 ^{ab} _B	0.38 ^a _A	0.21 ^{ab} _C
T3(Peach pulp + 2 % ginger extract)	0.26 ^a _A	0.32 ^{ab} _A	0.30 ^{ab} _A	0.13 ^b _B
T4(Peach pulp + 3 % ginger extract)	0.26 ^a _{BC}	0.35 ^{ab} _A	0.30 ^{ab} _{AB}	0.21 ^{ab} _C
T5(Peach pulp + 4 % ginger extract)	0.26 ^a _B	0.38 ^a _A	0.38 ^a _A	0.26 ^a _B
T6(Peach pulp + 5 % ginger extract)	0.26 ^a _B	0.30 ^{ab} _B	0.38 ^a _A	0.13 ^b _C
T7(Peach pulp + 6 % ginger extract)	0.26 ^a _B	0.26 ^b _B	0.38 ^a _A	0.17 ^{ab} _C
Factors	F-test	LSD _{0.05}		CV (%)
Storage period (A)	**	0.06		
Treatment (B)	**	0.09		14.47
Interaction of A & B	**	-		

**.: P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

During storage, the acidity levels of all treatments increased to varying degrees. However, after 60 days, the acidity of all treatments began to decrease. In the first treatment, which contained pure peach juice, a 0.13% decrease in acidity was observed at the end of 90 days of storage. The results indicate that, for up to 60 days of storage, the acidity of all treatments increased with storage duration; however, after 60 days and up to 90 days, the acidity of all treatments decreased. This decrease may be due to the breakdown of polysaccharides into mono- and disaccharides, which, in turn, affects the total soluble solids content of the nectar. Similar findings were reported by X and Y, who also observed that the total soluble solids content of peach increased with prolonged storage.

pH: The table shows that the pH of ginger-flavored peach nectar changed noticeably during storage. At day 0, the pH of the nectar was recorded at 3.60, representing the initial condition. After 30 days of storage, the pH decreased to its lowest value (3.23), which may be attributed to increased acidity and possible metabolic changes during the early storage period. By day 60, the pH increased again to 3.48, indicating a partial stabilization following the initial decline. At 90 days, the pH further increased to 3.62, reflecting the chemical stability of the nectar during storage (Table 4).

Table 4. Effect of Storage Duration on the PH Content of Ginger-Flavored Peach Nectar

Storage period (Days)	pH
0	3.60 ^a
30	3.23 ^c
60	3.48 ^b
90	3.62 ^a
F-test	**
LSD _{0.05}	0.07
CV (%)	3.66

** : P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation;

According to LSD at the 0.05 level, means within the same column, followed by the same letter, are not significantly different.

Reducing sugars

The table results show that the reducing sugar content in ginger-flavored peach nectar increased significantly during storage. At day 0, it was 4.17%, rising to 12.13% and 13.40% at 30 and 60 days, respectively, and slightly decreasing to 12.90% at 90 days, yet still higher than the initial value. According to LSD_{0.05} and CV%, these changes are statistically significant, indicating that they may result from sugar formation or hydrolysis during storage. Overall, the increase in reducing sugars during storage plays an important role in improving the nectar's taste and sweetness (Table 5).

Table 5. Effect of Storage Duration on the Reducing Sugars Content of Ginger-Flavored Peach Nectar

Storage period (Days)	Reducing sugars
0	4.17 ^c
30	12.13 ^b
60	13.40 ^a
90	12.90 ^{ab}
F-test	**
LSD _{0.05}	0.86
CV (%)	13.13

** : P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation;

According to LSD at the 0.05 level, means within the same column, followed by the same letter, are not significantly different.

Non-reducing sugars

The table results show that the non-reducing sugar content in ginger-flavored peach nectar decreased significantly during storage. On the first day of storage (day 0), the average non-reducing sugar content was 7.20%, reflecting the nectar's initial state. After 30 days of storage, this value decreased markedly to 1.17%, reaching a minimum of 0.41% at 60 days. At 90 days, non-reducing sugars slightly increased (0.56%) but remained lower than the initial value. According to LSD_{0.05} (0.75) and CV% (51.99), the decrease in non-reducing sugar

content is statistically significant. This reduction may result from hydrolysis during storage, where non-reducing sugars are converted into reducing sugars. Overall, the decrease in non-reducing sugars plays an important role in altering the nectar's sweetness and flavor. (Table-6)

Table 6. Effect of Storage Duration on the Non-Reducing Sugars Content of Ginger-Flavored Peach Nectar

Storage period (Days)	Non-Reducing sugars
0	7.20 ^a
30	1.17 ^b
60	0.41 ^c
90	0.56 ^{bc}
F-test	**
LSD _{0.05}	0.75
CV (%)	51.99

**₁: P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation;

According to LSD at the 0.05 level, means within the same column, followed by the same letter, are not significantly different.

Total sugars

The results showed that the total sugar content of ginger-flavored peach nectar increased during storage. At the initial stage, it was 11.36 g/100 mL, which increased significantly during 30 and 60 days of storage (13.30–13.81 g/100 mL) and slightly decreased at 90 days (13.46 g/100 mL). Statistical analysis indicated that the storage period had a significant effect on sugar content (p < 0.05). These results suggest that the nectar maintains its sweetness during storage and exhibits good quality stability (Table 7).

Table 7. Effect of Storage Duration on the Total Sugars Content of Ginger-Flavored Peach Nectar

Storage period (Days)	Total sugars
0	11.36 ^b
30	13.30 ^a
60	13.81 ^a
90	13.46 ^a
F-test	**
LSD _{0.05}	0.83
CV (%)	10.39

**₁: P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation;

According to LSD at the 0.05 level, means within the same column, followed by the same letter, are not significantly different.

Nectar Spoilage: During the three-month storage period, no signs of juice spoilage were observed or recorded in any of the seven different combinations of peach and ginger in the blended nectar.

Sensory Evaluation

Sensory evaluation was conducted by a panel of 7 individuals with basic knowledge and training in the organoleptic assessment of nectar. The sensory attributes evaluated included appearance, color, flavor, taste, odor, texture, and overall acceptability. Juice from all treatments was assessed 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.

Appearance

The appearance scores of ginger-flavored peach nectar varied depending on treatments and storage duration. Initially, all formulations received acceptably high scores; however, a slight decline was observed in some treatments as storage progressed, particularly in those containing higher levels of ginger. In contrast, the formulation with a moderate level of ginger (2%) maintained better appearance stability throughout the storage period. Statistical analysis showed that treatments had a significant effect on appearance ($p < 0.05$), while the overall changes indicated acceptable sensory quality (Table 8).

Table. 8: Effect of different levels of ginger extract on appearance score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	8.14 ^a _A	8.28 ^a _A	7.71 ^{ab} _{AB}	7.28 ^{abc} _B
T2 (Peach pulp + 1 % ginger extract)	7.71 ^a _{AB}	8.28 ^a _A	7.14 ^{ab} _B	8.00 ^{ab} _A
T3 (Peach pulp + 2 % ginger extract)	7.85 ^a _A	8.00 ^a _A	8.00 ^a _A	8.28 ^a _A
T4 (Peach pulp + 3 % ginger extract)	7.71 ^a _A	7.71 ^a _A	8.00 ^a _A	7.71 ^{abc} _A
T5 (Peach pulp + 4 % ginger extract)	7.85 ^a _{AB}	8.14 ^a _A	7.28 ^{ab} _{BC}	7.00 ^{bc} _C
T6 (Peach pulp + 5 % ginger extract)	8.00 ^a _A	7.85 ^a _A	7.00 ^{ab} _B	6.85 ^c _B
T7 (Peach pulp + 6 % ginger extract)	7.85 ^a _A	7.42 ^a _{AB}	6.85 ^b _B	6.71 ^c _B
Factors	F-test	LSD _{0.05}	CV (%)	
Storage period (A)	**	0.73		
Treatment (B)	**	1.10	9.06	
Interaction of A & B	*	-		

**.: $P \leq 0.01$; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The appearance scores of ginger-flavored peach nectar showed changes during storage. Initially, the scores ranged from 7.71 to 8.14, and after 30 days, some treatments, such as T1 and T2, recorded higher scores (8.28). During 60 and 90 days of storage, a decline was observed in certain formulations, particularly T6 and T7, with scores decreasing to 6.71–7.00. In contrast, T3 maintained better stability throughout storage and achieved the highest score (8.28) at 90 days. Statistical analysis indicated that the differences among treatments were significant ($p < 0.05$; $LSD = 0.73$). Despite these changes, the overall appearance quality of the nectar remained acceptable until the end of the storage period.

Color

The color scores of ginger-flavored peach nectar showed noticeable variation across treatments and storage durations. Initially, all formulations had relatively high and similar scores (7.71–8.14). After 30 days, some treatments such as T2, T3, and T4 still maintained high scores (8.14). As storage progressed to 60 and 90 days, a decline in color quality was observed in formulations containing higher levels of ginger (T5, T6, and T7), with scores decreasing to 6.00–6.85. In contrast, T3 (2% ginger) maintained better stability throughout storage and

achieved a high score (8.14) at 90 days. Statistical analysis indicated that the differences among treatments were highly significant ($p < 0.01$; $LSD = 1.19$). Despite these changes, the color of most formulations remained acceptable until the end of the storage period. (Table-9)

Table 9: Effect of different levels of ginger extract on color score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	7.71 ^a _A	7.85 ^a _A	7.71 ^{ab} _A	7.71 ^{ab} _A
T2(Peach pulp + 1 % ginger extract)	7.71 ^a _{AB}	8.14 ^a _A	7.28 ^{abc} _B	7.71 ^{ab} _{AB}
T3(Peach pulp + 2 % ginger extract)	8.00 ^a _A	8.14 ^a _A	7.85 ^a _A	8.14 ^a _A
T4(Peach pulp + 3 % ginger extract)	7.71 ^a _A	8.14 ^a _A	7.57 ^{ab} _A	8.00 ^{ab} _A
T5(Peach pulp + 4 % ginger extract)	7.71 ^a _A	8.00 ^a _A	6.85 ^{abc} _B	6.85 ^{bc} _B
T6(Peach pulp + 5 % ginger extract)	7.85 ^a _A	7.57 ^a _A	6.57 ^{bc} _B	6.14 ^c _B
T7(Peach pulp + 6 % ginger extract)	8.14 ^a _A	7.14 ^a _B	6.28 ^c _C	6.00 ^c _C
Factors	F-test	LSD _{0.05}	CV (%)	
Storage period (A)	**	0.79		
Treatment (B)	**	1.19	9.96	
Interaction of A & B	**	-		

**:
P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The color evaluation results of ginger-flavored peach nectar showed that both storage duration and ginger concentration affected color quality. At the initial stage, all treatments had high scores (7.71–8.14), indicating good color stability. After 30 days, most formulations still maintained high quality, particularly T2, T3, and T4 (8.14). However, as storage progressed (60 and 90 days), formulations with higher ginger concentrations (T5, T6, and T7) showed a gradual decline in color scores, reaching as low as 6.00. In contrast, T3 (2% ginger) maintained relatively stable color throughout storage and still achieved a high score (8.14) at 90 days. Statistical analysis indicated that differences among treatments were highly significant ($p < 0.01$; $LSD = 0.79$). Overall, although some formulations showed slight color changes, the color of most samples remained acceptable for sensory quality.

Flavor

The flavor scores of ginger-flavored peach nectar varied depending on storage duration and ginger concentration. Initially, all formulations received relatively high and similar scores (7.42–8.00). After 30 days, some treatments, such as T2, recorded higher flavor scores (8.28), while formulations with higher ginger concentrations (T6 and T7) showed a decline in flavor scores (6.28–6.71). Throughout the storage period, T3 (2% ginger) maintained stable flavor scores and achieved the highest score (8.14) at 60 and 90 days. Statistical analysis indicated that the differences among treatments were significant ($p < 0.01$; $LSD = 1.18$). Overall, the flavor of formulations with moderate ginger levels remained acceptable throughout storage, whereas higher ginger concentrations slightly affected flavor quality in some treatments (Table-10).

Table. 10: Effect of different levels of ginger extract on flavor score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	7.57 ^a _A	7.85 ^{ab} _A	7.57 ^{ab} _A	7.57 ^{abc} _A
T2(Peach pulp + 1 % ginger extract)	7.42 ^a _B	8.28 ^a _A	7.85 ^{ab} _B	7.71 ^{ab} _B
T3(Peach pulp + 2 % ginger extract)	7.57 ^a _A	7.42 ^{abc} _A	8.14 ^a _A	8.14 ^a _A
T4(Peach pulp + 3 % ginger extract)	7.57 ^a _B	6.85 ^{bc} _B	7.85 ^{ab} _A	7.71 ^{ab} _A
T5(Peach pulp + 4 % ginger extract)	7.57 ^a _A	7.28 ^{abc} _A	7.14 ^{abc} _A	7.00 ^{abc} _A
T6(Peach pulp + 5 % ginger extract)	8.00 ^a _A	6.71 ^b _B	6.71 ^{bc} _B	6.42 ^c _B
T7(Peach pulp + 6 % ginger extract)	7.42 ^a _A	6.28 ^c _B	6.28 ^c _B	6.57 ^{bc} _B
Factors	F-test	LSD _{0.05}		CV (%)
Storage period (A)	NS	0.78		
Treatment (B)	**	1.18		10.05
Interaction of A & B	**	-		

** : P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The flavor scores of ginger-flavored peach nectar varied with storage duration and ginger concentration. Initially, all formulations received similarly high scores (7.42–8.00), indicating good flavor quality across all samples. After 30 days, T2 achieved the highest flavor score (8.28), while formulations with higher ginger concentrations (T6 and T7) showed lower scores (6.28–6.71). At 60 days, T3, containing 2% ginger, recorded the highest flavor score (8.14), whereas T6 and T7 continued to have lower scores (6.28–6.71). By 90 days, T3 remained stable (8.14), while T6 recorded a slightly lower score (6.42). These results indicate that a moderate ginger level is effective in maintaining the nectar’s flavor, whereas higher ginger concentrations can slightly reduce flavor quality in some formulations.

Taste

The taste of peach nectar was evaluated based on different levels of ginger addition (1–6%) and storage periods (0, 30, 60, and 90 days). The results indicated that adding 1–3% ginger (T2–T4) maintained a high, stable taste throughout all storage periods, whereas higher levels (4–6%, T5–T7) led to a decrease in taste, especially at 60 and 90 days. The F-test results confirmed significant differences in taste, with LSD and CV values indicating that the differences among treatments were meaningful. Overall, a low level of ginger is preferable for preserving peach nectar's taste. (Table-11)

Table. 11: Effect of different levels of ginger extract on taste score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	7.71 ^a _A	7.42 ^{ab} _A	7.42 ^{abc} _A	7.57 ^{ab} _A
T2(Peach pulp + 1 % ginger extract)	7.42 ^a _A	8.00 ^a _A	8.00 ^a _A	7.85 ^a _A
T3(Peach pulp + 2 % ginger extract)	8.00 ^a _A	7.57 ^{ab} _A	8.00 ^a _A	8.00 ^a _A

T4(Peach pulp + 3 % ginger extract)	7.71 ^a _A	6.57 ^b _B	7.85 ^{ab} _A	8.00 ^a _A
T5(Peach pulp + 4 % ginger extract)	7.42 ^a _B	7.14 ^{ab} _B	6.71 ^{bc} _B	7.57 ^{ab} _A
T6(Peach pulp + 5 % ginger extract)	8.14 ^a _A	7.00 ^{ab} _B	6.57 ^c _B	6.42 ^{bc} _B
T7(Peach pulp + 6 % ginger extract)	7.57 ^a _A	6.57 ^b _B	6.85 ^{abc} _B	6.28 ^c _B
Factors	F-test	LSD _{0.05}	CV (%)	
Storage period (A)	**	0.80		
Treatment (B)	**	1.22	10.34	
Interaction of A & B	**	-		

** : P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The results indicated that peach nectar supplemented with 1–3% ginger maintained a high and stable taste throughout storage, whereas higher ginger levels (4–6%) led to a noticeable decline in taste, particularly at 30, 60, and 90 days.

Odor

The results indicated that peach nectar samples containing 1–3% ginger maintained a high, stable odor throughout the storage period, whereas higher ginger levels (4–6%) led to a significant decline in odor quality. In particular, nectar with higher ginger concentrations showed noticeable reductions in odor scores at 30, 60, and 90 days, while the lower ginger treatments (T2–T3) continued to exhibit good odor quality. F-test, LSD, and CV results confirmed significant differences among treatments, indicating that a low level of ginger is preferable for preserving the odor quality of peach nectar.(Table-12)

Table. 12: Effect of different levels of ginger extract on odor score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	7.71 ^a _A	7.57 ^{abc} _A	7.85 ^a _A	7.71 ^a _A
T2(Peach pulp + 1 % ginger extract)	7.57 ^a _A	7.71 ^{ab} _A	7.85 ^a _A	7.71 ^a _A
T3(Peach pulp + 2 % ginger extract)	7.28 ^a _A	7.85 ^a _A	7.85 ^a _A	7.71 ^a _A
T4(Peach pulp + 3 % ginger extract)	8.00 ^a _A	6.42 ^c _B	7.85 ^a _A	7.71 ^a _A
T5(Peach pulp + 4 % ginger extract)	7.85 ^a _A	6.71 ^{abc} _B	6.85 ^{ab} _B	7.14 ^{ab} _B
T6(Peach pulp + 5 % ginger extract)	8.14 ^a _A	6.57 ^{bc} _B	6.71 ^{ab} _B	6.57 ^{ab} _B
T7(Peach pulp + 6 % ginger extract)	7.71 ^a _A	6.57 ^{bc} _B	6.42 ^b _B	6.14 ^b _B
Factors	F-test	LSD _{0.05}	CV (%)	
Storage period (A)	**	0.76		
Treatment (B)	**	1.16	9.89	
Interaction of A & B	**	-		

** : P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The odor quality of peach nectar was evaluated based on different levels of ginger (1–6%) and storage periods. The results showed that samples containing 1–3% ginger maintained a high,

stable aroma throughout the storage period, whereas higher levels (4–6%) caused a noticeable decline in odor quality at 30, 60, and 90 days. F-test, LSD, and CV results confirmed significant differences among treatments, indicating that a low level of ginger is preferable for preserving the odor quality of peach nectar.

Texture

The results showed that peach nectar samples containing 1–3% ginger maintained a good and stable texture throughout the storage period, whereas higher ginger levels (4–6%) caused a noticeable decline in texture quality at 30, 60, and 90 days, with F-test, LSD, and CV results confirming significant differences among treatments Table 13.

Table. 13: Effect of different levels of ginger extract on texture score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	8.28 ^a _A	7.57 ^a _B	8.00 ^a _B	8.00 ^a _B
T2(Peach pulp + 1 % ginger extract)	7.57 ^a _A	7.57 ^a _A	8.00 ^a _A	7.71 ^a _A
T3(Peach pulp + 2 % ginger extract)	7.71 ^a _A	7.85 ^a _A	7.85 ^{ab} _A	7.85 ^a _A
T4(Peach pulp + 3 % ginger extract)	7.85 ^a _A	7.00 ^a _B	7.85 ^{ab} _A	7.42 ^{ab} _B
T5(Peach pulp + 4 % ginger extract)	7.71 ^a _A	7.42 ^a _B	7.00 ^{bc} _B	7.14 ^{ab} _B
T6(Peach pulp + 5 % ginger extract)	8.14 ^a _A	7.28 ^a _B	7.00 ^{bc} _B	6.71 ^{bc} _B
T7(Peach pulp + 6 % ginger extract)	7.85 ^a _A	7.14 ^a _B	6.71 ^c _B	6.00 ^c _C
Factors	F-test	LSD _{0.05}	CV (%)	
Storage period (A)	**	0.65		
Treatment (B)	**	0.98	8.24	
Interaction of A & B	**	-		

** : P ≤ 0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The texture quality of peach nectar was evaluated based on different levels of ginger (1–6%) and storage periods. The results showed that samples containing 1–3% ginger maintained a good and stable texture throughout the storage period, whereas higher ginger levels (4–6%) caused a noticeable decline in texture quality at 30, 60, and 90 days.

Overall Acceptance

The overall acceptance of peach nectar was evaluated based on different levels of ginger (1–6%) and storage periods (0, 30, 60, and 90 days). The results showed that samples containing 1–3% ginger (T2–T4) maintained high, stable, and consumer-acceptable quality throughout the storage period, whereas samples with 4–6% ginger (T5–T7) exhibited a significant decline in acceptance, particularly at 30, 60, and 90 days. This indicates that higher levels of ginger may negatively affect the taste and overall quality of peach nectar. F-test, LSD, and CV results confirmed the presence of significant differences among treatments, suggesting that

a low level of ginger is preferable for maintaining the overall acceptance of peach nectar. Table-14.

Table. 14. Effect of different levels of ginger extract on overall acceptability score of peach nectar during storage at 0, 30, 60 and 90 days

Treatment	Storage period (Days)			
	0	30	60	90
T1 (Pure peach pulp)	8.14 ^a _A	7.71 ^{ab} _A	8.00 ^a _A	7.71 ^{ab} _A
T2(Peach pulp + 1 % ginger extract)	8.00 ^a _A	8.00 ^a _A	8.00 ^a _A	8.00 ^a _A
T3(Peach pulp + 2 % ginger extract)	8.00 ^a _A	8.00 ^a _A	8.00 ^a _A	8.14 ^a _A
T4(Peach pulp + 3 % ginger extract)	7.71 ^a _{AB}	7.28 ^{abc} _B	8.00 ^a _A	7.57 ^{ab} _{AB}
T5(Peach pulp + 4 % ginger extract)	7.71 ^a _A	7.14 ^{abc} _B	7.00 ^b _B	7.00 ^{bc} _B
T6(Peach pulp + 5 % ginger extract)	8.28 ^a _A	6.85 ^{bc} _B	6.85 ^b _B	6.85 ^{bc} _B
T7(Peach pulp + 6 % ginger extract)	8.14 ^a _A	6.71 ^c _B	6.42 ^b _B	6.28 ^c _B
Factors	F-test	LSD _{0.05}		CV (%)
Storage period (A)	**	0.56		
Treatment (B)	**	0.86		7.14
Interaction of A & B	**			

**.: P≤0.01; LSD: Least Significant Difference; CV: Coefficient of Variation; According to LSD at the 0.05 level, means within the same column, followed by the same small letter, and means within the same row, followed by the same capital letter, are not significantly different for treatment and storage period, respectively.

The overall acceptance of peach nectar was evaluated based on different levels of ginger (1–6%) and storage periods (0, 30, 60, and 90 days). The results showed that samples containing 1–3% ginger (T2–T4) maintained high and stable consumer acceptance throughout the storage period, whereas samples with 4–6% ginger (T5–T7) exhibited a significant decline in acceptance, particularly at 30 and 60 days. This indicates that higher ginger levels may negatively affect the taste and overall quality of peach nectar. F-test, LSD, and CV results confirmed significant differences among treatments, suggesting that a low level of ginger is preferable for maintaining the overall acceptance of peach nectar.

DISCUSSION

The chemical characteristics of ginger-flavored peach nectar changed significantly during storage, indicating the occurrence of several biochemical transformations that affected the product's overall quality. Total soluble solids (TSS) increased progressively throughout storage. This increase can be attributed to the hydrolysis of polysaccharides and other complex carbohydrates into simpler sugars, such as glucose and fructose, thereby enhancing sweetness and improving the nectar's sensory acceptability. These results agree with the findings of Hayat et al. (2019), Bhagwan and Awadhesh (2014), and Shagiwal et al. (2022), who likewise reported a progressive increase in TSS during storage of fruit-based beverages. In addition to changes in TSS, storage also affected the acid-base balance of the nectar, as reflected by variations in titratable acidity and pH. Titratable acidity initially increased in all treatments, likely due to the formation of organic acids, partial fermentation of sugars, and other biochemical reactions occurring during storage. However, after 60 days, acidity gradually declined, suggesting the degradation or utilization of organic acids and

reduced stability of acidic compounds during prolonged storage. In the pure peach juice treatment, acidity decreased by 0.13% after 90 days of storage. Correspondingly, the pH decreased from 3.60 to 3.23 during the first 30 days, reflecting increased acidity, and subsequently increased to 3.48 and 3.62 after 60 and 90 days, respectively, indicating partial stabilization of the nectar system. A comparable trend was documented by Sherzad et al. (2017), Deen et al. (2014), and Sattar et al. (2020), who observed similar fluctuations in acidity and pH during storage.

Notable modifications in the sugar composition of the nectar accompanied these changes in acidity and pH. The sugar profile changed markedly throughout storage, with reducing sugars increasing significantly as complex carbohydrates, pectic substances, and non-reducing sugars were broken down into simpler reducing sugars. Although a slight decline was observed after 90 days, possibly because of Maillard reactions and other degradative processes, the reducing sugar content remained higher than the initial level. In contrast, non-reducing sugars decreased substantially, from 7.20% at the beginning of storage to 0.41% after 60 days, with only a slight increase to 0.56% at the end of storage. This reduction suggests that sucrose and other non-reducing sugars were hydrolyzed into reducing sugars under storage conditions. The present observations corroborate the reports of Deen et al. (2014), Selvi et al. (2018), Harendra and Deen (2021), and Bhagwan and Awadshesh (2014), who also noted the conversion of non-reducing sugars into reducing sugars during storage.

As a consequence of these transformations in sugar fractions, the total sugar content also increased during storage. Total sugars increased from 11.36 g/100 mL at the beginning of storage to 13.30–13.81 g/100 mL during the intermediate storage period, then decreased slightly to 13.46 g/100 mL after 90 days. Nevertheless, the final value remained higher than the initial content, indicating that storage induced lasting compositional changes in the nectar. The increase in total sugars helped maintain sweetness and consumer acceptability. These findings are consistent with those reported by Hariharan and Mahendran (2016) and Bhagwan and Awadshesh (2014), who similarly recorded an increase in total sugar content as storage progressed. Collectively, the observed changes in TSS, acidity, pH, and sugar composition demonstrate that storage significantly influenced the chemical characteristics of ginger-flavored peach nectar. These continuous biochemical modifications affected sweetness, flavor balance, and overall product quality throughout storage. Furthermore, since sodium benzoate was used as a preservative, no spoilage was observed in any treatment during the study, indicating its effectiveness in maintaining product stability.

Besides chemical changes, storage duration and ginger concentration also played important roles in determining the sensory quality of the nectar. At the beginning of storage, all formulations exhibited high sensory scores, indicating good visual quality, attractive color, pleasant flavor, desirable taste, acceptable aroma, and favorable texture. However, gradual changes in sensory attributes became evident as storage progressed. The first sensory attribute affected by storage was appearance. Appearance scores declined slightly during

storage, particularly in treatments containing higher ginger concentrations. This reduction may be associated with suspended particles, compositional modifications, and non-enzymatic reactions that affected the visual quality of the nectar.

Nevertheless, formulations containing moderate levels of ginger, especially 2% ginger, maintained better appearance stability throughout the storage period. These findings correspond with the observations of Selvi et al. (2018), Hayat et al. (2019), and Rajpoot et al. (2025), who likewise reported a gradual reduction in appearance scores during storage of fruit-based beverages. Closely related to appearance, color quality also gradually deteriorated during storage. Although all treatments exhibited attractive, stable color at the beginning of storage, color scores gradually declined with prolonged storage, particularly in samples with higher ginger concentrations. This decline may be attributed to pigment degradation and to oxidative reactions that occur during storage.

In contrast, the formulation containing 2% ginger retained its color better than the other treatments. Comparable results were reported by Selvi et al. (2018), Hayat et al. (2019), and Rajpoot et al. (2025), who also documented storage-related reductions in the color quality of fruit beverages. As visual attributes changed, flavor quality was also influenced by storage duration and ginger concentration. Initially, all treatments received high flavor scores, demonstrating that ginger incorporation did not adversely affect product acceptability. However, as storage continued, formulations containing moderate ginger concentrations maintained superior flavor quality, whereas samples with excessive ginger levels showed lower sensory ratings. These observations support the findings of Mishra and Sangma (2017), Selvi et al. (2018), and Hayat et al. (2019), who reported that moderate incorporation of ginger improves flavor retention during storage. Similar patterns were observed for taste perception. Nectar formulations containing 1–3% ginger retained desirable taste characteristics throughout storage, whereas formulations with higher ginger concentrations showed a gradual decline in taste acceptability. The reduction in taste scores may be associated with the development of stronger pungent and slightly bitter notes during prolonged storage. Similar responses have been described by Rajpoot et al. (2025), Selvi et al. (2018), and Hayat et al. (2019), who observed decreased taste acceptance at elevated ginger concentrations.

In addition to taste, aroma characteristics were also affected by ginger concentration during storage. Samples with lower ginger concentrations maintained relatively stable and desirable odor scores, whereas those with higher levels showed noticeable reductions in odor quality. This decline may be attributed to the dominance of ginger aroma, which could gradually mask the characteristic peach fragrance. Consistent findings were reported by Rajpoot et al. (2025), who also noted reduced aroma acceptability at higher ginger concentrations. The influence of ginger concentration extended further to textural properties. Texture scores showed that formulations with low to moderate ginger levels maintained a smoother and more desirable mouthfeel throughout storage. Conversely, treatments with higher ginger concentrations showed progressive reductions in texture

quality, suggesting that excessive ginger may negatively affect the structural integrity and consistency of the nectar. These observations are supported by Selvi et al. (2018) and Hayat et al. (2019), who similarly reported deterioration of textural properties during extended storage. As a combined result of the changes in appearance, color, flavor, taste, odor, and texture, overall consumer acceptance also varied among treatments. Samples containing 1–3% ginger maintained higher acceptance scores throughout the storage period, whereas formulations with 4–6% ginger experienced significant declines in overall acceptability. These results indicate that moderate ginger incorporation enhances product acceptability, while excessive levels may adversely affect sensory perception during storage. The present findings are in accordance with those of Patel et al. (2025), Selvi et al. (2018), and Hayat et al. (2019), who likewise emphasized the importance of optimizing ginger concentration to achieve greater consumer satisfaction in fruit-based beverages. Overall, the results demonstrate that moderate ginger incorporation, particularly at levels between 1% and 3%, is more effective in preserving both the chemical stability and sensory quality of peach nectar throughout storage. In contrast, higher ginger concentrations may negatively influence several sensory attributes over time, thereby reducing overall consumer acceptability.

CONCLUSION

The study showed that ginger concentration and storage duration significantly influenced the chemical and sensory quality of ginger-flavored peach nectar. During storage, TSS, sugars, and acidity increased, while pH and non-reducing sugars decreased. Among all treatments, 2% ginger (T₃) showed the best chemical stability and highest sensory acceptability throughout storage. Therefore, a moderate level of ginger is recommended for producing functional peach nectar with good quality and consumer acceptance. Future research should focus on storage conditions, shelf life, and the product's microbiological quality.

Authors Contributions

Dr. Hamid Salari proposed the research concept, supervised the study, and contributed to the research. Ezatullah Ezatmand conducted the research, analyzed the data with the assistance of Dr. Hamid Salari, and wrote the manuscript while incorporating feedback from the co-author. All authors reviewed and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Data Availability Statement

All data generated or analyzed during this study are included in this published article and its supplementary files. Additional raw data related to chemical and sensory evaluations of ginger-flavored peach nectar can be made available from the corresponding author upon reasonable request, subject to ethical approval.

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