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PREPARATION AND CHARACTERIZATION OF PERSIMMON FRUIT LEATHER DURING STORAGE

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Abstract

The present study was performed to prepare persimmon fruit leather and evaluate the physicochemical quality characteristics during storage. Persimmon fruit was processed into puree and mixed with sugar in different ratios [T_0 (100:0), T_1 (80:20), T_2 (75:25), and T_3 (70:30)] to prepare fruit leather by dehydration at 65°C for 6 hours. Leather was then stored in polyethylene bags at ambient temperature for 90 days and analyzed for titratable acidity, ascorbic acid content, total soluble solids (TSS), firmness, color (L, a*, b*), and sensory parameters at 30 day intervals. The results revealed decrease in titratable acidity, ascorbic acid and firmness across all treatments whereas T_3 retained comparatively higher acidity (0.54%) and ascorbic acid content (30.40 mg/100ml) at the end of storage. TSS increased and color parameters also shifted among all treatments throughout the storage. Sensory evaluation performed at 90 days of storage indicated that T_2 achieved the highest scores for taste, aroma and overall acceptability, outperforming other treatments. The findings of this study demonstrate that fruit leather prepared from puree-to-sugar ratio of 75:25 (T_2) and 70:30 (T_3) performed better in terms of retaining physicochemical and sensorial quality characteristics. The development of persimmon leather presents a viable approach for reducing postharvest losses, diversifying fruit-based products, and offering consumers a convenient, nutritious, and marketable snack option.*

INTRODUCTION

Persimmon (*Diospyros kaki*) is a widely popular fruit recognized for its abundance of health-promoting biologically active compounds and is grown in subtropical and warm temperate regions. It belongs to the family Ebenaceae and is native to China and Japan. More than 700 cultivars of persimmon are grown globally and *Diospyros kaki*, *Diospyros virginiana*, *Diospyros oleifera*, *and Diospyros lotus* are some of the important varieties (Bibi *et al.*, 2007). Carotenoids (βcarotene, β-cryptoxanthin, zeaxanthin, lutein, and lycopene), proteins, lipids, carbohydrates, sugars, tannins, vitamin C, and pectic compounds are among the nutrients and

bioactive components that are abundant in persimmon. It also contains minerals, dietary fiber, and polyphenols (Novillo *et al.*, 2015). Reported health benefits of persimmon are numerous including decreasing blood pressure and cholesterol, boosting immunity, promoting eye health, controlling gastrointestinal functioning, reducing depression, stress, and fatigue, delaying aging, preventing cell damage, and cleansing the liver (Yildiz *et al.*, 2024; Zhao *et al.*, 2021).

The excellent flavor, aroma and visual appearance of persimmon make it a highly acceptable fruit on commercial scale. However, postharvest losses occur both at the end of production process and in transport due to lack of awareness regarding factors relevant to storage and transportation of fruit. Rot, peel browning, loss of firmness, and excessive ripening are the causes of these losses. Therefore, processing this fruit is one strategy to reduce postharvest losses and increase its availability to customers (Sharma *et al.*, 2021).

Fruit leather is a dehydrated fruit-based product prepared by concentration and drying of fruit pulp into then sheets under controlled conditions. The leather retains a significant portion of natural color, flavor and nutritional composition of the fruit while serving as a means to reduce the postharvest losses. It is a shelf-stable and convenient product with high popularity as a healthy snack among consumers (Bandaru & Bakshi, 2020; Shere *et al.*, 2023). Various factors that determine the consumer's preference and sensory acceptability of leather include water activity, TSS, pH, color, bioactive components such as phenolics and flavonoids, ascorbic acid, antioxidant activity, textural properties and microstructure. These factors are used for characterization of quality characteristics of fruit leather (de Menezes Rodrigues *et al.*, 2023).

Research conducted on fruit leathers made from various fruits has revealed excellent results in terms of texture, color retention, nutritional stability, and sensory acceptability (Bandaru & Bakshi, 2020; Yildiz *et al.*, 2024). Papaya fruit leather prepared with citric acid, pectin and honey has demonstrated acceptable sensory profile with retention in phenolic compounds and antioxidant activity (Addai *et al.*, 2016) whereas mango fruit leather has been reported to retain sensory parameters as well as high levels of texture and color (Shende *et al.*, 2020). Moreover, different mixed fruit leathers have also been prepared with desirable sensory profiles and optimum physicochemical quality attributes with extended shelf life (Abdullah *et al.*, 2025; Ohijeagbon *et al.*, 2024).

Persimmon fruit leather has not received much scientific attention, despite a great deal of research on other fruits. Due to its distinct composition, which includes a high concentration of soluble solids, natural sugars, pectin, and carotenoids, persimmon can be a good option for preparing fruit leather. Therefore, the present study was designed to prepare persimmon fruit leather with varying concentrations of persimmon puree and sugar followed by physicochemical quality evaluation during storage.

METHODOLOGY

Procurement of raw material

Fresh persimmon fruits were purchased from the local market of Faisalabad. Fruits were checked for any visible defects and washed with running tap water.

Pulping

Fruits were passed through pulper to obtain persimmon puree which was then transferred in clean plastic containers till further processing.

Preparation of fruit leather

To prepare fruit leather, persimmon puree was mixed with sugar in different concentrations and resulting mixture was spread evenly in steel trays. The trays were kept in cabinet dryer at 65°C for 6 hours to prepare fruit leather. Table 1 shows the treatment plan of persimmon fruit leather.

Table 1: Treatment plan of persimmon fruit leather with varying ratios of puree and sugar.

Treatment	Puree : Sugar
T_o	100:0
T_1	80:20
T_2	75:25
T_3	70:30

The prepared fruit leather was packed in Ziploc polyethylene bags and evaluated for following physicochemical quality characteristics at ambient temperature throughout storage of 3 months.

Titratable acidity (%)

Titratable acidity was assessed by titration method (Islam *et al.*, 2013). 10ml of juice sample was taken in a 100 mL volumetric flask and volume was made up to the mark with distilled water. From this mixture, 10 ml of aliquot was taken and mixed with 2-3 drops of phenolphthalein indicator. It was finally titrated against 0.1 N NaOH till light pink color appeared.

Titratable acidity was calculated with the following formula:

$$\text{Titratable Acidity (\%)} = \frac{T \times N \times V1 \times E}{V2 \times W \times 1000} \times 100$$

where V_1 is the volume made up, E is the equivalent weight of citric acid (64.04 g mol^{-1}), V_2 is the volume of aliquot, W is the sample weight, T is the titer (volume of NaOH used), and N is the normality of NaOH. Titratable acidity was presented as a percentage of anhydrous citric acid.

Ascorbic acid (mg/100ml)

Ascorbic acid content of plum juice was determined using the titration method with indophenol dye (Theba *et al.*, 2024). A volumetric flask containing 10 g of the material was filled with 100 ml of a 3% metaphosphoric acid solution to make up the volume. Wattman No. 1 filter paper was used to filter the suspension after 30 minutes. A standard dye solution was used to titrate a 5 ml filtrate sample. Titration was continued till the light pink color persisted. For determining the dye factor, the dye solution was first standardized by titration against a standard ascorbic acid solution. Finally, the ascorbic acid content was determined using following equations:

$$\text{Ascorbic acid content (mg /100 ml)} = \frac{\text{titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Volume of aliqout} \times \text{weight of sample}}$$

$$\text{Die Factor} = \frac{0.5}{\text{titre value}}$$

Total soluble solids (TSS)

TSS of the persimmon fruit leather was determined using digital refractometer (HI 96801, Hanna Instruments, USA) using the method described by Kaushik *et al.* (2015) with some modifications. Leather

was processed in blender to make paste from which a drop was placed on prism of refractometer to record reading. Before taking the reading, distilled water was used to calibrate the refractometer to zero.

Firmness

To measure the firmness of fruit leather, a penetrometer (Force Gauge, PCE-FM200) with a 3mm plunger size was used. Firmness was recorded at three different points of each sample and mean value was noted expressed as kg (Ganai *et al.*, 2018).

Treatments	0 day	30 days	60 days	90 days
To	1.28±0.04b	0.64±0.01g	0.38±0.01i	0.22±0.00j
T1	1.39±0.01a	0.90±0.01d	0.63±0.02g	0.55±0.00h
T2	1.13±0.02c	0.89±0.01d	0.77±0.01f	0.61±0.01g
T3	1.27±0.02b	0.85±0.02e	0.64±0.01g	0.54±0.01h

Color (L*, a* and b*)
The color parameters of fruit leather in terms of L* (brightness), a* (red-green) and b* (yellow-blue) were determined using digital colorimeter (Chroma Meter CR-400, Konica Minolta, Japan) using the method of Tontul and Topuz (2018).

Sensory evaluation
Sensory evaluation of persimmon fruit leather was performed using 9-point hedonic scale in terms of taste, aroma and overall acceptability at the end of storage study (Meilgaard *et al.*, 2006)

Statistical analysis
The values of all parameters were recorded in triplicate and reported as mean ± standard deviation. The results were statistically analyzed using 2-way factorial design under CRD in Minitab software with $p < 0.05$ to determinate significant differences. Tukey HSD test was performed as post hoc test to compare the treatment groups (Montgomery, 2017).

RESULTS AND DISCUSSION

Titratable acidity
The acidity of persimmon fruit leather significantly decreased ($p < 0.05$) during storage across all treatments (Table 1). Initially, acidity values ranged from 1.15% (T_2) to 1.41% (T_1) at day 0. After 90 days, these values declined to 0.32% (T_0), 0.45% (T_1), 0.36% (T_2), and 0.40% (T_3), respectively. Temperature-induced chemical reactions between the organic components of pulp and the activity of enzymes during preservation may also be the cause of the decrease in acidity. Fruit leather with higher acidity can help preserve the fruit's color and

flavor while also inhibiting the growth of microbes (Rahman *et al.*, 2025). Similar decreasing trend was also reported by Kaushal *et al.* (2017) in appetized ginger-plum leather and in kinnow leather (Das & Das, 2025) during storage.

Table 1. Titratable Acidity (%) of persimmon fruit leather
Values as Means ± S.D containing different letters are significantly different ($p < 0.05$) from each other.

Ascorbic acid
Ascorbic acid content exhibited a progressive decline in all treatments with increasing storage time (Table 2). At day 0, ascorbic acid levels ranged between 27.8 mg/100 g (T_0) and 39.5 mg/100 g (T_3), decreasing to 17.2–25.3 mg/100 g after 90 days. Ascorbic acid is rapidly degraded by heat, and its instability in thermally processed foods makes it difficult to utilize. Ascorbic acid degradation due to complex oxidation and intermolecular rearrangement events is believed to be one of the main reasons why food quality and color varies throughout processing and storage. (Yin *et al.*, 2022). The rate of degradation was relatively lower in formulations with higher sugar ratios (T_2 and T_3), possibly because sugar-rich matrices provide some protection by limiting oxygen diffusion and reducing water activity (Herbig & Renard, 2017; Yin *et al.*, 2022). Similar decrease in ascorbic acid content was also reported during storage in blended fruit leather from date, pomegranate and fig (Abdullah *et al.*,

2025) and in mulberry-aloe vera blended leather (Rahman *et al.*, 2025).

Table 2. Ascorbic acid content (mg/100ml) of persimmon fruit leather

Treatments	0 day	30 days	60 days	90 days
T_o	95.55±0.43e	77.06±0.36f	51.41±0.64h	43.93±1.15i
T_1	76.54±0.40f	58.25±0.96g	44.94±0.70i	39.51±0.68j
T_2	177.44±1.29a	156.44±3.75b	33.69±0.61kl	28.18±0.41m
T_3	125.47±1.79c	100.16±1.90d	36.46±0.49jk	30.40±0.64lm

Values as Means ± S.D containing different letters are significantly different ($p < 0.05$) from each other.

Total soluble solids (°Brix)

The total soluble solids (TSS) content showed a gradual increase during storage (Table 3). At day 0, TSS ranged from 48.9°Brix (T_2) to 78.2°Brix (T_3), while after 90 days, the values increased to 51.3°, 81.2°, 50.4°, and 84.5°Brix for T_o–T_3, respectively. be an additional contributing factor (Abdullah *et al.*, 2025). Similar gradual increase in TSS have been reported in blended leathers prepared from pomegranate and strawberry (Ahmed *et al.*, 2025) and guava and papaya (Mounisha *et al.*, 2022) during storage. The TSS values were consistently higher in sugar-rich formulations (T_1–T_3), confirming that sugar addition improves total solids, sweetness, and overall sensory appeal. Over time, complex carbohydrates (polysaccharides) may hydrolyze into simpler, soluble sugars like glucose and fructose, which is probably the main reason of this increasing trend during storage. The small increase in concentration of solids brought on by tiny variations in moisture during storage could

Table 3. TSS (°Brix) of persimmon fruit leather

Treatments	0 day	30 days	60 days	90 days
T_o	74.19±1.38e	77.57±1.82cde	80.68±1.94abcd	80.40±1.23abcd
T_1	75.54±1.06e	77.32±0.86de	80.79±1.45abcd	83.49±1.83a
T_2	48.40±0.89g	75.52±2.39e	82.20±0.83ab	83.51±0.96a
T_3	77.85±2.63bcde	60.44±1.62f	81.64±0.13abcd	81.87±0.62abc

Values as Means ± S.D containing different letters are significantly different ($p < 0.05$) from each other.

Firmness

Changes in firmness of persimmon fruit leather with storage are demonstrated in table 4. The highest firmness was reported at 0 day in all treatments with maximum value of 5.03 kg (T_o). Decrease in firmness was observed as the storage progressed irrespective of the treatments. The lowest firmness value was reported in T_2 (0.47) at 90 days of storage. the highest firmness value was recorded in control (T_0) probably due to formation of dense matrix structure in the absence of added sugar. On the contrary, softer textures were recorded with higher sugar levels throughout the storage due to reduction of intermolecular binding forces as a result of humectant effect of sugar (Lin *et al.*, 2020; Wang & Hartel, 2021). Azeredo *et al.* (2006) reported a comparable decline in texture of mango fruit leather during storage due to changes in moisture permeation through packaging material.

Table 4. Firmness (kg) of persimmon fruit leather

Treatments	0 day	30 days	60 days	90 days
T_o	5.03±0.10a	4.54±0.04b	4.30±0.07c	3.88±0.14d
T_1	3.32±0.11e	2.74±0.04f	2.00±0.04g	1.83±0.03g
T_2	0.79±0.02ij	0.62±0.01jkl	0.59±0.02kl	0.47±0.01l
T_3	0.97±0.02h	0.83±0.01hi	0.75±0.02ijk	0.64±0.01jkl

Values as Means ± S.D containing different letters are significantly different ($p < 0.05$) from each other.

Table 5. color(L*,a* and b*) of persimmon fruit leather during 90 days of storage

Color (L*, a* and b*)

The changes in color values of persimmon fruit leather with storage are given in table 5. L* value which indicates brightness increased slightly with storage in all treatments The lowest L* value was observed in T_1 (52.69) at 0 day whereas the lowest value (33.37) was observed in control (T_o) at 90 days of storage. The decrease in lightness of samples could be attributed to non-enzymatic browning reactions and pigments oxidation during storage (Bork *et al.*, 2022). Moreover, increasing trend was observed in a* values (redness to blueness) across all treatments during storage with minimum and maximum values of 5.81 and 19.21 in T_o at 0 and 90 days of storage respectively. Similarly, b* values (yellowness to greenness) also increased in all treatments throughout the storage with minimum value of 15.78 in T_o and maximum value of 47.63 in T_1 at 0 and 90 days of storage respectively. Comparable color changes in color profile of mango and papaya have been reported (Ramasamy *et al.*, 2021). A decline in all color parameters of pear leather enriched with wild bilberry and black currant whereas a decreasing trend in L* and b* values and rise in a* values of mango leather enriched with natal plum leather (Mphaphuli *et al.*, 2020).

Values as Means ± S.D containing different letters are significantly different ($p < 0.05$) from each other.

Sensory evaluation

The results of sensory evaluation in terms of taste, aroma and overall acceptability are illustrated in figure 1. As evident from the figure, T_2 scored the highest followed by T_3, T_1 and T_o. The better sensory scores achieved by T_2 might be due to optimum puree and sugar concentration resulting in improved palatability. Contrarily, T_o (control) scored the lowest due to firm texture and less preferable flavor.

Comparable changes in sensory profiles has been reported in strawberry leather made with varying rations of honey and sucrose (Khan *et al.*, 2017). Likewise, minor changes in sensory scores were observed in red dragon fruit peel–mango leathers, with or without added spices, during storage, indicating that formulation and ingredient composition strongly influence the sensory perception of fruit leathers (Das *et al.*, 2025).

	Treatments	0 day	30 days	60 days	90 days
L*	T_o	51.81±1.41ab	50.63±1.47abc	37.99±0.46g	33.37±0.23h
	T_1	52.69±0.83a	50.83±0.11abc	48.55±1.49c	41.38±0.81ef
	T_2	50.14±0.40abc	45.34±0.85d	45.32±0.74d	41.91±0.52ef
	T_3	49.00±0.89bc	42.41±0.80e	41.67±1.62ef	39.34±0.09fg
a*	T_o	5.81±0.10l	8.54±0.12k	16.51±0.12d	19.21±0.23a
	T_1	10.94±0.23ij	11.21±0.05i	17.68±0.38c	18.49±0.48b
	T_2	7.88±0.11k	11.35±0.09i	13.45±0.01g	15.49±0.10e
	T_3	10.50±0.12j	11.42±0.19i	12.49±0.38h	14.43±0.13f
b*	T_o	15.78±0.62i	23.53±0.10h	40.48±0.53c	45.74±1.13ab
	T_1	30.83±1.09f	32.59±0.43ef	44.72±0.30b	47.63±1.03a
	T_2	23.22±0.49h	34.01±0.07e	31.18±0.32f	36.52±0.86d
	T_3	25.85±0.20g	32.38±0.93ef	41.22±0.89c	45.96±0.40ab

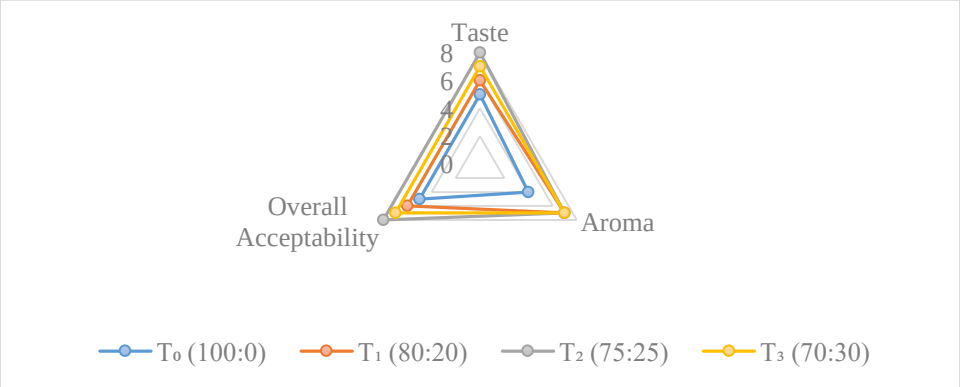


Figure 1: Sensory attributes of persimmon fruit leather

CONCLUSION

The study demonstrated that persimmon (Diospyros kaki) can be successfully developed into a stable, high-quality fruit leather with desirable nutritional and sensory characteristics. Among all formulations, T_2 (75:25 puree-to-sugar ratio) exhibited the most favorable results in terms of physicochemical stability,

vitamin C retention, color preservation, and sensory acceptability after 90 days of storage. The moderate sugar level in T_2 provided optimal sweetness and texture without excessive softening or color darkening observed in higher sugar formulations.

Overall, T_2 proved to be the best treatment, indicating that a balanced puree-to-sugar ratio enhances both product quality and consumer preference. Persimmon leather thus offers a valuable option for postharvest utilization and value addition, and future studies may focus on optimizing packaging and natural preservatives to further improve storage stability.

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