Development of Mixed Fruit Leather Using Five Tropical Fruits

D B G Madusanka[1], K H Sarananda[2], T Mahendran[1#] and G Hariharan[1]

[1] *Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Sri Lanka*
[2]*Horticultural Research and Development Institute, Gannoruwa, Sri Lanka*
[#]corresponding author <*thevamahen@yahoo.com*>

***Abstract*—**Fruit leathers are dehydrated sheets of fruit purees or a mixture of fruit juice concentrate and other ingredients with high nutritive value and organoleptic properties. The mixed fruit leathers were produced from purees of five tropical fruits namely mango, pineapple, banana, papaya and passion. The fresh fruits were pureed and they were mixed with other ingredients such as sugar and pectin and then dried in a cabinet air dryer at 60°C for 12-14 hours. All fruits were mixed in the same proportion while different sugar levels such as no sugar, 10%, 20% and 30% used as treatments. The physico-chemical, microbial load and organoleptic properties of the freshly prepared samples were evaluated. The titratable acidity of 0.5% (as citric acid) and pH of 3.8 were low just after preparation of product. The moisture content and the TSS of the fruit leather was 22% and 56.7 °Brix respectively, immediately after drying. The physico-chemical parameters such as pH and titratable acidity were not significantly differed while the TSS and the moisture content of the treatments were significantly differed at 5% significant level immediately after preparation. Sensory analysis was carried out using 14 trained panellists to evaluate the colour, taste, mouth feel and overall acceptability of the developed fruit leathers using a 5-point hedonic scale. Results of sensory analysis revealed that there were significant differences ($p<0.05$) for colour, aroma, taste, mouth feel and overall acceptability and no significant differences ($p>0.05$) for aroma among freshly developed treatments. Based on sensory analysis, the fruit leather produced with 20% sugar showed the best organoleptic characteristics. The product was highly acceptable when it was stored in polypropylene (300 gauge) at the ambient temperature of 30°C based on the nutritional, microbiological and sensory qualities. The produced leather could be used to replace fresh fruits and 36g is equivalent to 200g of fresh fruits. It is very much convenient to consume 36g of fruit leather to fulfil the fresh fruit recommended requirement of 200g per day.

***Keywords*— Fruit leather, nutritive value, tropical fruits**

I. INTRODUCTION

Fruits are universally promoted as healthy foods, diverge greatly in content of energy and nutrients and usually consumed in the form of raw or processed. They are very rich source of dietary fibre, vitamins and minerals; and they have substantial quantities of naturally occurring phytochemicals that function as anti-oxidants, phytoestrogens and anti-inflammatory agents and through other protective mechanisms (Slavin and Lloyd, 2012). Though the fruits have always been main agricultural product, it is only in recent years that there is an increasing consciousness of the potential value of native tropical fruit species (Mal *et al*., 2011).

Mango (*Mangifera indica),* Pineapple *(Ananas comosus),* Banana *(Musa spp.),* Papaya *(Carica papaya) and* Passion fruit *(Passiflora edulis)* are commonly available tropical fruits in Sri Lanka. Mango comprises ample amount of appreciable β-carotene, vitamin C and dietary fibre (Pal, 1998) as well as soluble sugars and different minerals which are used as good sources of nutrition and readily available and simply assumable in human body (Singh *et al*., 2000). People consume mango simply because of its pleasant taste and delicious flavor. Pineapples are low in calories, rich in carbohydrates and can provide essential minerals, vitamins B_1, B_2 and C and dietary fibre. Furthermore, pineapple contains some enzymes such as peroxidase, polyphenol oxidase and proteinase bromelain.

Banana is very rich in carbohydrates, vitamins A, B, and C and several essential minerals including potassium, copper, magnesium, calcium and iron. The green matured fruits of banana are to be consumed as staple food or specialised product are further cooked or processed. Papaya often ranks high in fruit nutritional charts as a strong source of vitamin C, carotenoids, potassium, magnesium and folate (Gebhardt and Thomas, 2002). Passion fruit provides a good source of nutrients such as vitamin C, vitamin A and potassium and non-nutritive phytochemicals, carotenoids and polyphenols (Talcott *et al*., 2003) that make passion fruit a tasteful and healthy addition to the diet. The unique aroma of passion fruit juice is often accepted by consumers in variety of passion fruit based food products. There are several methods of utilizing and processing of such fruits into juice, jams, concentrates, pulp, dehydrated products, jellies and fruit leathers.

Fruit leather is a dehydrated fruit based confectionary can also be called as fruit bar or a fruit slab and it refers to fruit

purees or a mixture of fruit juice concentrate with other ingredients which are cooked, dried on a non-sticky surface and rolled (Huang and Hsieh, 2005). A soft, rubbery textured, sweet taste and flavourful characteristics of fruit leathers are generally accepted by the consumers. Fruit leathers are often eaten as snacks or desserts, used to make beverages by blending water or into other sources (Raab and Oehler, 1999) and can also be used as ingredients in products such as biscuits and breakfast cereals (Irwandi *et al*., 1998). Consuming fruit leather is an economic and convenient value-added substitute for natural fruits as a source of various nutritional elements (Diamante *et al*., 2014).

Most fresh fruits have a short harvest season and are sensitive to deterioration even when stored under refrigerated conditions; therefore, making fruit leather from fresh fruits is an effective way to preserve fruits (Maskan *et al*., 2002). Development of mango, pineapple, banana, papaya and passion fruit incorporated fruit leather will add to the variety of product already available in markets. This study aimed at production and evaluation of physico-chemical, microbiological and sensorial characteristics of the mixed fruit leather developed from following five tropical fruits such as Mango (*Mangifera indica),* Pine apple *(Ananas comosus),* Banana *(Musa spp.),* Papaya *(Carica papaya) and* Passion fruit *(Passiflora edulis)*.

II. Materials and Methods

A) Sample Collection

Fresh, firmly ripe and undamaged fruits of Mango, Pineapple, Banana, Papaya and Passion were obtained from a commercial Horticultural Farm and sugar was bought from Cargills Food City in Kandy. This study was undertaken at the Food Research Unit, Department of Agriculture, Gannoruwa, Sri Lanka.

B) Preparation of Mixed Fruit Leather

All fruits were thoroughly washed in clean water, manually peeled with a stainless steel knife, seeds of mango and papaya were discarded, and flesh of the fruits were chopped into pieces and crushed into purees by using an electric grinder (KENSTAR Classique 540) separately. In case of Passion, the fruits were cut into two halves by using stainless steel knife, flesh was removed and juice was separated by using a clean muslin cloth to remove the seeds. Equal weight from each pulp was taken and all the fruit purees were mixed thoroughly together to get a uniform mixture. After that, the mixed fruit puree was divided into four equal parts and 10%, 20% and 30% of sugar was weighed and added to three parts respectively and the remaining part was served as control where sugar was not added. Table 1 shows the treatments of freshly made mixed fruit leathers used in this study.

The pH of the samples was adjusted to 3.8 by adding of citric acid during preparation. Then each sample was separately heated up to 90^{o}C and kept for 20 minutes. After 20 minutes, pectin was added to each sample at 5g/kg rate. It was pre-dissolved thoroughly in small amount of puree and then it was added to the puree and mixed thoroughly.

Table 1: The % Sugar added for the development of different mixed fruit Leathers

Treatment code	Sugar Content (%)
C	No added sugar
T_1	10% sugar
T_2	20% sugar
T_3	30% sugar

C: Control, T_1: Treatment 1, T_2: Treatment 2 and T_3: Treatment 3

After adding of pectin the mixtures were taken off from the heat and then Sodium metabisulphite was added at the rate of 0.2g/kg and mixed thoroughly. The mixture was poured as a 1.00 cm thick layer in stainless steel trays previously smeared with glycerol and dried in cabinet air dryer (phoenix) at 60^{o}C for 12 to 14 hours. Dryness of the leather was frequently inspected during the drying period. The trays were turned and rotated every hour throughout the drying time.

C) Physico-chemical Analysis

For the determination of pH, titratable acidity and Total Soluble Solids (TSS), 1g of fruit leathers were homogenized immediately after preparation by using 9ml of distilled water for 1 minute and the filtrate was used. The pH of the sample was measured by using Digital pH meter (HANNA HI 98130). The Total Soluble Solid (TSS) content of freshly made mixed fruit leathers were measured using the hand held refractrometer (ATAGO-S-28E). The titratable acidity was determined by titrating the filtrates with 0.5 N NaOH and the results were expressed as percentage of citric acid. The moisture content of the freshly developed fruit leathers were determined using the method recommended by AOAC (2005). Each measurement was triplicated during analysis.

D) Microbial Analysis

Total plate count, yeast and mold count and coliform test were done for the freshly prepared fruit leather. Mixed fruit leather sample of 1g was transferred to test tubes containing 9ml of distilled water and it was stirred well in sterilized condition. Thereafter 1ml of diluted samples were put into other test tubes containing 9ml of distilled water separately. By following same procedure dilution series of 10^{-3}, 10^{-4} and 10^{-5} were prepared. Diluted sample of 1ml were inoculated

and incubated for 30^{0}C for 48 hours. After 48 hours the colonies were counted by using Colony counter (Quebec).

E) Sensory Analysis

Sensory evaluation was conducted to evaluate the organoleptic characteristics of developed fruit leathers using a sensory panel consisting of 14 trained and semi trained panellists. The colour, aroma, taste, mouth feel (chewiness) and overall acceptability were evaluated using five-point hedonic scale ranging from 1= Extremely dislike and 5= Extremely like. A ballot sheet was given to the panellists containing all the details for the sensory evaluation.

F) Statistical Analysis

Data related to physico-chemical parameters were analyzed by using Analysis of Variance (ANOVA) (α = 0.05) and mean separation was done with Duncan's Multiple Range Test (DMRT). Data related to sensory evaluation were analyzed using Friedman Test. Chemical analyses was done through Statistical Analysis System (SAS) software statistical package (Version 9.1) and data related to organoleptic characteristics were analyzed through Minitab (Version 16).

III. Results and Discussions

A) Physico-chemical Analysis

I. pH and titratable acidity

Acids presents in the food not only improve the palatability but also influences their nutritive value. High acidity in fruit leather inhibits the growth of microorganisms and helps to maintain the colour and flavour of the fruit (Karki, 2011). This indicates the importance of acidity. The pH and the titratable acidity of the treatments that measured just after preparation are shown in below Table 2. The study revealed that there was no significant differences (p>0.05) observed among freshly developed fruit leathers for pH and titratable acidity.

Table 2: The pH and titratable acidity of the mixed fruit leathers just after preparation

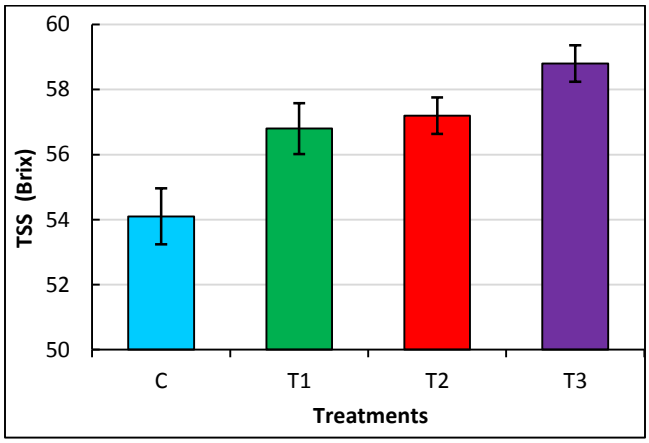
Treatments	pH	Titratable Acidity (as % citric acid)
No sugar (C)	3.8±0.12^a	0.4±0.33^a
10% sugar (T_1)	3.8±0.11 ^{a}	0.5±0.12^a
20% sugar (T_2)	3.8±0.15 ^{a}	0.4±0.32^a
30% sugar (T_3)	3.8±0.12 ^{a}	0.5±0.21^a

Values are means of triplicates.
Treatment means in a column having common letter(s) are not significantly different by DMRT 5%.

All the treatments of the pH of freshly made mixed fruit leathers were adjusted initially to 3.8 by adding citric acid during development. The pH and the titratable acidy are highly correlated among them. This might be the reason for the no significant differences among tested treatments related to pH and titratable acidity.

II. Total soluble solids (TSS)

The soluble solid content is one of the important quality parameters in food processing. An average of 55% soluble solids is sugars such as glucose and fructose and the amount of proportions influence the organoleptic qualities of the fruit and fruit leathers. The lowest TSS content of 54.1˚Brix was observed in Control treatment whereas highest TSS content of 58.8 ˚Brix was recorded in 30% sugar added mixed fruit leather as shown in Figure: 1.



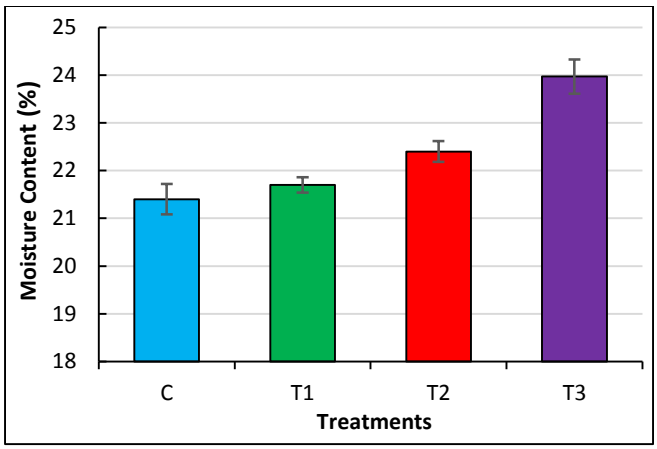
Values are means of triplicates.
Vertical bars indicate the standard error.

Figure 1: Total Soluble Solids of Freshly Prepared Mixed Fruit Leathers

The total soluble solids of freshly prepared mix fruit leather prepared using four different combinations were significantly (p<0.05) differed among the tested samples and increased as the percentage of sugar added increased. This observation was consonance with Phimpharian *et al*. 2011 in the development of pineapple fruit leather where the TSS has significantly increased as the concentration of added glucose syrup increased from 2 to 6%.

III. Moisture Content

Moisture content of the fruit leather is mainly influenced by the type of fruit, drying process, temperature and humidity during development. The preservation of fruit leathers depends on the moisture content (typically 15 to 25%) (Perera, 2005). Accordingly, the moisture content of the all developed samples was typically between 21 to 25%. Moisture content was significantly (p<0.05) increased when the sugar levels were increased. The minimum moisture content of was observed in no sugar control treatment and the maximum level of moisture was observed the treatment added with 30% sugar level as shown in Figure: 2. The differences of moisture contents between the samples may due to different added sugar levels during development. Our findings were supported by Karki (2011).



Values are means of triplicates.
Vertical bars indicate the standard error.

Figure 2: Moisture Content of Freshly Prepared Fruit Leather

B) Microbiological Studies

Microbiological status of the developed products determines the consumer safety. There were no significant ($p > 0.05$) differences observed in total plate count and yeast and mould count in the all treatments that immediately after prepared as shown in the Table 3. The counts were below the standard limits for safe consumption. This may due to preliminary processes such as heating for 20 minutes eliminated a large number of microorganisms. The all the freshly made samples of mixed fruit leather were free in coliform, therefore it is very safe for human consumption.

Table 3: Microbiological Assay of Freshly-made Fruit Leather

Treatments	Total Plate Count (CFU/g x 10-3)	Yeast and Mould Count (CFU/g x 10-3)	Coliform Test
C	1^a	2^a	Negative
T_1	1^a	1.5^a	Negative
T_2	0.5^a	1^a	Negative
T_3	0.5^a	1^a	Negative

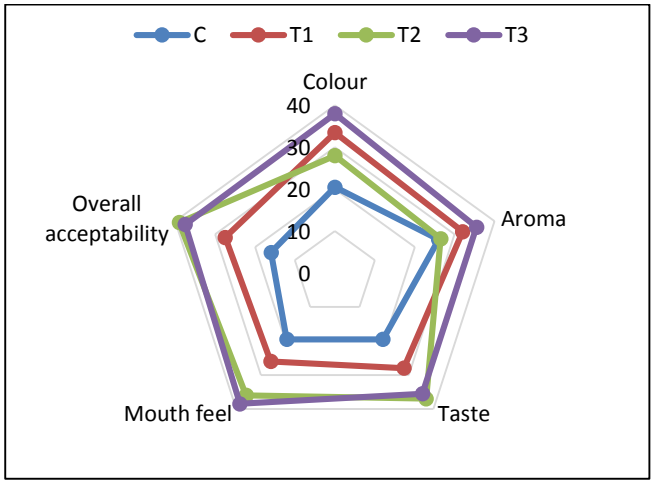
The values are means of triplicates.
Treatment means in a column having common letter(s) are not significantly different by DMRT 5%.

C) Sensory Analysis

Organoleptic properties of any newly developed products determine the willingness to eat and consumer acceptability. The sensory evaluation ranks for colour, aroma, taste, mouth feel and overall acceptability of freshly prepared mixed fruit leather are shown in Figure: 3.

I. Colour

Regarding organoleptic quality, colour is generally selected as quality parameter, because it has a high impact on consumers and is useful as browning index. The colour of the freshly developed fruit leathers were significantly differed ($p<0.05$) among treatments. According to the Friedman ranking, colour of control sample had lowest rank and 30% sugar sample had the highest rank. This is because of no sugar sample had some dark colour and crusty surface, but when the amount of sugar increasing the colour of product getting light colour. Therefore, consumer preference is high for light brown coloured samples as shown in the below given Figure: 3.



The values are means of 14 replicates.
The ranks in organoleptic properties are based on Friedman Test.
Sensory parameters were measured using five-point hedonic scale.
1: Extremely dislike, 5: Extremely like.

Figure 3: Sensory Evaluation based on Friedman Test

II. Aroma

Aroma of the mixed fruit leather is due primarily to the type and the amount of the fruits used for leather preparation. The study showed that there were no significant ($p>0.05$) differences among treatments for aroma. In this mixed fruit leather the type and amount of fruits which is used in development of all treatments are same. This might be the reason for no significant differences among treatments for aroma. Therefore, all the tested treatments had pleasant aroma so consumer preference for all treatments was high.

III. Taste

The taste of fruit leather is contributed by the amount of sugars contained in the fresh pulp and the amount of the sugar added during preparation. The taste of the freshly made fruit leathers were significantly ($p<0.05$) differed among treatments. The lowest ranking for taste was observed in no sugar added sample whereas highest rank was given to the sample with 20% sugar added mixed fruit. Among the tested samples, the treatment with high % of sugar (T_3) had highest score next to the sample T_2 as shown in the Figure 3. This might be due to increasing the amount of sugar beyond the optimum level may reduce the taste ratings thus requiring optimization. Our view is in agreement with Jain and Nema (2007). However, there was no significant ($p>0.05$) difference between 20% and 30% sugar added fruit leathers.

IV. Mouth feel

Dried food products should be prepared as easy to chew. There were significant differences ($p<0.05$) among the samples for mouth feel. No sugar sample had the lowest preference value and 30% sugar sample had the highest preference value. This is because of when sugar content increasing product being smooth and increase chewiness. That increased the consumer preference.

V. Overall acceptability

The rankings of overall acceptability were significantly differed ($p<0.05$) among freshly prepared fruit leathers. The treatment without sugar had low score of preference and both 20% and 30% sugar added treatments have high scores (Figure: 3). The 20% sugar added treatment had highest value in overall acceptability than other tested combinations. It could be seen that all the developed fruit leathers were accepted by the panellists.

VI. CONCLUSIONS

Mixed fruit leather can successfully be produced with mango, pineapple, banana, papaya and passion fruit and could be help in utilizing of such fruits when their peak in availability to extend their shelf life. The leather was highly palatable when sugar was added at 20% level. Consuming 36g of the leather produced can supply the nutrient requirement coming from 200 g of fresh fruits. Since the consumption of 200g of fresh fruits per day with five different fruits is not practically possible the supply of the same level of nutrients can be achieved by consuming 36g of the developed product. It is concluded that the tropical mixed fruit leather prepared using 20% of sugar could be packaged in polypropylene (gauge 300) and stored at ambient conditions without any significant changes to the physico-chemical, microbiological and organoleptic quality.

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