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Review Article

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Development and Storage Behavior of Persimmon-based Flavored Functional Beverage

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Abstract

Persimmon is a rich reservoir of essential nutrients including protein, dietary fiber, minerals, carbohydrates, carotenes, phenolic compounds, and vitamins. This research study was designed with the aim to develop ready-to-serve beverages infused with persimmon and citrus juices and investigating the impact on their physical as well as chemical attributes over a storage period of two months. Various combinations of ingredients were employed, encompassing honey, galgal, ginger juice, mint extract, and spice extract, with total soluble solids (TSS) 10 °Brix and titratable acidity 0.30%. Among all the persimmon ready-to-serve (RTS) beverages prepared using different proportions of ingredients, the blend (T_8) incorporating persimmon pulp (10%), galgal juice (7%), ginger juice (3%), mint extract (3%) and spice extract (3%) was particularly preferred by the panelists with a higher overall acceptability score of 7.07 ± 0.44 respectively. Treatment T_8 (10% pulp + 3% ginger juice + 3% mint extract + 3% spice extract) recorded to have the higher ascorbic acid (21.60 ± 0.34), total phenols (10.16 ± 0.38), total flavonoids (10.98 ± 0.43) beside higher antioxidant activity 69.35 ± 0.27 percent among all the treatment. It was revealed that treatment T_8 using galgal and honey was found to be the best based on sensory evaluation and chemical parameters. Furthermore, the findings strongly indicate that persimmons with honey, galgal, ginger juice, mint extract, and spice extract hold the potential for the preparation of flavored persimmon beverages.

Keywords

Persimmon, Flavored beverage, Ready-to-serve beverage, Shelf life, Storage, Total soluble solids, Phenolic content, Flavonoids

Introduction

The commercial persimmon fruit, Diospyros kaki, is a member of the Ebenaceae family with the popular name Japanese phal or food of the god [1]. Diospyros is a genus of plants native to Asia, primarily China and, there are reports of it being cultivated centuries after Christ [2]. Because of its remarkable tolerance to tropical and temperature climates, it expanded from Korea to other continents [3]. The trees range in size from small to medium. Fruits begin to become greenish but as they grow, chlorophyll is lost, and carotenoids cause the color to change from yellow to orange. The color of the peel and consistency of the pulp define the crop's ripening stage [4]. Additional species in this genus include *Diospyros virginiana*, sometimes known as the American persimmon and widespread throughout North America. It is occasionally cultivated for its fruits or as an adornment. However, Diospyros lotus is widely cultivated in the Middle East [5, 6].

The *Diospyros oleifera* species is another native African plant [7]. The cultivars of the persimmon fruit are divided into groups based on how well they respond to flower pollination, color change, fruit astringency persistence, and pulp. Based on the astringency, persimmon is divided into astringent cultivars (Hachiya, Tonewase, RojoBrillante, Giboshi, KakiTipo, Aizumishirazu A, Gimbo) and non-astringent cultivars O'Gosho, Hana Fuyu, and Jiro) [8]. China, Japan, Brazil, and Italy are the major persimmon producers. Minor producers include the United States, Spain, Egypt, Australia, and India [6]. Persimmon is grown in India in areas such as Himachal Pradesh, Jammu & Kashmir, Uttarakhand, and Tamil Nadu, and is known as Japaniphal [9].

Persimmon is a valuable fruit that provides protein, fiber, minerals, vitamin sources, phenolic compounds, carbohydrates, and carotenoids [10, 11]. The persimmon fruits contain sugars that comprise of most of the glucose and less fructose [12]. Except for Na, persimmons have a higher concentration of minerals in their skin (Mn, K, Zn, Mg, Fe, Cu, and Ca) than in the pulp [13]. Persimmon fruit contains high levels of carotenoids, tannins, polyphenols, ascorbic acid, and sugars, indicating that it has several health benefits. Flavonoids (condensed tannins and catechins) and vitamin C are also abundant in persimmon. The major antioxidants contained in persimmons include phenolic compounds, vitamin C, and carotenoids, which may inhibit free radicals from causing damage and aid in preventing antimutagenic and anti-carcinogenic disorders [14]. One unique characteristic of the persimmon fruit is its high concentration of proantho cyanidins, which is referred to as persimmon tannin. Its consumption has been associated with various health advantages, such as hypoglycemic, hypolipidemic, antibacterial, antiviral, antioxidant, and anti-inflammatory effects. It also facilitates detoxification from snake venom [15]. Since persimmon is a seasonal fruit, it could easily be developed into a value-added product, like beverages, to prolong the shelf life and make it easily accessible to consumers. Traditionally, persimmons are predominantly marketed and consumed in their fresh form. However, in recent times, a variety of persimmon-based products have emerged in the market. These encompass items like dried persimmons [16], ice cream [17], persimmon wine [18], vinegar [19], and persimmon snacks [20].

The popularity or consumption trend of fruit-based beverages in the Indian market is increasing day by day as it provides various nutrients and natural antioxidants. Some varieties of persimmon fruit contain high level of astringency due to which it is not explored for beverage preparation. However, it is rich in polyphenols, carotenoids, ascorbic acid, and sugars. Also, due to its limited shelf life, it could be made available to people throughout the year in the form of nutritious beverages after the exploration of both astringent and non-astringent cultivars. The persimmon fruit beverage is a triumph of flavor innovation that brings the unique qualities of persimmons to the forefront. Its distinct taste, coupled with its nutritional benefits, make it an excellent choice for those seeking a flavorful and health-conscious beverage option. The current study aims to formulate a flavored RTS beverage with various proportions of ingredients like ginger extract, galgal juice, mint extract, and spice extract with a constant portion of persimmon pulp to increase the nutritional value of the prepared beverage with higher antioxidant potential. The study also investigated the physicochemical properties and sensory attributes of formulated beverages for the storage life of 2 months at ambient and refrigerated conditions.

Material and Methods

Raw material

The matured persimmon fruits were obtained from the local market of Delhi and kept at room temperature for ripening. The completely matured persimmons were selected based on visual inspection and utilized for pulp preparation and preservation. The pulp was used to create RTS drinks. Honey, spices, ginger, mint, and other materials used in the study were acquired from a local market in Phagwara. Chemicals used for the study are of Loba chemicals.

Methods

Preparation of ingredients for flavored persimmon beverage

Persimmon pulp: The persimmons were properly cleaned. The calyx was manually removed and cut into half using a stainless-steel knife. The seeds were removed manually and then the fruit was cooked in a pressure cooker with addition of 20% water for 8 min.

Ginger juice: The fresh ginger rhizomes were washed and peeled. After grating the ginger manually, the shreds were ground in a Sujata super mixer grinder (900 watt) by adding water (1:2). The mixture was passed through muslin cloth and juice was collected.

Mint extract: The mint extract was prepared using fresh mint leaves. The leaves were grounded in a mixer (Sujata super mixer grinder 900 watt). The juice was extracted by passing it through muslin cloth.

Spice extract: The spice extract was prepared using black cardamon (1 g), cumin (2.5 g), black pepper (2.5 g), black salt (2.5 g), and common salt (2.5 g). The spices were grounded in a mixer (Sujata super mixer grinder 900 watt) and the volume was made up to 200 ml by water followed by boiling and straining of extract.

Galgal juice: With the use of a stainless-steel knife, the galgal was cut in half, and the juice was removed manually by squeezing through muslin cloth.

Lemon juice: With the assistance of a stainless-steel knife, lemon was split in half and the lemon juice was extracted manually using handheld lemon squeezer.

Preparation of RTS beverage

RTS beverage was developed in accordance with FSSAI guidelines. Different combinations of persimmon pulp, spice extract, ginger juice, mint extract, lemon juice, galgal juice, sugar, and honey were used to prepare the beverages (Table 1). Sterilized glass bottles (200 ml) were hot filled with the prepared product and then sealed with crown corks. Then, the product was pasteurized at 85-90 °C for 30 min. The bottles were allowed to cool at room temperature. A panel of ten judges evaluated the RTS beverage in various combinations

Table 1: Treatment combinations for preparation of RTS beverage using honey, galgal juice and persimmon pulp.

Treatment (T)	Persimmon pulp (%)	Galgal juice (%)	Ginger juice (%)	Mint extract (%)	Spice extract (%)	TSS (°B)
T_1	10	8	-	-	-	10
T_2	10	7	3	-	-	10
T_3	10	7	-	3	-	10
T_4	10	7	-	-	3	10
T_5	10	7	3	3	-	10
T_6	10	7	3	-	3	10
T_7	10	7	-	3	3	10
T_8	10	7	3	3	3	10

for sensory evaluation. The combination with the best overall approval score was chosen for the storage analysis.

Physico-chemical properties

The percentage of total soluble solids present in the samples was directly measured using a refractometer. The determination of titratable acidity involved titration of a known volume of the sample against a standard solution of 0.1 N NaOH, employing phenolphthalein as an indicator. The total flavonoid content was determined according to the standard procedures [21]. The method outlined by Brand-Williams et al. [22] was employed to determine the antioxidant activity. Meanwhile, the total phenolic content was evaluated using the procedure elucidated by Singleton and Rossi [23].

Sensory evaluation

A panel of judges evaluated the RTS beverage in various combinations for sensory evaluation using 9-point hedonic scale [24]. Ten judges were chosen with great concern to assess the given samples based on a range of sensory attributes, including color, consistency, taste, aroma, and overall acceptability. To ensure impartial results, the products were assigned unique codes before being presented to the judges. Additionally, the judges evaluated the samples in separate locations to eliminate the potential for biases or undue influence during the assessment process.

Statistical analysis

Persimmon based RTS beverage was evaluated for various physicochemical properties using IBM SPSS version 25. This was also used to analyze the data related to the sensory assessment. Three independent replications of various experiments were performed.

Results and Discussion

Physicochemical and sensory analysis of persimmon RTS beverage prepared using different treatments

The chemical characteristics of RTS beverage made using honey, persimmon pulp and galgal juice are mentioned in table 2. It is observed from the data that the titratable acidity ranged 0.33 to 0.38%, with maximum value in T_8 (3% ginger juice + 3% mint extract + 3% spice extract) and minimum value in T_1 (control). The ascorbic acid was highest in T_8 i.e., 21.6 mg/100 g and lowest in T_1 i.e., 14.4 mg/100 g. The total phenols and total flavonoids were also observed to be highest in T_8 i.e., 10.16 mg/100 g and 10.98 mg/100 g and lowest in T_1 i.e., 7.16 mg/100 g and 9.4 mg/100 g, respectively. The antioxidant activity ranged from 61.25 to 69.35% where maximum value was observed in T_8 and minimum in T_1. The addition of ginger juice (3%), mint extract (3%), spice extract (3%), and honey in persimmon RTS increased the chemical characteristics like antioxidant activity, total phenols, flavonoids, and ascorbic acid as compared to other combinations.

Table 2: Chemical characteristics of RTS beverage prepared using honey, galgal juice and persimmon pulp.

Treatment	TSS (°B)	Titratable acidity (%)	Ascorbic acid (mg/100 g)	Total phenols (mg/100 g)	Total flavonoids (mg/100 g)	Antioxidant activity (%)
T_1	10	0.33 ± 0.12^{b}	14.4 ± 0.23^{a}	7.16 ± 0.35^{a}	9.40 ± 0.42^{a}	61.25 ± 0.11^{a}
T_2	10	0.35 ± 0.14^{bc}	18.9 ± 0.21^{c}	7.76 ± 0.36^{c}	9.50 ± 0.4^{b}	63.75 ± 0.17^{b}
T_3	10	0.34 ± 0.17^{a}	15.75 ± 0.22^{b}	7.56 ± 0.31^{b}	9.80 ± 0.44^{c}	64.37 ± 0.18^{c}
T_4	10	0.34 ± 0.17^{b}	18.45 ± 0.25^{c}	7.86 ± 0.39^{d}	10.17 ± 0.40^{d}	61.87 ± 0.21^{a}
T_5	10	0.37 ± 0.19^{d}	19.80 ± 0.23^{d}	8.56 ± 0.37^{e}	10.60 ± 0.36^{e}	63.85 ± 0.13^{d}
T_6	10	0.36 ± 0.18^{d}	20.25 ± 0.29^{e}	9.26 ± 0.33^{f}	10.82 ± 0.35^{f}	65.82 ± 0.24^{d}
T_7	10	0.36 ± 0.16^{d}	19.35 ± 0.31^{d}	9.66 ± 0.40^{g}	10.90 ± 0.34^{g}	67.75 ± 0.15^{d}
T_8	10	0.38 ± 0.15^{de}	21.60 ± 0.34^{f}	10.16 ± 0.38^{h}	10.98 ± 0.43^{h}	69.35 ± 0.27^{e}

Note: T_1 (control 10% pulp), T_2 (10% pulp + 3% ginger), T_3 (10% pulp + 3% mint), T_4 (10% pulp + 3% spice), T_5 (10% pulp + 3% ginger + 3% mint), T_6 (10% pulp + 3% ginger + 3% spice), T_7 (10% pulp + 3% mint + 3% spice) and T_8 (10% pulp + 3% ginger juice + 3% mint extract + 3% spice extract).

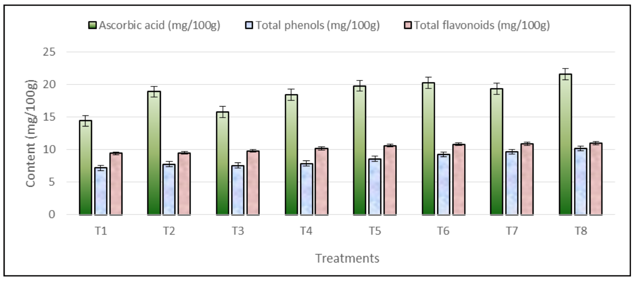

Figure 1: Chemical characteristics of RTS beverage prepared using honey, galgal juice and persimmon pulp.

Figure 1 represents the comparison of chemical characteristics of beverages made using different treatments. An evaluation of data (Table 3) indicated that the highest overall acceptability (7.07) was obtained by T_8 (3% ginger juice + 3% mint extract + 3% spice extract) and minimum (6.93) was found in T_1 (control). The highest mean score for taste (7.68) was awarded to treatment T_8 (3% ginger juice + 3% mint extract + 3% spice extract), and highest mean score for aroma (7.06), was awarded to T_6 (3% ginger + 3% spice), as shown in figure 2. The addition of honey enhanced the color and consistency of the RTS beverages. A similar effect of honey addition was observed by Leite et al. [25], in the preparation of apple and passion fruit mixed beverage [25]. The aroma and flavor of the spices made the T_4 and T_8 treatments like be liked compared with other treatments by the panelist. In a similar research study, observations revealed that Kinnow-Aonla blends lacking herbal additives received lower scores compared to RTS samples incorporating a blend of herbs [26].

Storage studies of functional beverage

According to the results of the chemical and sensory analyses (Table 2 and table 3), T_8 (3% ginger juice + 3% mint extract + 3% spice extract using persimmon pulp, galgal juice, and honey) is considered most acceptable. The chemical and functional parameters such as ascorbic acid, total flavonoids, antioxidant activity and total phenols value were also highest as compared to other treatments. Therefore, T_8 was chosen for storage studies. Also, based on the evaluation by sensory panelist, the TSS content of best-selected treatment was revised to 12 ˚B for further storage. Packaging materials such as glass bottles and PET bottles were employed for storage experiments. The durations for storage under refrigeration and at room temperature were 0, 1, and 2 months.

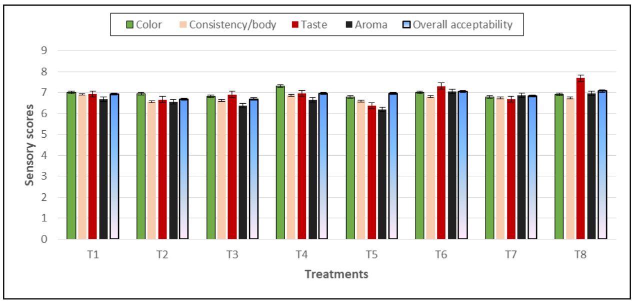

Figure 2: Sensory scores of RTS prepared using honey, galgal juice and persimmon pulp.

Total soluble solids (TSS)

The effect of storage on TSS of persimmon RTS beverage made by hot pulping (5%), is represented in table 4. It was observed that the TSS gradually increased with the progression of storage in drinks of various treatments. Using a glass bottle as a packing medium, the TSS varied from 12 to 12.70 ºB in ambient and 12 to 12.50 ˚B in refrigerated conditions after 2 months of storage. TSS in PET bottles varied from 12 to 12.80 ˚B in ambient and 12 to 12.70 ˚B in refrigerated conditions after 2 months of storage. When compared to glass bottles as a packaging material, the results show that PET bottles in ambient condition have the highest mean value of TSS during storage. As a result, TSS was elevated to a higher level under ambient conditions when stored for an extended period. TSS may have increased during storage due to the solubilization of particulates in the juice. Similarly, an increasing pattern of TSS was observed throughout the storage period of therapeutic ready-to-serve drink made from combinations of *Aloe vera*, aonla, and ginger juice [27]. These results were nearby to results reported for papaya *A. vera* RTS [28], and litchi and pineapple juice [29], mulberry RTS [30].

Ascorbic acid

The data from table 5 indicates the impact of storage on the ascorbic acid content in RTS beverages. The results showed

Table 3: Sensory scores of RTS beverage prepared using honey, galgal juice and persimmon pulp.

Treatment	Color	Consistency	Taste	Aroma	Overall acceptability
T_1	7.00 ± 0.24^{c}	6.91 ± 0.12^{e}	6.93 ± 0.38^{c}	6.68 ± 0.41^{d}	6.93 ± 0.36^{c}
T_2	6.95 ± 0.23^{ab}	6.57 ± 0.17^{a}	6.66 ± 0.36^{b}	6.56 ± 0.43^{c}	6.68 ± 0.34^{a}
T_3	6.82 ± 0.27^{a}	6.62 ± 0.14^{b}	6.91 ± 0.37^{c}	6.37 ± 0.44^{b}	6.69 ± 0.43^{a}
T_4	7.31 ± 0.29^{d}	6.87 ± 0.13^{d}	6.96 ± 0.33^{c}	6.65 ± 0.48^{d}	6.95 ± 0.38^{c}
T_5	6.8 ± 0.28^{a}	6.6 ± 0.15^{b}	6.37 ± 0.34^{a}	6.18 ± 0.47^{a}	6.96 ± 0.40^{c}
T_6	7.01 ± 0.21^{c}	6.81 ± 0.19^{d}	7.31 ± 0.32^{d}	7.06 ± 0.42^{g}	7.05 ± 0.37^{d}
T_7	6.8 ± 0.22^{a}	6.73 ± 0.11^{c}	6.68 ± 0.39^{b}	6.86 ± 0.49^{e}	6.84 ± 0.31^{b}
T_8	6.9 ± 0.2^{ab}	6.75 ± 0.2^{c}	7.68 ± 0.3^{e}	6.95 ± 0.4^{f}	7.07 ± 0.44^{e}

Note: T_1 (control 10% pulp), T_2 (10% pulp + 3% ginger), T_3 (10% pulp + 3% mint), T_4 (10% pulp + 3% spice), T_5 (10% pulp + 3% ginger + 3% mint), T_6 (10% pulp + 3% ginger + 3% spice), T_7 (10% pulp + 3% mint + 3% spice) and T_8 (10% pulp + 3% ginger juice + 3% mint extract + 3% spice extract).

Table 4: Effect of storage on total soluble solids (°B) of persimmon RTS beverage.

Treatment (T)	Ambient storage (months)			Refrigerated storage (months)		
	0	1	2	0	1	2
T_1	12.00 ± 0.09	12.30 ± 0.16	12.60 ± 0.21	12.00 ± 0.11	12.20 ± 0.18	12.50 ± 0.24
T_2	12.00 ± 0.15	12.40 ± 0.19	12.70 ± 0.20	12.00 ± 0.16	12.30 ± 0.21	12.60 ± 0.29
T_3	12.00 ± 0.15	12.50 ± 0.21	12.70 ± 0.26	12.00 ± 0.25	12.30 ± 0.16	12.50 ± 0.28
T_4	12.00 ± 0.18	12.60 ± 0.24	12.80 ± 0.17	12.00 ±0.21	12.40 ± 0.27	12.70 ± 0.25

Note: T_1: Control packed in glass bottles, T_2: Control packed in PET bottles, T_3: 3% ginger + 3% mint + 3% spice extract packed in glass bottles and T_4: 3% ginger + 3% mint + 3% spice extract packed in PET bottles.

Table 5: Effect of storage on total ascorbic acid (mg/100 g) of persimmon RTS beverage.

Treatment (T)	Ambient storage (months)			Refrigerated storage (months)		
	0	1	2	0	1	2
T_1	14.40 ± 0.19	14.00 ± 0.31	13.60 ± 0.27	14.40 ± 0.21	14.14 ± 0.26	13.88 ± 0.30
T_2	14.40 ± 0.13	13.60 ± 0.32	12.80 ± 0.35	14.40 ± 0.19	13.80 ± 0.24	13.20 ± 0.27
T_3	20.25 ± 0.21	19.45 ± 0.36	18.85 ± 0.31	20.25 ± 0.24	19.65 ± 0.26	19.05 ± 0.22
T_4	20.25 ± 0.21	19.85 ± 0.23	19.45 ± 0.29	20.25 ± 0.21	19.99 ± 0.25	19.73 ± 0.29

Note: T_1: Control packed in glass bottles, T_2: Control packed in PET bottles, T_3: 3% ginger + 3%mint + 3% spice extract packed in glass bottles and T_4: 3% ginger + 3% mint + 3% spice extract packed in PET bottles.

a decreasing trend in ascorbic acid throughout a 2 months storage period, with the mean value lowering from 14.40 to13.60 mg/100 g and 20.25 to 18.85 mg/100 g in ambient conditions and from 14.40 to 13.88 mg/100 g and 20.25 to 19.05 mg/100 g under refrigerated conditions utilizing glass bottles as a packaging material. After 2 months of storage, the titratable acidity in PET bottles ranged from 14.40 to 12.80 mg/100 g and 20.25 to 19.45 g/100 g in ambient conditions and 14.40 to 13.20 mg/100 g and 20.25 to 19.73 mg/100 g in refrigerated conditions. The least mean value for ascorbic acid was reported in glass bottles during 2 months of storage of persimmon RTS beverage made using 5% hot pulp method. Dehydroascorbic acid degradation might explain the decrease in ascorbic acid concentration during storage. The relationship between the combination of storage conditions and storage interval was shown to be important. Because ascorbic acid is particularly sensitive to heat, higher deterioration was observed under ambient circumstances than refrigerated storage. The ascorbic acid loss might be related to the irreversible conversion of L-ascorbic acid into dehydroascorbic acid oxidase generated by trapped or residual oxygen inside the glass bottles [31]. Although, the slow ascorbic acid degradation during refrigerated storage could potentially be attributed to reduced reaction rate in refrigerated conditions when compared with room temperature. The results were in line with the results obtained for evaluation of RTS beverage from cape gooseberry [32] and mulberry [30], respectively.

Total phenols

According to the data presented in table 6, there is a decreasing trend in total phenols throughout a two-month storage period. The overall effect of storage period showed that total phenols decreased from 7.16 to 6.96 mg/100 g and 10.16 to 9.96 mg/100 g in ambient conditions and from 7.16 to 7.05 mg/100 g and 10.16 to 10.05 mg/100 g under refrigerated conditions using glass bottles as packaging material. After 2 months of storage, the total phenols in PET bottles ranged from 7.16 to 6.58 mg/100 g and 10.16 to 9.58 mg/100 g in ambient conditions and 7.16 to 6.64 mg/100 g and 10.16 to 9.94 mg/100 g in refrigerated conditions. The lowest mean value for total phenols was reported in PET bottles during 2 months of storage of persimmon RTS beverage utilizing 5% hot pulp. This reduction in total phenolic content may be attributed to the oxidation of phenols during storage [33, 34]. Total phenols may decrease considerably during storage due

Table 6: Effect of storage on total phenols (mg/100 g) of persimmon RTS beverages.

Treatment (T)	Ambient storage (months)			Refrigerated storage (months)		
	0	1	2	0	1	2
T_1	7.16 ± 0.19	7.06 ± 0.17	6.96 ± 0.25	7.16 ± 0.30	7.10 ± 0.26	7.05 ± 0.28
T_2	7.16 ± 0.19	6.87 ± 0.22	6.58 ± 0.23	7.16 ± 0.17	6.9 ± 0.25	6.64 ± 0.21
T_3	10.16 ± 0.20	10.06 ± 0.31	9.96 ± 0.32	10.16 ± 0.23	10.10 ± 0.29	10.05 ± 0.31
T_4	10.16 ± 0.20	9.87 ± 0.41	9.58 ± 0.39	10.16 ± 0.24	9.9 ± 0.36	9.64 ± 0.32

Note: T_1: Control packed in glass bottles, T_2: Control packed in PET bottles, T_3: 3% ginger + 3% mint + 3% spice extract packed in glass bottles and T_4: 3% ginger + 3% mint + 3% spice extract packed in PET bottles.

to their role in the synthesis of polymeric compounds complexed with protein and their subsequent precipitation [35]. The outcomes related to total phenols from this research align with the findings for guava-mango drink [36] and pumpkin RTS beverages [37].

Total flavonoids

The data in table 7 reveals a decreasing trend in total flavonoids of RTS beverage prepared using persimmon pulp by hot pulping (5%) method during entire storage period of 2 months. The overall effect of storage period showed that total flavonoids decreased from 9.4 to9.20 mg/100 g and 10.98 to 10.62 mg/100 g in ambient conditions and from 9.4 to 9.28 mg/100 g and 10.98 to 10.86 mg/100 g under refrigerated conditions using glass bottles as packaging material. After 2 months of storage, the total flavonoids in PET bottles ranged from 9.4 to 8.82 mg/100 g and 10.98 to 10.40 mg/100 g in ambient conditions and 9.4 to 8.85 mg/100 g and 10.98 to 10.46 mg/100 g in refrigerated conditions. The least mean value for total flavonoids was reported in PET bottles during 2 months of storage of persimmon RTS beverage using 5% hot pulp. The decline in total flavonoid content during storage is evident. However, refrigeration effectively retained much content of total flavonoids. The degradation of total flavonoids was notably faster at room temperature storage compared to refrigeration, relative to the initial flavonoid levels [38]. The study on sapodilla RTS beverage revealed that as the storage duration increased, there was a gradual reduction in the total flavonoid content [39].

Antioxidant activity

As presented in table 8, the overall effect of storage period showed that antioxidant activity decreased from 61.25 to 61.05% and 69.35to 69.15% in ambient conditions and from 61.25 to 61.14% and 69.35 to 69.24% under refrigerated conditions using glass bottles as packaging material. After 2 months of storage, antioxidant activity in PET bottles ranged from 61.25 to 60.67% and 69.35 to 68.77% in ambient conditions and 61.25 to 60.73% and 69.35 to 68.83% in refrigerated conditions. The least mean value for antioxidant activity was reported in PET bottles during 2 months of storage of persimmon RTS beverage (5% hot pulp method) stored in ambient condition. The reduction in antioxidant activity observed over time could be due to the potential oxidation of bioactive elements under favorable environmental circumstances during the storage period [40]. Likewise, storage of orange juice and its impact on antioxidant potency was examined, noting a downward trend in the activity of antioxidants within the juices [41]. Reduction in antioxidant activity during storage was similarly noticed in beverages formed from a mixture of beetroot and passion fruit [42], bayberry and yellow Himalayan raspberry [43] and Kinnow juice [44].

Conclusion

The study outcomes suggest the application of persimmon, which is an infrequently utilized ingredient in food processing industries. Contrary to conventional understanding, the results indicate that persimmon fruits have the potential to yield premium, nutritionally dense flavored beverages. The research indicated that the most favorable outcomes were observed in the RTS beverages formulated using the treatment T_8. Among all the persimmon RTS beverages treatments, the blend incorporating persimmon pulp (10%), ginger juice (3%), mint extract (3%) and spice extract (3%) was particularly preferred by the panelists, achieving an overall acceptability score of 7.07 ± 0.44 respectively. The developed RTS beverage (T_8) was found to have the highest antioxidant activity among others. The total phenols and total flavonoids were also observed to be highest in treatment T_8 as 10.16 mg/100 g and 10.98 mg/100 g, respectively. The final product was subjected to both refrigerated and room temperature storage over a period of two months. Notably, the study highlights a difference

Table 7: Effect of storage on total flavonoids (mg/100 g) of RTS beverage.

Treatment (T)	Ambient storage (months)			Refrigerated storage (months)		
	0	1	2	0	1	2
T_1	9.4 ± 0.23	9.30 ± 0.15	9.20 ± 0.19	9.4 ± 0.35	9.34 ± 0.26	9.28 ± 0.31
T_2	9.4 ± 0.16	9.11 ± 0.25	8.82 ± 0.34	9.4 ± 0.24	9.14 ± 0.27	8.85 ± 0.18
T_3	10.98 ± 0.29	10.72 ± 0.24	10.62 ± 0.34	10.98 ± 0.19	10.92 ± 0.26	10.86 ± 0.24
T_4	10.98 ± 0.35	10.69 ± 0.32	10.40 ± 0.32	10.98 ± 0.21	10.72 ± 0.23	10.46 ± 0.31

Note: T_1: Control packed in glass bottles, T_2: Control packed in PET bottles, T_3: 3% ginger + 3% mint + 3% spice extract packed in glass bottles and T_4: 3% ginger + 3% mint + 3% spice extract packed in PET bottles.

Table 8: Effect of storage on antioxidant activity (%) of RTS beverage prepared.

Treatment (T)	Ambient storage			Refrigerated storage		
	0	1	2	0	1	2
T_1	61.25 ± 0.19	61.15 ± 0.22	61.05 ± 0.26	61.25 ± 0.21	61.19 ± 0.26	61.14 ± 0.34
T_2	61.25 ± 0.24	60.96 ± 0.19	60.67 ± 0.35	61.25 ± 0.26	60.99 ± 0.34	60.73 ± 0.25
T_3	69.35 ± 0.22	69.25 ± 0.41	69.15 ± 0.38	69.35 ± 0.32	69.29 ± 0.30	69.24 ± 0.24
T_4	69.35 ± 0.26	69.06 ± 0.31	68.77 ± 0.26	69.35 ± 0.29	69.09 ± 0.30	68.83 ± 0.24

Note: T_1: Control packed in glass bottles, T_2: Control packed in PET bottles, T_3: 3% ginger + 3% mint + 3% spice extract packed in glass bottles and T_4: 3% ginger + 3% mint + 3% spice extract packed in PET bottle.

between the levels of functional component in RTS beverages contained in PET bottles versus those stored in glass bottles. As a result, further investigation on large-scale commercial production of this beverage can help to utilize this fruit in the food industry.

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Conflict of Interest

None.

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