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Nutritional and sensory analysis of prepared plum *(Prunus domestica)* fruit leather

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Abstracts - The aim of this study was to analyze the nutritional and chemical values of the plum pulp and prepared leather, as well as the sensory evaluation of prepared plum leather. Six samples A, B, C, D, E and F were prepared with 50:50, 60:40, 70:30, 80:20, 90:10 and 100:0 fruit pulp:sugar ratio respectively. The findings revealed that as the proportion of pulp in the leather increases, proximate constituents, titratable acidity, and vitamin C content also increases, while pH decreases significantly. Conversely, increasing the amount of sugar in the leather leads to a significant increase in carbohydrate content, energy, and total soluble solids. For sensory analysis, a 9-point hedonic rating test was conducted. The sensory evaluation revealed that all sensory attribute scores were significantly higher ($P \leq 0.05$) in leather prepared using 60 parts and 70 parts plum pulp. Nevertheless, nutritional characteristics in sample C (70 parts pulp) were significantly higher than those in sample B (60 parts pulp). Therefore, sample C was selected as the best among all the samples and had moisture (18.01±0.01), crude protein (0.87±0.02%), crude fat (0.46±0.03%), total ash (1.32±0.06%), crude fiber (1.01±0.01%), titratable acidity

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(1.46±0.01%), vitamin C (4.90±0.01 mg/100 g), pH (4.67±0.02), total soluble solids (58.02±0.03 °Bx), energy value (393.05±0.03 Kcal/100 g), and carbohydrate (96.35±0.03%). The thickness of the final product was 0.64 cm.

Keywords: Plum, fruit leather, sensory evaluation, nutritional, chemical analysis

1. Introduction

Fruit leathers are dried fruit-based products consumed as candies or snacks, often presented in flexible strips or sheets. They earn their name from their final appearance, which is shiny and possesses a texture reminiscent of leather (Suna et al., 2014). The process of preparing fruit-based products from fruits that have higher moisture content has the potential to extend the shelf life of these fruits (Dangal et al., 2023). Fruits with high moisture content levels can be used to prepare various fruit-based products, as performed by Dangal et al. (2021) and Parajuli et al. (2022). Fruit leather, known by various names such as fruit rolls, tafes, kome, or pestil in different regions, is produced through diverse methods and with different ingredients (da Silva Simão et al., 2020; Yildiz, 2013). In addition to broadening the range of fruit consumption options, preparing fruit leathers offers a viable alternative for preserving and enhancing the value of various fruits (Concha-Meyer et al., 2016; Sai Srinivas et al., 2020). These fruit snacks were initially developed on a small scale at home as an alternative preservation method, but acknowledging their nutritional benefits, they have recently emerged in industrial scale production (Torres et al., 2015). Due to its low moisture content and lightweight nature, fruit leather is convenient for both storage and transportation, making it an effective method for preserving nutritious fruits (Diamante et al., 2014; Maskan et al., 2002). The leathers are reasonably priced and readily preserved forms of fruits in a variety of varieties and shapes and are directly marketed for human consumption without requiring refrigeration (Roknul Azam et al., 2018).

Plum (*Prunus domestica*) is considered an important temperate stone fruit that thrives in various regions worldwide despite differing geographical conditions (Birwal et al., 2017; Ucar et al., 2022). The most commonly grown species of plum are *P. domestica* L. (the European plum) and *P. salicina* Lindl. (the Japanese plum) (Ertekin et al., 2006). In Nepal, the plum is locally referred to as 'Aaru Bakhada,' and it is cultivated commercially in nearly 70% of the districts. According to data from the fiscal year 2020/21, the total area devoted to plum cultivation was 1585 hectares, with a total production of 10,284 metric tons. The productivity of plums during this period was approximately 6.49 metric tons per hectare (MoALD, 2022). In the Mustang district, plum productivity stands at an impressive 7.9 metric tons per hectare, exceeding the global average plum productivity of 4.64 metric tons per hectare (FAO, 2020). This highlights the immense potential for commercial plum production in the region. The plum fruits have attractive color, flavor, and taste and are an excellent source of antioxidants, calcium, magnesium, iron, potassium, fiber and others minerals, besides substantial amounts of vitamin A and C (Mehta et al., 2014). Several health advantages have been linked to plum consumption, such as increased antioxidant levels, anti-allergenic

qualities, better cognitive function, and a lower risk of cardiovascular disease (Igwe & Charlton, 2016). The benefits of plums extend to various aspects, including the reduction of food poisoning (Lee et al., 2003), inhibition of nitrite scavenging (Ahn et al., 2007), and a higher antioxidant potential, which is reported to be 4.4 times greater compared to apples (Wang et al., 1996). Additionally, it scavenges free radicals produced from oxygen, including peroxyl and hydroxyl radicals (Murcia et al., 2001).

Plum (*P. domestica*) is considered a popular drupe fruit and one of the indigenous minor fruits of Nepal (Karki et al., 2017) and holds significant potential as a cash-generating commodity. Due to their promising benefits, P. *domestica* fruits hold significant potential in both the food and health industries. Moreover, they present a great opportunity to flourish in the international market (Kafle et al., 2023; Momchilova et al., 2016). Due to the potential benefits of fruits, studies are being conducted to utilize them in the development of products such as amala fruit leather (Guragain & Yadav, 2020), as well as mango leather, apricot fruit leather, grape leather, papaya leather, and many others, which are extensively discussed in the literature (Natalia et al., 2011).Similarly, Singh et al. (2019) prepared plum leather using different combinations of sugar (50%, 40%, 30%, 20%, 10%, 0%) and varying concentrations of plum pulp, drying thin layers in a hot air oven (60 ºC, 70 ºC, 80 ºC). However, the nutritional quality losses of all samples during processing were not studied, a gap that our study addresses. Therefore, this study aims to establish the nutritional significance of plum fruit leather and introduce the product to consumers.

2. Materials and methods

2.1. Collection of raw materials

Plum (*P. domestica*) variety and table sugar were bought from the local market in Dharan (26.8065° N, 87.2846° E), Nepal. The fruits were fresh and sound and of almost uniform fruit size (length ranges from 3.5-5.5 cm and width ranges from 2.5-3.5 cm) and maturity (reddish-purple skin color fruit). They were stored under refrigeration until preparation started. Ripened plum was used for the preparation of the product.

2.2 Chemicals

The chemicals used were petroleum ether (boiling point: 60-80 °C, specific density: 0.68, Himedia Laboratories Pvt. Ltd., India), catalyst mixture (potassium sulphate and copper sulphate pentahydrate), hydrochloric acid (HCL) (Thermofisher Scientific India Pvt. Ltd., assay 35-37% LR grade), sulphuric acid (H_2SO_4) (Thermofisher Scientific India Pvt. Ltd., assay 90-91% LR grade), ethanol (Sisco, assay 99.9%), phenolphthalein indicators, methanol (Sisco, assay 99.9%), sodium carbonate (Na_2CO_3) (Qualigens Fine Chemicals, assay 99%), sodium hydroxide (NaOH) (Qualigens Fine Chemicals, assay 97%), and meta-phosphoric acid (HPO_3) from Oxford Lab Fine Chemicals LLP, India.

2.3. Preparation of plum leather

Plum fruit leather was prepared as described by Singh et al. (2019), with slight modifications (Figure 1). Fresh, ripe plums of uniform size and maturity were

washed and subsequently boiled in water for 8-10 min. at a temperature of 90-100 °C in a stainless-steel vessel. It was drained immediately and cooled with tap water. After that, seeds were removed by pulping, and the obtained pulp was combined with sugar in various proportions (Table 1). The edible oil was used as a releasing agent in the tray, and the pulp mixture was spread uniformly for drying. The drying process was carried out in a cabinet dryer for 5-6 hours at 70 °C to obtain a moisture content of 18±1%. Thus, the obtained fruit leather (Figure 2) was cut into uniform square shapes, approximately 2.5 cm × 2.5 cm in size, using a sharp knife. The final product was packed using low-density polyethylene (LDPE) plastic. Each package was labeled and then stored in a cool, dry place for further analysis.

Experimental trials were conducted, revealing that a pulp content of less than 40% resulted in a loss of aroma and taste, whereas a content exceeding 60% led to a more astringent taste, which was deemed unacceptable for consumption by the majority of panelists. After this, the design of the experiment was conducted using the software Design Expert version 11, as in the study by Singh et al. (2019), and coded as A, B, C, D, E, and F, as shown in Table 1.

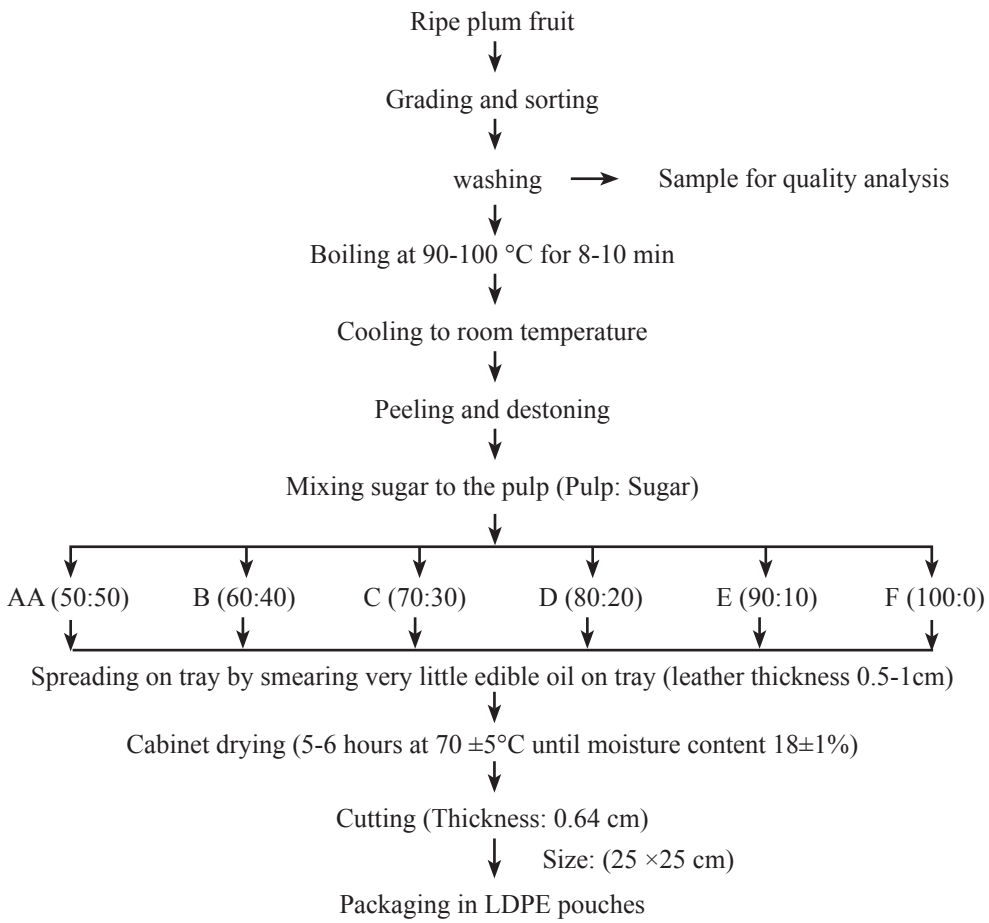
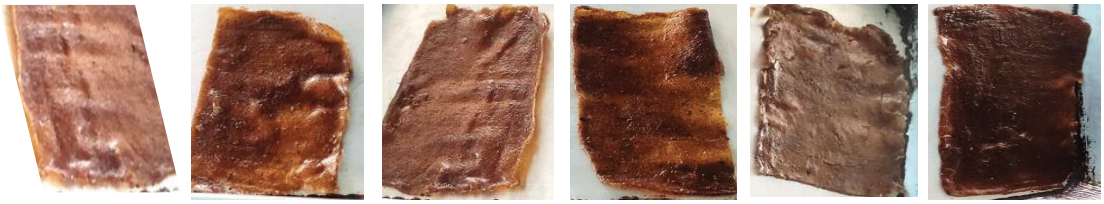


Figure 1. Preparation of plum fruit leather



A B C D E F

Figure 2. Plum fruit leather of different formulation

Table 1. Samples formulations with different proportion of plum pulp and sugar

Sample	Plum pulp (parts)	Sugar (parts)
A	50	50
B	60	40
C	70	30
D	80	20
E	90	10
F	100	0

2.4 Proximate and chemical analysis

2.4.1 Determination of moisture content

The moisture content was determined using the hot-air oven method (Rangana, 1986). A 10 g sample was taken from a Petri dish of known weight. It was then placed in a hot air oven set to 100±5 °C and dried until a constant weight was observed. The difference in the sample weight was interpreted as the presence of water in the sample. The experiment was performed in triplicate.

2.4.2 Determination of titratable acidity

The titratable acidity was calculated using the titrimetric method described by Rangana (1986). A 10 g sample was taken and finely ground with water to make a final volume of 100 ml. 10 ml of the prepared sample was placed in a conical flask for acidity determination, and a 0.1N NaOH solution was used as a titer in a burette. Phenolphthalein was used as an indicator. The volume used for neutralization was recorded, and the acidity was calculated using a formula, as presented in Equation 1.

$$\text{Titratable acidity (as citric acid) \%} = \frac{\text{Titer value} \times \text{N of NaOH} \times \text{volume made up in ml} \times 64}{\text{Aliquot} \times \text{wt.of sample (g)} \times 1000} \times 100 \quad (1)$$

Where, 64= equivalent weight of citric acid anhydrous
N = Normality of NaOH
1000 is the factor relating mg to grams (mg/g)

2.4.3 Determination of total soluble solid (TSS)

The TSS of the plum pulp and prepared fruit leather were measured using a portable refractometer (Hanna® make) with a range of 0-32°Bx, 28-62°Bx and 58-92°Bx The values are given in °Brix (Rangana, 1986).

2.4.4 Determination of ascorbic acid

Ascorbic acid (Vitamin C) content was determined using the 2, 6-ddichlorophenol indophenol visual dye method described by Rangana (1986). To measure vitamin C, the fruit leather was ground and extracted with 3% meta-phosphoric acid (HPO_3). The dye factor was determined using the following formula, as presented in Equation 2.

$$\text{Dye factor} = \frac{\text{mg of ascorbic acid}}{\text{Weight of sample}} \quad (2)$$

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titer value} \times \text{dye factor} \times \text{volume made up}}{\text{Weight of sample}} \quad (3)$$

2.4.5 Determination of crude fat content

The crude fat content of the samples was determined by the solvent extraction method using a Soxhlet apparatus and petroleum ether solvent (Rangana, 1986).

2.4.6 Determination of crude protein content

The crude protein content of the samples was determined indirectly by measuring the total nitrogen content using the micro-Kjeldahl method. Factor 6.25 was used to convert nitrogen content to crude protein (Rangana, 1986).

2.4.7 Determination of total ash

The total ash content of the sample was determined following the method described by Rangana (1986) using a muffle furnace.

2.4.8 Determination of crude fiber content

The crude fiber content of the samples was determined using the method described by Rangana (1986).

2.4.9 Determination of pH

A digital pH meter calibrated with seven pH and four pH standard buffer solutions was used to measure the pH. 10 g of fruit leather were dissolved in 10 ml of distilled water and swirled for 3 to 4 min. (Rangana, 1986).

2.4.10 Determination of carbohydrates

Total carbohydrate was calculated by difference method (Rangana, 1986).

2.4.11 Determination of energy

The energy values were determined by multiplying the quantities of crude protein, fat, and carbohydrates by their respective factors (4, 9, and 4). The energy data were given in Kcal/100g (Valdez-Solana et al., 2015), as presented in Equation 4.

Energy = crude protein × 4 + crude fat × 9 + carbohydrates × 4 (4)

2.5. Data analysis

Each analysis was conducted in triplicate, and the resulting values were subjected to one-way and two-way analysis of variance (ANOVA) using Genstat Release 12.1 (Copyright 2009, VSN International Ltd.). Means were separated using Tukey's HSD post hoc test at a significance level of 5% (KC et al., 2022).

2.6. Sensory evaluation

Ten semi-trained panelists evaluated the samples of plum fruit leather who were familiar with fruit leather, comprising consumers, teachers, and senior students of Sunsari Technical College, Dharan, Nepal, by using a 9-point hedonic rating test (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) Rangana (1986). The panelists were provided with a uniform quantity of prepared plum fruit leather samples on a stainless steel plate to analyze color, flavor, taste, texture, and overall acceptability.

3. Results and discussion

3.1 Physio-chemical characteristics of fresh plum fruit pulp

The organoleptic evaluation, nutritional analysis, and chemical analysis results of fresh plum pulp are displayed in tables 2, 3, and 4, respectively.

Table 2. Organoleptic evaluation of plum fruit

Parameters	Results
Color	Red
Taste	Sweet and sour
Order	Odorless
Texture	Pulpy and tender

Table 3. Nutritional analysis of plum fruit pulp

Parameters	Values (wb)
Moisture content (%)	86.00±1.00
Crude protein (%)	1.28±0.32
Crude fat (%)	0.75±0.25
Crude fiber (%)	1.46±0.18
Total ash content (%)	1.81±0.08
Total carbohydrate (%)	8.70±1.15
Total energy (Kcal/100g)	**46.67±1.18**

* Values are means of triplicate analysis ± standard deviations.

Moisture, crude protein, crude fat, crude fiber, total ash, total carbohydrate and energy of the plum pulp (Table 3) were within the range of the findings of Esehaghbeygi et al. (2013), who reported the moisture content (79.25%-87.49%), protein content (1.1%-2.1%), fat content (0.8%-1.0%), ash content (1.7%-2.9%), crude fiber (1.4-2.3%), and carbohydrates (7.51%-12.45%) in three different varieties of plum *P. domestica* L. Similarly, Ertekin et al. (2006) reported moisture (87-89%) and protein (2.81-3.88%) in two plum (*P. domestica* L.) cultivars (Stanley and Frenze 90), but in the study of Kaushal et al. (2017), moisture was found to be similar, i.e., 86.93%, protein (0.6%), crude fiber (0.07%), and ash (0.42%) found to be lower. Some of the parameters were similar and some were different when compared to the value provided by Stacewicz-Sapuntzakis et al. (2001), i.e., moisture (78%), protein (0.8%), crude fiber (1.5%), crude fat (0.2%), and carbohydrate (21%).

The pH of plum pulp was found to be 3.70 (Table 4), which was similar to that of Erturka et al. (2009), who reported pH (3.13-3.70) in plum *Prunus spinosa* and Singh et al. (2019), i.e., 3.8, but slightly higher than in Çalışır et al. (2005), i.e., 3.05. The sugar content of pulp was found to be 9.93%, which was similar to the findings of Kaushal et al. (2017), i.e., 9.26%, and Singh et al. (2019), i.e., 9.36%. The ascorbic acid was found to be 9 mg/100g, which was similar to the value obtained by Stacewicz-Sapuntzakis et al. (2001), i.e., 9.5 mg/100g, a value within the range recorded by Erturka et al. (2009), i.e., 3.8-12.1 mg/100g in plum *P. spinosa*, lower than reported in Kaushal et al. (2017), i.e., 18.30 mg/100g, but higher than in Singh et al. (2019), i.e., 6 mg/100g. The titratable acidity was found to be 0.69%. The result obtained was within the range reported by Ertekin et al. (2006), i.e., (0.379-0.893%), similar to the value displayed by Singh et al. (2019), i.e., 0.6%, but with a highly lower value compared to Erturka et al. (2009), who found 3.87%-4.99% in dark purple, red, and yellow color-fruited plum genotypes belonging to *P. spinosa.*

Table 4. Chemical analysis of plum fruit pulp

Parameters	Values (wb)
pH	3.70±0.90
Total sugar (%)	9.93±2.97
Ascorbic acid/Vitamin C (mg/100g)	9.00±1.00
Titratable acidity (as citric acid) (%)	0.69±0.14
Total soluble solids (°Brix)	21.00±1.00

*Values are means of triplicate analysis ± standard deviations.

TSS was found to be 21 °Brix, which was a higher value than presented by Kaushal et al. (2017) and Singh et al. (2019), i.e., 13.86 and 20, respectively. Similarly, Erturka et al. (2009) also reported TSS (11.98-14.78) °Brix in dark purple, red, and yellow color-fruited plum genotypes belonging to *P. spinosa,* which had a

lower value compared to our findings. The variation of the nutritional and chemical components of plum pulp might be due to different factors like varietal differences, variations in agronomic practices, climate, geography, and soil conditions.

3.2 Nutritional and chemical analysis of plum leather

All the samples of plum leather were analyzed for the determination of moisture, pH, TSS, titratable acidity (TA), ascorbic acid (AA), crude protein, crude fat, crude fiber, total ash, carbohydrate and energy. The results obtained are tabulated in Tables 5 and 6.

3.2.1 Moisture content

The moisture content of samples A, B, C, D, E, and F was found to be 18.01±0.01%, 18.13±0.06%, 18.01±0.01%, 17.97±0.06%, 18.02±0.01%, and 18.01±0.01%, respectively (Table 5). Samples A, C, D, E, and F were not significantly different from each other, but they were significantly different from samples B.

3.2.2 Crude protein

The crude protein content of product samples A, B, C, D, E, and F was found to be 0.61%, 0.76%, 0.87%, 1.10%, 1.23%, and 1.40%, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the crude protein content of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F. Sample A has lowest and F has highest crude protein. The increasing trend of crude protein content was due to the increasing concentration of plum pulp and the decreasing concentration of sugar in the product samples, as pulp contains protein and there is zero protein in sugar (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

3.2.3 Crude fat

The crude fat content of samples A, B, C, D, E, and F was found to be 0.26%, 0.34%, 0.46%, 0.60%, 0.65%, and 0.79%, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the crude fat content of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between samples A, B, C, D, E, and F with respect to each other, except for samples A, B, and D, E. Sample A has lowest and F has highest crude fat. The increasing trend of crude fat content was due to the increasing concentration of plum pulp and the decreasing concentration of sugar in the product samples, as pulp contains fat and there is zero fat content in sugar (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

Table 5. Nutritional analysis of different samples of plum fruit leather.

Samples	A	B	C	D	E	F
Moisture (%)	18.01±0.01^{a}	18.13±0.06^{b}	18.01±0.01^{a}	17.97±0.06^{a}	18.02±0.01^{a}	18.01±0.01^{a}
Crude protein (db %)	0.61±0.02^{a}	0.76±0.03^{b}	0.87±0.02^{c}	1.10±0.01^{d}	1.23±0.06^{e}	1.40±0.01^{f}
Crude fat (db%)	0.26±0.03^{a}	0.34±0.06^{a}	0.46±0.03^{b}	0.60±0.01^{c}	0.65±0.02^{c}	0.79±0.02^{d}
Total ash (db%)	0.88±0.01^{a}	1.09±0.10^{b}	1.32±0.06^{c}	1.50±0.02^{d}	1.62±0.03^{e}	2.07±0.02^{f}
Crude fiber (db %)	0.63±0.03^{a}	0.81±0.02^{b}	1.01±0.01^{c}	1.21±0.10^{d}	1.24±0.06^{d}	1.48±0.02^{e}
Total carbohydrates (db %)	97.62±0.04^{f}	97.01±0.05^{e}	96.35±0.03^{d}	95.6±0.06^{c}	95.25±0.04^{b}	94.26±0.02^{a}
Total energy (Kcal/100g) (db)	**395.23±0.05^{f}**	**394.14±0.05^{e}**	**393.05±0.03^{d}**	**392.16±0.06^{c}**	**391.77±0.04^{b}**	**389.77±0.02^{a}**

*Values are means of triplicate determinations ± standard deviations. The values in the rows bearing the different superscripts are significantly different ($p < 0.05$).

3.2.4 Crude fiber

The crude fiber content of samples A, B, C, D, E, and F was found to be 0.63%, 0.81%, 1.01%, 1.21%, 1.24%, and 1.48%, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the crude fiber content of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F with respect to each other, except for D and E. Sample A has the lowest and Sample F has the highest crude fiber. The increasing trend of crude fiber content was due to the increasing concentration of plum pulp and the decreasing concentration of sugar in the product samples, as pulp contains fiber and there is zero fiber content in sugar (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

3.2.5 Total ash content

The ash content of samples A, B, C, D, E, and F was found to be 0.88%, 1.09%, 1.32%, 1.50%, 1.62%, and 2.07%, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the ash content of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F. Sample A has lowest and F has highest ash content. The increasing trend of ash content was due to the increasing concentration of plum pulp and the decreasing concentration of sugar in the product samples, as pulp contains ash and there is zero ash content in sugar (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

3.2.6 Total carbohydrates

The carbohydrates of samples A, B, C, D, E, and F were found to be 97.62%, 97.01%, 96.35%, 95.60%, 95.25%, and 94.26%, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of sugar on the carbohydrate content of the sample at the 5% level of

significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F. Sample A has highest and F has lowest carbohydrate content. An increase in the sugar proportion resulted in increased carbohydrate content in the product samples (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

3.2.7 Total energy

The energy values of samples A, B, C, D, E, and F were found to be 395.23 Kcal/100 g, 394.14 Kcal/100 g, 393.05 Kcal/100 g, 392.16 Kcal/100 g, 391.77 Kcal/100 g, and 389.77 Kcal/100 g, respectively (Table 5). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the energy value of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F. Sample A has highest and F has lowest energy values. An increase in the sugar proportion resulted in increased energy values in the product samples (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

Table 6. Chemical analysis of different samples of plum leather

Samples	pH	Titratable acidity % (citric acid)	Total soluble solids (°Bx)	Ascorbic acid / Vitamin C (mg/100g)
A	5.34±0.04^{f}	1.37±0.01^{a}	77.20±0.05^{f}	4.81±0.01^{a}
B	4.98±0.08^{e}	1.43±0.01^{b}	67.72±0.06^{e}	4.84±0.01^{a}
C	4.67±0.02^{d}	1.46±0.01^{bc}	58.02±0.03^{d}	4.90±0.01^{b}
D	4.42±0.02^{c}	1.49±0.03^{c}	48.23±0.05^{c}	4.94±0.03^{b}
E	4.01±0.03^{b}	1.73±0.01^{d}	38.64±0.05^{b}	5.01±0.01^{c}
F	3.67±0.04^{a}	1.75±0.01^{d}	28.98±0.08^{a}	5.05±0.02^{c}

* Values are means of triplicate determinations ± standard deviations. The values in the columns bearing the different superscripts are significantly different ($p < 0.05$).

3.2.8 Total soluble solids (TSS)

The TSS of samples A, B, C, D, E, and F were found to be 77.20 °Bx, 67.72 °Bx, 58.02 °Bx, 48.23 °Bx, 38.64 °Bx, and 28.98 °Bx, respectively (Table 6) at almost constant moisture (18%) for all samples. Sugar had a significant influence ($p < 0.05$) on the sample's total soluble solids (TSS) at the 5% level of significance, according to statistical analysis. The statistical analysis reveals a substantial difference between samples A, B, C, D, E, and F. Sample A has the highest TSS levels, whereas sample F has the lowest. The TSS of the product samples rose in proportion to the amount of sugar used (Table 6). Guragain and Yadav (2020) reported a similar TSS trend in amala (*Phyllanthus emblica* L.) fruit leather, and Chhetri et al. (2022) observed the same in tomato (*Solanum lycopersicum*) leather, with no significant variation in moisture content across treatments (15.50-15.72% and 19-20% moisture, respectively).

3.2.9 Titratable acidity (TA)

The TA of samples A, B, C, D, E, and F were found to be 1.37%, 1.43%, 1.46%, 1.49%, 1.73%, and 1.75%, respectively

(Table 6). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the titratable acidity of the sample at the 5% level of significance. Sample A has the lowest and F has the highest TA values in prepared leather products. Acidity increases with the addition of pulp (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020), which is due to the higher acid content in raw pulp.

3.2.10 Ascorbic acid (AA)/ Vitamin C

The vitamin C content of samples A, B, C, D, E, and F was found to be 4.81 mg/100 g, 4.84%, 4.90%, 4.94%, 5.01%, and 5.05%, respectively (Table 6). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the vitamin C content of the sample at the 5% level of significance. Sample A has lowest and F has highest vitamin C content. The increasing trend of vitamin C content might be due to the increasing concentration of plum pulp and the decreasing concentration of sugar in the product samples, as pulp contains vitamin C and there is an absence of vitamin content in sugar (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020). Various factors, such as heat processing, oxidation, and exposure to light, play a role in the loss of vitamin C. It is reported that the loss of vitamin C can amount to 10% to 60% of the original content in fruits and vegetables (Srivastava & Kumar, 2002).

3.2.11 pH

The pH of samples A, B, C, D, E, and F were found to be 5.34, 4.98, 4.67, 4.42, 4.01, and 3.67, respectively (Table 6). Statistical analysis showed that there is a significant effect ($p < 0.05$) of pulp on the pH of the sample at the 5% level of significance. The statistical analysis shows that there was a significant difference between the samples A, B, C, D, E, and F. Sample A has highest and F has lowest pH values. The decrease in pulp content resulted in an increased pH of the product samples (Chhetri et al., 2022; KC et al., 2022; KC et al., 2020).

It has been observed that increasing the proportion of fruit pulp significantly increased the acidity of plum leather ($P < 0.05$), with a simultaneous decrease in pH (Table 6). A similar trend has been observed in *Lapsi* (*Choerospondias axillaris*) fruit leather, as reported by KC et al. (2022).

3.3 Sensory analysis of plum leather

The six plum leather samples were made by varying the sugar formulation. The graph of mean scores and significant differences in terms of color, texture, taste, flavor and overall acceptance is shown in Figure 3. The similar alphabet above the bar graph indicates that there is no significant difference, and the error bars show the standard deviation of scores given by 10 panelists.

3.3.1 Color

The mean sensory scores for color of samples A, B, C, D, E, and F were found to be 5.70, 7.10, 7.90, 7.20, 6.50, and 6.40, respectively, out of a possible score of 9 (Figure 3). The obtained mean values are represented as a bar diagram in Figure 3. The statistical analysis showed that there was no significant difference between samples B and D with respect to each other. Similarly, E and F also have the same significance difference. Among the

product samples, sample C got the highest score (7.90), and sample A got the lowest score. The panelists did not prefer the lighter color of plum fruit leather (Figure 2), which contained a lower proportion of fruit pulp. It is possible that sugar acted as a diluent, resulting in a lighter color of the product. Similar findings have been reported for mango fruit leather, where increasing the sucrose proportion led to an increase in the lightness of the leather's color (Gujral & Khanna, 2002). Samples E and F, which had a higher proportion of plum pulp, exhibited a dark brownish color (Figure 2) that was not preferred by the panelists. This could be attributed to the thermal processing of fruits, which causes the breakdown of color pigments and the formation of brown pigments through both enzymatic and non-enzymatic browning reactions (Bejar et al., 2011). Similarly, comparable pattern color scores were obtained in amala (*P. emblica* L.) fruit leather (Guragain & Yadav, 2020), with the maximum score of almost 7 out of 9. Singh et al. (2019) found that the highest color scores for plum (*P. domestica)* leather were 7.90, 8.56, and 7.50 at varied drying temperatures of 80°C, 70°C, and 60°C, respectively.

3.3.2 Flavor

The mean sensory scores for flavors in samples A, B, C, D, E, and F were found to be 5.90, 8.00, 8.10, 7.10, 6.60, and 5.50, respectively (Figure 3). Statistical analysis showed that there is a significant effect ($p < 0.05$) on the flavor of the samples at the 5% level of significance. The results of the statistical analysis indicate that there was not a noticeable flavor difference between samples B and C. However, samples A, D, E, and F differed significantly from one another. Sample C got the highest score. Similar patterns of flavor scores have been observed in amala (*P. emblica* L.) fruit leather (Guragain & Yadav, 2020) and tomato (*S. lycopersicum*) leather (Chhetri et al., 2022).

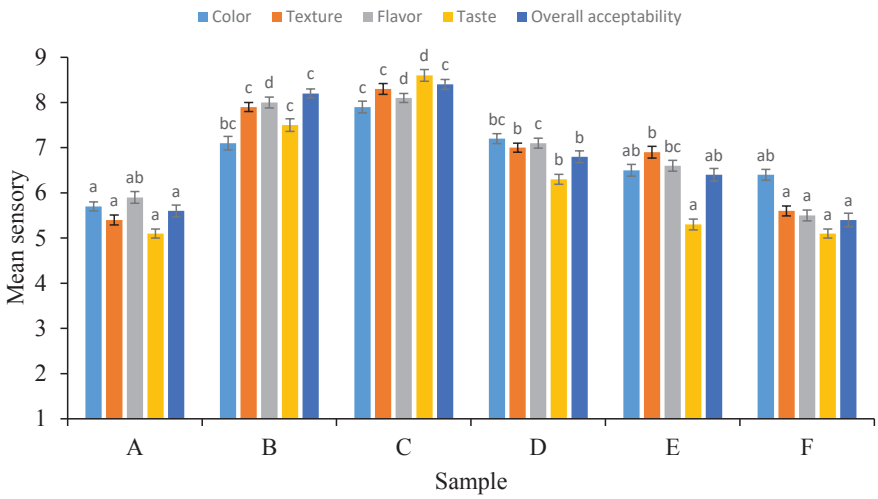


Figure 3. Sensory analysis of the different samples of plum fruit leather. *Vertical error bars show the standard deviation and, error bars bearing different superscripts within the same sensory parameter are significantly different (P < .05). **Plum fruit pulp to sugar ratio (w/w): A-50:50, B-60:40, C-70:30, D-80:20, E-90:10 and F-100:0

3.3.3 Texture

The mean sensory scores for texture in samples A, B, C, D, E, and F were found to be 5.40, 7.90, 8.30, 7.00, 6.90, and 5.60, respectively (Figure 3). Statistical analysis showed that there is a significant effect ($p < 0.05$) on the texture of the samples at the 5% level of significance. The statistical analysis shows that there was no significant difference in texture between samples A and F, D and E, and B and C, respectively. Sample C got a higher score for texture, followed by B because panelists might like the soft and leathery texture provided by the proportion of sugar. The panelists noted that samples with a higher proportion of sugar resulted in a softer texture, which made the samples less chewy. This observation suggests that the presence of sugar contributes to a softer and more tender texture in the plum leather, reducing its overall chewiness. Similar findings have been reported by KC et al. (2022). indicating consistency in the effect of sugar on the texture of fruit-based products.

3.3.4 Taste

The mean sensory scores for taste in samples A, B, C, D, E, and F were found to be 5.10, 7.50, 8.60, 6.30, 5.30, and 5.10, respectively (Figure 3). The statistical analysis shows that there was a significant difference in taste between samples B, C, and D, but not between samples A, E, and F. With a 5% level of significance, panelists liked the taste of sample C, who got a higher score for taste, followed by sample B. This might be due to the balance of sugar and pulp in the prepared plum leather, where extreme astringency and sourness were covered (Chhetri et al., 2022).

3.3.5 Overall acceptability

The mean sensory scores for overall acceptability of samples A, B, C, D, E, and F were found to be 5.60, 8.20, 8.40, 6.80, 6.40, and 5.40, respectively (Figure 3). The statistical analysis shows that there was no significant difference in overall acceptance between samples A and F. Similarly, there was no significance between samples B and C. But there was a significant difference between samples D and E. The overall acceptability (OA) of samples B and C was significantly higher than that of the other samples (Figure 3). Sample B (leather with 60 parts pulp and 40 parts sugar) and sample C (leather with 70 parts pulp and 30 parts sugar) were found superior in sensory characteristics. This phenomenon could be attributed to a perfect balance between titratable acidity and sweetness in the sample. The equilibrium between sweetness and acidity is a fundamental aspect of sensory perception through which a person judges the quality of many fruits and fruit products. Therefore, a crucial quality factor for gaining customer acceptability is the sugar-acid balance (Jayasena & Cameron, 2008). The sensory evaluation here found desirable characteristics such as smooth brownish appearance, pleasant aroma and desirable sweet taste, soft and leathery texture, and overall acceptability. These findings suggest that the 60:40 and 70:30 proportions of pulp and sugar, respectively, were more desirable for plum leather preparation. A similar pattern has been observed in amala (*P. emblica* L.) fruit leather (Guragain & Yadav, 2020).

3.4 Selection of the best product

The selection of the best product was based on both sensory scores and nutritional characteristics. Samples with high sensory scores were compared based on their nutritional profiles to determine the best product. Samples B and C had similar and highest sensory scores out of all the samples, while Sample C's nutritional attributes were considerably greater ($P<0.05$) than Sample B's. Additionally, sample C contained a lower sugar content. Thus, the C sample showed a higher health benefit. Therefore, sample C was chosen as the best among all the samples.

4. Conclusion

Plum is an indigenous, minor, and underutilized wild fruit in Nepal, rich in vital nutrients. Due to its nutritional richness, it has the potential to uplift the economic status of farmers. Plum leather enhances sensorial acceptability and market value, serving as a dehydrated product with an extended shelf life compared to fresh fruit. Sample C formulation with 70% pulp and 30% sugar in leather preparation was considered to be the best sample product, balancing nutritional benefits with sensory appeal. Certainly, this information could be valuable for small- and medium-scale industries, as it could assist them in producing nutritional delicacies that cater to the preferences of consumers.

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