DEVELOPMENT OF FRUIT LEATHER USING UNDERUTILIZED FRUITS

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INTRODUCTION

Fruits are energy sources rich in minerals, vitamins, fibers, and phytochemicals. Phytochemicals function as antioxidants, phytoestrogens, and anti-inflammatory agents and influence protective mechanisms against diseases (Slavin and Lioyd.,2012). Fruit crops that have value but are not widely grown or rarely found in the market are called underutilized fruit crops (Yadav et al.,2018). Underutilized fruits have not been experimented to the same extent for their chemical and biological properties or developed into value-added products like other fruits.

Lovi fruit (*Flacourita indica/Flacourita inermis*), Star fruit (*Averrhoa carambola*)- also known as Kamaranga, and Bilin (*Averrhoa bilimbi*) are recognized as underutilized fruits in Sri Lanka (Dahanayake.,2015). Lovi fruit is rich in fiber and vitamins A, B, and C, and calcium and phosphorus (Jayawardane.,2016). Polyphenolic compounds (methyl 5- O -caffeoylquinate, methyl 4- O -caffeoylquinate, n-butyl chlorogenate, n-butyl 5- O -caffeoylquinate, and a rare phenolic glucoside (rel)-6α-benzoyloxy-1α, 2-(6-O-benzoyl-β-D-glucopyranosyloxy)-5-hydroxy benzyl ester, together with quinic acid and malic acid) that act as antioxidants are found in lovi fruit (Jayasinghe.,2012). Star fruit provides vitamins A, B5, B9, C, and Zn, Na, Mg, Cu, and K minerals with low calories. (Lakmal et al.,2021), which aids in treating hypoglycemia and hypercholesterolemia (Muthu et al.,2016). Bilin is a good source of minerals such as potassium, calcium, phosphorus, and iron and is rich in fibers and low in calories, which qualify as excellent natural antioxidants (Dangat et al.,2104).

Fruit leather refers to fruit puree made from juice concentrate with other cooked ingredients, spread on non-stick surfaces, dried, and rolled. The dried sheets of fruit pulp contain a soft, rubbery texture, a sweet taste, and flavorful properties (Madhav and Parmita.,2016).

Due to the seasonality and highly perishable nature of the fruits, their optimum utilization is hindered. Therefore, the preparation of fruit leather will effectively preserve the fruits' taste and other nutritional values. This study aimed to develop natural value-added fruit leather products (Lovi, star fruit, and bilin fruits) that can replace chemically flavored confectionaries in the market. Furthermore, the best fruit leather was determined concerning consumer preferences and physicochemical parameters.

METHODOLOGY

METHOD

Fresh, firmly ripened, and undamaged fruits of lovi, star fruits, and bilin fruits were obtained from the supermarkets and home gardens in Gampaha area. Fruits were cleaned using clean water. Then the fruits were peeled, seeds were removed, and blanched for 5 minutes using steam. Next, all the fruits were cut into small pieces. After that, the small pieces were chopped for 15 minutes using a blender to make a pulp. Thereafter, the fresh fruit pulps were evaluated for physicochemical parameters and then mixed with 5% of sugar. Then, the pulp was boiled for about 10 minutes to concentrate. After that, the puree was strained using a filter. All the steps were done separately for

each fruit pulp. Finally, fruit pulps were individually spread on a tray and dried in a hot air oven at 60 ^{0}C for 5 hrs. The compositions of four types of fruit leather are presented in Table 1.

Table.1 Final composition of the fruit leather.

Treatment	Puree content %		Sugar content %
T1-Lovi fruit leather	Lovi	95	5
T2-Kamaranga fruit leather	Kamaranga	95	5
T3-Bilin fruit leather	Bilin	95	5
T4-Mixed fruit leather	Mix leather	95	5

SENSORY ANALYSIS

The sensory evaluation was carried out using a 5-point hedonic scale to assess the organoleptic characteristics of the samples. Fifteen trained panelists evaluated the samples. Panelists were asked to rate the color, aroma, mouthfeel, taste, and overall acceptability of these fruit leather samples.

PHYSICOCHEMICAL ANALYSIS

AOAC-recommended procedures were used to analyze the moisture content, total soluble solids (TSS), titratable acidity, pH, and color of fruit pulp. During storage, the leathers were analyzed. Every analysis was done with three replicates

MICROBIAL ANALYSIS

Microbial analysis was performed using the total plate count (TPC) method (Arifan.,2019). A test sample of 100 µl was spread on nutrient agar media and incubated at the 37 ^{0} C for 24 hrs to determine the (TPC).

PROXIMATE ANALYSIS OF FRUIT LEATHER

Proximate analysis was conducted according to the AOAC method (2012). The Moisture, ash, crude fat and crude protein contents were determined using the oven drying method, muffle furnace, Soxhlet extraction, and Kjeldhal method respectively. Finally, the carbohydrate content was determined using the following formula.

Carbohydrates % = 100% - (protein%+fat%+ ash%+moisture %+ crude fiber%)

STATISTICAL ANALYSIS

Complete Randomized Design and analysis of variance (ANOVA) were used for data analysis. All tests were performed in triplicate, and data were expressed as Mean ± standard deviation. The mean comparisons were carried out by Tuckey test at $p \leq 0.05$ using MINITAB 17 software package.

SENSORY ANALYSIS

Sensory data were analyzed by non-parametric method (Freidman test) using MINITAB 17 software package and 15 trained panelists.

RESULT AND DISSCUISSION

Initially, physicochemical parameters of fresh fruit pulps were studied before making fruit leathers.

The results are shown in Table (2). The moisture content of the fresh fruit pulp was high in star fruit pulp (94%) compared to lovi (*F.inermis*) and bilin (*A.bilimbi*) (91% and 82.83% respectively). The pH values of lovi (2.09) and bilin (1.28) fruit pulp were lower (2.09 and 1.28) than the pH value of star fruit (2.123) fruit pulp. A high TSS content was recorded in lovi fruit pulp (15.20), compared to both kamaranga pulp and bilin pulp (13.16 and 10.16 respectively).

Table 2. Physicochemical characteristics of the fresh fruit pulps

Fruit Pulp	**Moisture content**	**pH value**	**Total soluble solid**
Lovi puree	91 ± 3.61[a]	2.09± 0.47 [ab]	15.20± 0.20 [a]
Bilin Puree	82.83 ± 3.01[b]	1.28± 0.25 [b]	10.16± 0.20 [c]
Kamaranga Puree	94.33± 3.06 [a]	2.123± 0.15 [a]	13.16±0.20 [b]

The analysis was performed in triplicates. The results are expressed as mean ± SD. Within a column, mean values followed by different lowercase letters are significantly different ($p < 0.05$).

SENSORY EVALUATION

Sensory evaluation was performed for four treatments, and the best treatment was selected. The results of sensory evaluation are given in Table 3.

According to the data obtained from the sensory evaluation of fruit leather, there were significant ($p<0.05$) differences in all tested sensory attributes such as color, aroma, mouthfeel, taste, and acceptability of the treatments. Mixed fruit leather (T4) showed the highest median rank for all sensory attributes compared to other treatments.

Treatment	**Color**		**Aroma**		**Mouth feel**		**Taste**		**Over acceptability**	
	Est median	Sum of rank	Est median	Sum of rank	Est median	Sum of rank	Est median	Sum of rank	Est median	Sum of rank
T 1	4.00	39	3.12	30	3.00	24	3.12	24.5	3.25	29
T 2	4.25	41.5	3.37	42.5	4.00	45	3.87	39.5	3.75	42.5
T 3	3.000	17.5	2.87	23	3.25	26.5	3.37	28.0	2.500	21
T 4	4.75	52	4.12	54.5	4.75	54.5	5.12	58	4.50	57.5
P value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DF	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

Table 3. Results of the Freidman test of sensory evaluation

Median rank values are significantly different at ($p < 0.005$).

The Web diagram for the sensory evaluation of four types of fruit leathers is shown in Figure 1 and it clearly demonstrate that T4 had the highest ranks for all the sensory attributes.

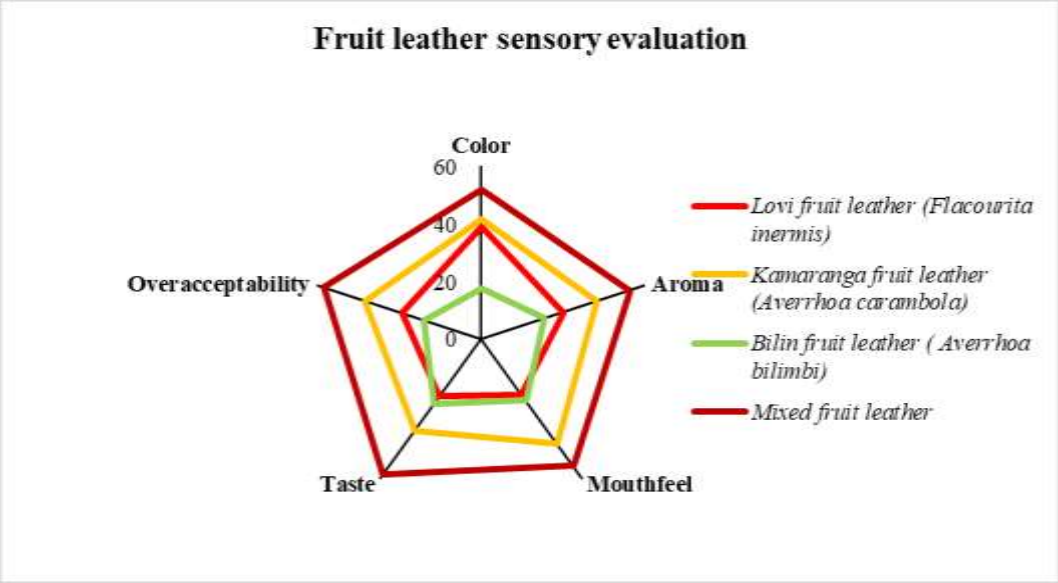

Figure 1. Web diagram of the sensory evaluation

PHYSIOCHEMICAL PROPERTIES AND MICROBIOLOGICAL QUALITY DURING THE STORAGE STUDY

Mixed fruit leather - which was selected as the best, was subjected to the analysis of physicochemical properties and microbiological quality for 35 days. The results, presented in Table 4. There was no significant difference($p<0.05$) in the moisture content during the storage. The moisture content of fruit leather is influenced by the type of fruit, the drying process, and the temperature at the time of development. The highest moisture content was in the 1st week of storage (21.33±6.43) and the lowest was in the 3rd week (12.86±1.02). The moisture content of our product is in line with the typical moisture content of 15–25% found in fruit leather according to Madushanka et al., (2016). Irwandi et al., (1996) also mentioned the importance of moisture content on the durability of dried fruit products, highlighting the significance of moisture and equilibrium relative humidity of dried fruits in packaging design and storage conditions. The acidity levels on the 7th day and 35th day showed significant differences compared to the other three weeks. The acidity level influences the palatability of the food, controls nutritive value, controls microbial growth and maintains the color and flavor of the food (Madushanka et al.,2016). There was no significant difference in the pH value in the first three weeks compared to the last two weeks. There was a significant difference in total soluble solid content in the sample in the second and third weeks. Surprisingly, there were no any microbial counts over the storage period. This may be due to the low pH level and the applied heat while processing fruit leather.

Table 4. Physicochemical and microbiological counts of the storage study

Parameter	7 days	14 days	21 days	28 days	35 days
Moisture content	21.33±6.43^{a*}	14.67±3.06^{a}	12.86±1.026^{a}	15.67±2.52^{a}	14.33±4.04^{a}
Titratable Acidity	3.66±0.208^{a}	3.4±0.00^{ab}	2.96±0.63^{abc}	2.63±0.30^{bc}	2.31±0.02^{c}
pH	2.36±0.01^{a}	2.41±0.09^{a}	2.3±0.01^{a}	2.103±0.08^{b}	2.12±0.026^{b}
TSS	14.38±0.621^{c}	19.63±0.45^{a}	17.56±0.05^{b}	13.27±0.14^{c}	14.5±1.38^{c}

TPC $\times 10^3$CFU/g	Not detected	Not detected	Not detected	Not detected	Not detected

The analysis was performed in triplicates. The results are expressed as mean ± SD. The mean values of moisture content were followed by the same lowercase letters and are not significantly different. The mean values of acidity, pH, TSS, and TPC were followed by different lowercase letters and are significantly different ($p < 0.05$).

PROXIMATE ANALYSIS

Results of the proximate analysis are given in Table 5. Proximate analysis of the mixed fruit leather showed 2.06% of ash, 15.03% of fat, 2.41% of crude fiber, 0.55% of crude protein, and 45.43% of carbohydrates.

Table 5. Proximate analysis

Parameters	Fruit leather
Moisture content	31.63±0.44
Ash	2.06±0.13
Fat	15.03±3.74
Crude fiber	2.41±0.25
Crude protein	0.55±0.02
Carbohydrates	45.43±0.53

CONCLUSION

Mixed fruit leather consists the best sensory attributes - namely color, aroma, mouthfeel, taste, and overall acceptability. In addition, the mixed fruit leather was effectively stored at room temperature for 35 days in 300-gauge polypropylene with no changes in physicochemical or microbiological quality. Therefore, the developed mixed fruit leather could be used as a healthy energy-providing snack due to the high crude fiber content and carbohydrates. Accordingly, mixed fruit leather can be successfully introduced to the industrial market as a healthy, natural, and value-added product with outstanding organoleptic attributes.

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