



# Studies on Guava Based Protein Enriched Fruit Leather Rollups

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

**Aims:** To standardize the protocol for protein enriched guava leather rollups preparation and to study the biochemical and organoleptic quality of guava-based protein enriched fruit leather rollups

**Study Design:** Completely Randomized Factorial Design

**Place and Duration of Study:** It was conducted at Post Harvest Technology Laboratory, College of Horticulture, Dr Y.S.R Horticultural University in the year 2023.

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**Methodology:** The ripe guava fruits of Lalit variety were thoroughly washed and the pulp was extracted by homogenizing the slices in the mixer. The pulp was sieved to remove lumps and divided into two batches. Palmyra jaggery and sugar were added separately to each batch of the pulp. Later, protein sources were added (Whey or Soya or Cashew or Almond) in the concentration of 5% separately for each treatment combination. The pulp mixture was spread evenly on the trays and allowed for drying at 65° C for 12 hours. Dried fruit bars were cut into rectangular pieces, rolled and packed in polyethylene covers. The biochemical changes and organoleptic quality of the guava leather rollups were studied for 3 months at monthly interval under ambient conditions.

**Results:** It was observed that vitamin-C ( $\text{mg } 100 \text{ g}^{-1}$ ), protein content ( $\text{mg } 100 \text{ g}^{-1}$ ), TSS ( $^{\circ}\text{B}$ ), taste, flavor and overall acceptability followed a decreasing trend from the initial day of storage to 90 days after storage. The fruit leather roll-ups prepared from Lalit and Palmyra jaggery using tray drying method fortified with whey protein ( $\text{B}_1\text{C}_1$ ) recorded the highest vitamin-C content and protein content and the highest TSS was recorded for the fruit leather roll-ups prepared from Lalit and sugar by tray drying fortified with whey protein ( $\text{B}_2\text{C}_1$ ). Whereas, the lowest vitamin-C content was noticed in the leather rollups made from Lalit and sugar using tray drying treated with almond ( $\text{B}_2\text{C}_4$ ), the minimum TSS was observed in the rollups made from Lalit and palmyra jaggery by tray drying treated with almond ( $\text{B}_1\text{C}_4$ ) and the minimum protein content was resulted in the rollups prepared from ( $\text{B}_2\text{C}_3$ ) Lalit and sugar by tray drying treated with cashew. The maximum flavour score was noticed in fruit leather roll-ups prepared from Lalit and Palmyra jaggery using tray drying method fortified with whey protein ( $\text{B}_1\text{C}_1$ ) and the maximum taste and overall acceptability score was observed in fruit leather roll-ups prepared from Lalit and sugar by tray drying fortified with whey protein ( $\text{B}_2\text{C}_1$ ). While, the lowest taste and overall acceptability score was obtained in the rollups made from Lalit and palmyra jaggery by tray drying treated with almond ( $\text{B}_1\text{C}_4$ ) and minimum flavour score was obtained in the rollups prepared from Lalit and sugar by tray drying treated with almond ( $\text{B}_2\text{C}_4$ ).

**Conclusion:** The highest vitamin-C and protein content was observed in rollups prepared from Lalit and palmyra jaggery by tray drying treated with whey protein ( $\text{B}_1\text{C}_1$ ). Whereas, the highest TSS was observed in the rollups prepared from Lalit and sugar by tray drying treated with whey protein ( $\text{B}_2\text{C}_1$ ). The maximum taste and overall acceptability score was observed in fruit leather roll-ups prepared from Lalit and sugar by tray drying fortified with whey protein ( $\text{B}_2\text{C}_1$ ) and the maximum flavour score was noticed in fruit leather roll-ups prepared from Lalit and Palmyra jaggery using tray drying method fortified with whey protein ( $\text{B}_1\text{C}_1$ ).

**Keywords:** Guava leather rollups; protein fortification; palmyra jaggery; sensory attributes.

## 1. INTRODUCTION

The guava (*Psidium guajava*) is a member of the Myrtaceae family and it is a typical fruit grown in different parts of tropical and subtropical regions of the world. Guava is rich in nutrients, antioxidants, Vitamin C and A, lycopene, calcium, manganese and potassium. It is low in calories and high in fibre. The variety Lalit with firm pink flesh is suiannex for both table and processing purpose.

Since a few decades ago, food fortification has become popular and refers to the addition of vital nutrients that are either missing or depleted during processing. The guava bar is a well-liked guava product, but it lacks protein. Soya flour is an excellent source of high quality protein and provides all the essential amino acids. It also has no cholesterol and very little to no saturated fat. Defatted soya flour contains 55% protein. These benefits have led to the inclusion of soyabean

and soya products as a component in a variety of processed goods, such as the apricot-soy fruit bar [1].

Whey protein is a functional ingredient that is known for its positive health benefits such as immunity enhancement, reducing blood pressure, cholesterol reduction, inhibition of dental plaques and tooth decay. Whey protein is a pure, natural high quality protein complex derived through cheese production. It is known for some time to have biological value superior to that of other naturally occurring protein [2]. It is very good food supplement of making fruit and energy bars. The mild flavour of whey protein ingredients make compatible with a variety of flavours and ensures high consumer acceptability.

The use of whey protein in snack and sports products delivers the nutrients that positively affect body compositions. Whey protein has

functional properties like high solubility, gelation or thickening, water binding, foaming, emulsification, flavour and colour generation [3].

Cashew have health benefits like reduce risk of anaemia, boosts bone and oral health, diabetic friendly, works as cancer chemo-preventive agent and prevent gallstones. Almonds are used to lower cholesterol, helps in keeping a healthy weight, lowers blood pressure, better blood sugar control and for better gut health. Hence, the guava leather roll-ups were fortified with different protein sources.

## 2. MATERIALS AND METHODS

### 2.1 Procedure for Preparation of Protein Enriched Guava Leather Rollups

The general procedure for preparation of guava leather rollups was given by Bisen and Verma [4].

#### 2.1.1 Preparation of fruit pulp

The fruit pulp was extracted by homogenizing the slices in the mixer and later the pulp was sieved.

#### 2.1.2 Pre-treatments

The TSS of the pulp was checked by refractometer and then different sugar sources were added to maintain the TSS (30° Brix). Acidity of 0.3% was maintained by adding citric acid. 0.1% potassium metabisulphite to the pulp as preservative. After that protein was added (Whey or Soya or Cashew or Almond) based on the treatment in the concentration of 5%.

#### 2.1.3 Heating

The pulp was heated at 85 °C for 20 minutes and to avoid charring the pulp was stirred continuously on a low flame.

#### 2.1.4 Dehydration

The protein enriched leather rollups was dried using tray drier. The moisture content of 15-20% was maintained in the end product.

#### 2.1.5 Packing and storage

Dried fruit bars were cut into rectangular pieces and are rolled. They are packed in polypropylene covers and were subjected to storage studies at ambient conditions for a period of 3 months at 30 days interval.

## 2.2 Biochemical Analysis

Biochemical parameters like vitamin-C content, protein content and TSS were analysed for different treatment combinations. The vitamin-C content was estimated by using 2,6 dichlorophenol indophenol dye [5] and protein content by using Lowry [6] method and TSS with the help of digital refractometer by placing the sample in refractometer at room temperature. The average total soluble solids were calculated and expressed in °Brix.

## 2.3 Sensory Evaluation

The guava leather rollups prepared from fresh fruits and which is stored over a period of 90 days were subjected to organoleptic evaluation by a panel of six judges following hedonic rating tests as described by Ranganna [7]. The product was evaluated for taste, flavour and overall acceptability. The characters with mean scores of 5 or more out of 9 marks were considered acceptable.

## 3. RESULTS AND DISCUSSION

### 3.1 Biochemical Changes During Storage of Protein Enriched Guava Leather Rollups

#### 3.1.1 Vitamin- C content (mg 100 g<sup>-1</sup>)

The data related to the vitamin-C content (mg 100 g<sup>-1</sup>) of protein enriched guava leather rollups at 0, 30, 60, 90 days of storage under ambient conditions are presented in Table 1.

Data revealed that the mean vitamin-C content among the different treatment combinations decreased gradually from 74.12 mg 100 g<sup>-1</sup> (on initial day of storage) to 67.50 mg 100 g<sup>-1</sup> (at 90 days after storage). Significant differences were found between interactions at 0, 30, 60 and 90 days after storage. At 30 days after storage, the maximum vitamin-C content (74.44 mg 100 g<sup>-1</sup>) was obtained in the leather rollups prepared from Lalit and palmyra jaggery by tray drying fortified with whey protein (B<sub>1</sub>C<sub>1</sub>) whereas, the minimum vitamin-C content (70.99 mg 100 g<sup>-1</sup>) was resulted in the leather rollups prepared from Lalit and sugar by tray drying treated with almond (B<sub>2</sub>C<sub>4</sub>). The highest vitamin-C content was observed in the leather rollups made from Lalit and palmyra jaggery using tray drying fortified with whey protein (B<sub>1</sub>C<sub>1</sub>) at 60 days (72.91 mg

100 g<sup>-1</sup>) and 90 days (69.68 mg 100 g<sup>-1</sup>) while, the lowest vitamin-C content was noticed in the leather rollups made from Lalit and sugar using tray drying treated with almond (B<sub>2</sub>C<sub>4</sub>) at 60 days (69.12 mg 100 g<sup>-1</sup>) and 90 days (65.92 mg 100 g<sup>-1</sup>) after storage.

A perusal of data revealed that the vitamin-C content decreased with increase in storage

period. The decrease in vitamin-C content might be due to the oxidation of ascorbic acid to dehydro ascorbic acid followed by further degradation to 2, 3-diketogluconic acid and finally to furfural compounds which enter into browning reaction as reported by Kuchi et al. [8] in guava jelly fruit bar, Majid et al. [9] in guava fruit bar and Basha et al. [10] in guava fruit bar.

**Table 1. Effect of vitamin-C content (mg 100 g<sup>-1</sup>) in protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	76.06	74.96	74.48	74.36	74.97	74.44	73.34	72.88	72.23	73.22
<b>B2</b>	73.87	73.82	72.73	72.60	73.26	72.11	71.79	71.20	70.99	71.52
<b>Mean C</b>	74.97	74.39	73.61	73.48	74.12	73.27	72.57	72.04	71.61	72.37
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	72.91	71.86	71.39	70.74	71.73	69.68	68.71	68.14	67.47	68.50
<b>B2</b>	70.35	70.00	69.64	69.12	69.78	67.08	66.75	66.30	65.92	66.51
<b>Mean C</b>	71.63	70.93	70.51	69.93	70.76	68.38	67.73	67.22	66.69	67.50

*Vitamin-C content of different treatment combinations*

**Table 2. Effect of protein content (mg 100 g<sup>-1</sup>) on protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	2849	2197	1937	2069	2263	2647	1999	1741	1874	2065
<b>B2</b>	1475	726	464	595	815	1277	635	385	516	703
<b>Mean C</b>	2162	1461	1201	1332	1539	1962	1317	1063	1195	1384
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	2463	1829	1576	1709	1894	2345	1714	1470	1600	1782
<b>B2</b>	1128	578	330	457	623	1058	508	305	412	571
<b>Mean C</b>	1795	1203	953	1083	1258	1702	1111	887	1006	1176

*Protein content of different treatment combinations*

**Table 3. Effect of TSS (°Brix) on protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	67.65	67.21	66.34	65.87	66.77	67.18	66.77	65.90	65.55	66.35
<b>B2</b>	70.26	69.80	68.58	68.22	69.21	69.70	69.22	68.37	67.69	68.75
<b>Mean C</b>	68.95	68.51	67.46	67.04	67.99	68.44	67.99	67.14	66.62	67.55
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	66.76	66.37	65.52	65.20	65.96	66.66	66.26	65.44	65.13	65.87
<b>B2</b>	69.21	68.87	67.96	67.49	68.38	69.06	68.73	67.87	67.36	68.26
<b>Mean C</b>	67.99	67.62	66.74	66.34	67.17	67.86	67.50	66.66	66.25	67.06

*TSS of different treatment combinations*

**Table 4. Effect of different protein sources on taste of protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	8.03	7.56	6.87	6.66	7.28	7.80	7.47	6.70	6.53	7.12
<b>B2</b>	8.23	7.77	7.36	7.17	7.63	8.06	7.60	7.20	7.03	7.48
<b>Mean C</b>	8.13	7.67	7.12	6.92	7.46	7.93	7.53	6.95	6.78	7.30
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	7.70	7.27	6.50	6.33	6.95	7.60	7.03	6.30	6.10	6.76
<b>B2</b>	7.96	7.43	7.03	6.83	7.32	7.80	7.27	6.80	6.63	7.12
<b>Mean C</b>	7.83	7.35	6.76	6.58	7.14	7.70	7.15	6.55	6.36	6.94

*Taste of different treatment combinations*

**Table 5. Effect of flavour on protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	8.23	7.86	7.47	7.30	7.72	8.10	7.70	7.27	7.06	7.53
<b>B2</b>	8.06	7.67	6.93	6.76	7.36	7.87	7.50	6.73	6.50	7.15
<b>Mean C</b>	8.15	7.76	7.20	7.03	7.54	7.98	7.60	7.00	6.78	7.34
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	7.83	7.43	7.07	6.86	7.30	7.60	7.23	6.86	6.67	7.09
<b>B2</b>	7.63	7.26	6.53	6.33	6.94	7.43	7.07	6.40	6.23	6.78
<b>Mean C</b>	7.73	7.35	6.80	6.60	7.12	7.52	7.15	6.63	6.45	6.94

*Flavour of different treatment combinations*

**Table 6. Effect of overall acceptability on protein enriched guava leather rollups**

Treatment	0th day of storage					30th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	8.20	7.80	7.27	7.06	7.58	8.03	7.63	7.03	6.83	7.38
<b>B2</b>	8.40	8.00	7.66	7.47	7.88	8.23	7.83	7.40	7.23	7.68
<b>Mean C</b>	8.30	7.90	7.46	7.26	7.73	8.13	7.73	7.22	7.03	7.53
Treatment	60th day of storage					90th day of storage				
	C1	C2	C3	C4	Mean B	C1	C2	C3	C4	Mean B
<b>B1</b>	7.83	7.43	6.80	6.60	7.17	7.60	7.30	6.60	6.40	6.98
<b>B2</b>	8.10	7.60	7.20	7.00	7.48	7.90	7.43	7.03	6.83	7.30
<b>Mean C</b>	7.96	7.52	7.00	6.80	7.32	7.75	7.37	6.82	6.62	7.14

*Overall acceptability of different treatment combinations*

Vitamin-C content was decreased gradually with the advancement of storage period which also might be due to the fact that ascorbic acid is sensitive to heat, light and is oxidized quickly in the presence of oxygen, hence, it might have been destroyed during processing and subsequently during storage Raut et al. [11] in wood apple fruit bar and Rakhi et al. [12] in guava leather.

### 3.1.2 Protein content (mg 100 g<sup>-1</sup>)

The data pertaining to the protein content (mg 100 g<sup>-1</sup>) of protein enriched guava leather rollups at 0, 30, 60, 90 days of storage under ambient conditions are represented in the Table 2.

Results noticed that the mean protein content among the different treatment combinations decreased gradually from 1539 mg 100 g<sup>-1</sup> (on

initial day of storage) to 1176 mg 100 g<sup>-1</sup> (at 90 days after storage). Significant difference among different treatment combinations in the protein content was observed. Throughout the storage, the highest protein content was observed in the rollups prepared from (B<sub>1</sub>C<sub>1</sub>) Lalit and palmyra jaggery by tray drying fortified with whey protein (2849, 2467, 2463 and 2345 mg 100 g<sup>-1</sup> respectively during 0, 30, 60 and 90 days). Whereas, the minimum protein content was resulted in the rollups prepared from (B<sub>2</sub>C<sub>3</sub>) Lalit and sugar by tray drying treated with cashew (385, 330 and 305 mg 100 g<sup>-1</sup> respectively at 30, 60 and 90 days after storage).

A remarkable decrease in protein content of protein enriched fruit leather roll-ups during storage has been attributed to its possible participation in Maillard browning reactions. Similar results of decrease in protein percent was also observed in sea buckthorn leather by Kaushal et al. [13] and Kumar and Madhumathi [14] in papaya guava fruit bar fortified with skim milk powder and defatted soya flour and Awati et al. [15] in protein fortified sapota based mixed fruit bar.

### 3.1.3 TSS (°Brix)

The data related to TSS of protein enriched fruit leather rollups at 0, 30, 60, 90 days of storage under ambient conditions are presented in Table 3.

The mean TSS content among the different treatment combinations decreased gradually from 67.99 °B on initial day of storage to 67.06°B at 90 days after storage. Significant differences in the TSS was observed between interactions during all the days of storage. From day one to 30th day of storage, the maximum TSS content (70.26°B and 69.70°B respectively) was observed in the rollups prepared from Lalit and sugar by tray drying fortified with whey protein (B<sub>2</sub>C<sub>1</sub>) and the minimum TSS content (65.87°B and 65.55°B respectively) was noticed in the rollups prepared from Lalit and palmyra jaggery by tray drying fortified with almond (B<sub>1</sub>C<sub>4</sub>).

The highest TSS content was obtained in the rollups made from Lalit and sugar by tray drying treated with whey protein (B<sub>2</sub>C<sub>1</sub>) at 60 days (69.21°B) and 90 days (69.06°B) after storage and the lowest TSS content was observed in the rollups made from Lalit and palmyra jaggery by tray drying treated with almond (B<sub>1</sub>C<sub>4</sub>) at 60 days (65.20°B) and 90 days (65.13°B) after storage.

There was a gradual decrease in TSS during the storage period. The decrease in TSS might be due to the increase in moisture content during the storage period. Similar observations were recorded by Attri et al. [16] in papaya toffee and leather, Kuchi et al. [8] in guava jelly fruit bar. Kumar and Madhumathi [14] in papaya guava fruit bar fortified with skim milk powder and defatted soya flour.

## 3.2 Changes in Sensory Quality of Protein Enriched Guava Leather Rollups During Storage

### 3.2.1 Taste

The data pertaining taste of protein enriched fruit leather roll-ups as influenced by different protein sources are presented in the Table 4.

The mean taste value of protein enriched roll-ups steadily decreased from 7.46 on day one of storage to 6.94 at 90 days after storage. On day one and 30th day of storage, the minimum taste score (6.66 and 6.53 respectively) was observed in the leather rollups prepared from Lalit and palmyra jaggery by tray drying fortified with almond (B<sub>1</sub>C<sub>4</sub>) and the maximum taste score (8.23 and 8.06 respectively) was noticed in the leather rollups prepared from Lalit and sugar by tray drying fortified with whey protein (B<sub>2</sub>C<sub>1</sub>).

Significant differences are found between interactions at 60 and 90 days after storage. At 60 and 90 days after storage, the lowest taste score was obtained in the rollups made from Lalit and palmyra jaggery by tray drying treated with almond (B<sub>1</sub>C<sub>4</sub>) at 60 days (6.33) and 90 days (6.10) and the highest taste score was observed in the rollups made from Lalit and sugar by tray drying treated with whey protein (B<sub>2</sub>C<sub>1</sub>) at 60 days (7.96) and 90 days (7.80). The decrease in taste score during storage might be due to fluctuations in acids, pH and sugar/acid ratio. Organic acid and sugars ratio primarily creates a sense of taste which is perceived by specialized taste buds on the tongue. The findings are in consonance with Attri et al. [16] in papaya toffee and leather.

There are certain enzymatic, physiological or biochemical changes, which results in the production of off-flavour of the product. Similar results were recorded by Punam et al. [17] in bael and mango fruits and Parekh et al. [18] in mango fruit bar fortified with desiccated coconut powder.

### 3.2.2 Flavour

From the Table 5, it is revealed that different protein sources had a significant effect on the flavour of protein enriched guava based fruit leather roll-ups. The mean value of flavour decreased gradually from 7.54 (initial day) to 6.94 (90 days after storage). On day one, 30th, 60th and 90th of storage, the lowest flavour score (6.76, 6.50, 6.33 and 6.23 respectively) was obtained in the rollups prepared from Lalit and sugar by tray drying treated with almond (B<sub>2</sub>C<sub>4</sub>) and the highest flavour score (8.23, 8.10, 7.83 and 7.60 respectively) was observed in the rollups prepared from Lalit and palmyra jaggery by tray drying treated with whey protein (B<sub>1</sub>C<sub>1</sub>).

Aroma results from volatile substances such as esters, ketones, terpenes, aldehydes and others. The loss of these volatiles leads to a decrease in aroma detection. A decreasing pattern of flavour rating value was observed during storage of the protein enriched guava based fruit leather roll-ups. The reason for this is the production of off-flavour adversely which affects the taste and aroma of product and there are certain enzymatic, physiological or biochemical changes, which resulted in the production of off-flavour of the product. Similar results were reported by Khan and Zubairi [19] in development and storage studies of guava-chiku blended fruit leather.

### 3.2.3 Overall acceptability

The results of overall acceptability of protein enriched fruit leather roll-ups are presented in the Table 6. Significant difference in the mean value of overall acceptability was observed during the storage. A perusal of data showed that mean overall acceptability decreased from 7.73 on initial day of storage to 7.14 at 90 days after storage.

Significant differences are found between interactions at 0, 30, 60 and 90 days after storage. At 30, 60 and 90 days after storage, the highest overall acceptability scores (8.23, 8.10 and 7.90 respectively) were observed in the rollups prepared from Lalit and sugar by tray drying treated with whey protein (B<sub>2</sub>C<sub>1</sub>). During the storage, the lowest overall acceptability scores (7.06, 6.83, 6.60 and 6.40 respectively on day one, 30th, 60th and 90th days) were obtained in the rollups prepared from Lalit and palmyra jaggery by tray drying fortified with almond (B<sub>1</sub>C<sub>4</sub>). Overall acceptability score has decreased during storage due to changes in loss of taste, flavour and chemical composition of the

product. Similar observations were recorded by Vijayanand et al. [20] in guava fruit bar, Narayana et al. [21] in banana fig fruit bar, Attri et al. [16] in papaya toffee and leather, Latif et al. [22] in guava and strawberry fruit bars and Rana et al. [23] in fruit bars with omega rich food source fortification.

## 4. CONCLUSION

The highest vitamin-C and protein content was observed in rollups prepared from Lalit and palmyra jaggery by tray drying treated with whey protein (B<sub>1</sub>C<sub>1</sub>). Whereas, the highest TSS was observed in the rollups prepared from Lalit and sugar by tray drying treated with whey protein (B<sub>2</sub>C<sub>1</sub>).

The maximum flavour score was noticed in fruit leather roll-ups prepared from Lalit and Palmyra jaggery using tray drying method fortified with whey protein (B<sub>1</sub>C<sub>1</sub>) while, the maximum taste and overall acceptability score was observed in fruit leather roll-ups prepared from Lalit and sugar by tray drying fortified with whey protein (B<sub>2</sub>C<sub>1</sub>).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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