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Chemical Composition, Physicochemical Properties, and Sensory Attributes of Pawpaw-Banana Mixed Fruit Leather

Ohijeagbon O.R.[1], Quadri J.A.[2*], Adesola M.O.[1], Adediwura R.A.[1] and Bolarinwa I.F.[1]

[1]Department of Food Science, Ladoke Akintola University of Technology, PMB 4000 Ogbomoso, Nigeria.
[2]Department of Nutrition and Dietetics, Ladoke Akintola University of Technology, PMB 4000 Ogbomoso, Nigeria.

*Corresponding author email: jaquadri@lautech.edu.ng

Abstract

Fruits offer nutrient-dense and satiety choice for a healthy diet; However, they are highly perishable and prone to progressive undesired changes if stored untreated. Post-harvest losses in fruits vary between 15-90% in developing countries. In order to reduce fruits post-harvest losses, it is important to process them into shelf stable products such as fruit leather. Thus, this study assessed the quality attributes of pawpaw-banana mixed fruit leather. The fruit leather was produced by blending varying proportions of banana puree (0 – 40%) with pawpaw puree, and evaluated for chemical and physicochemical properties, carotenoid contents, antioxidant activities, microbiological characteristics and sensory attributes. The vitamin C contents (13.07 mg/100 g) and brix level (12.0 °brix) of the 70%pawpaw leather were the highest among the mixed fruit leather. The beta-carotene and lycopene contents of the mixed fruit leather ranged from 19.78 – 31.88 mg/100g and 70.47- 91.95 mg/100g, respectively. The total phenolic and the FRAP contents of the mixed fruit leather are 0.65 – 0.86 mg/GAE g and 2.34 – 3.84 mmolFe^{2+}/g respectively, while that of the plain pawpaw leather was 0.61 mg/GAE g and 4.11 mmolFe^{2+}/g for total phenolic and the FRAP. The total bacteria count in the fruit leather were within the safe level, while the total coliform and total fungi were not detected. The sensory evaluation results showed that 70%pawpaw leather was highly rated for flavor, taste, texture and overall acceptance. Thus, 70% Pawpaw leather is recommended due to its high nutritional value and sensory attributes.

Keywords: *Fruit leather, banana, pawpaw, postharvest losses, antioxidant activities, carotenoid contents*

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1. Introduction

Fruits are important part of a healthy and balanced diet in all societies around the world. Fruits contain high level of antioxidants, anthocyanin, carotenoids, phenolic compounds, vitamins and minerals thus they have beneficial effect for eye health and weight loss (Herforth, 2019) Fruits contains vitamins (C, A, E,thiamine), minerals and dietary fibre that helps to prevent and control different type of diseases such as cardiovascular disease, cancer, stroke and other chronic diseases (Boeing *et al*,2012). Fruits that are rich in dietary fibers reduces constipation by improving digestive tract functions (Dreher 2018)

Fruit leather is a dehydrated product having shiny, soft rubbery texture and sweet in taste that possesses an extended shelf life. Fruit leather can be made from a single fruit or blend or mixture of different fruits (Ruiz et al, 2012). They may be eaten as snack foods or as a healthy alternative to boiled sweets, as topping of cakes, in ice cream and manufacturing of flavored cookies (Azeredo *et al.*, 2009). Fruit leathers are nutritious and organoleptically acceptable to customers, it contains substantial quantities of dietary fibers, carbohydrates, minerals, vitamins and antioxidants (Damodaran *et al*., 2010).

Pawpaw (*Carica papaya* L.) is a commercial fruit crop in many tropical regions of the world. It is a plant with potential medicinal value and belongs to the family *Caricacae* (Anon, 2010). The fruit is a rich source of vitamins (A and C), potassium, calcium, iron and dietary fibre making it an excellent food source (Ahmed *et al*., 2002, Anon, 2010). It is also a very good source of free-radical scavenging vitamin A (in form of beta-carotene) (Dimitrovski *et al*., 2010).

Bananas are one of the world's important food crops in terms of nutrition, well balanced rich in minerals, vitamins, carbohydrates, flavonoids, and phenolic compounds (Singh *et* *al*., 2018) and they are one of the most widely available and economically viable fruit crops. Therefore, producing a shelf stable fruit leather from fresh banana and pawpaw will reduce postharvest losses of the fruits and reduce micronutrients deficiency among the vulnerable groups in Nigeria.

2. Materials and Methods

Materials

Freshly harvested pawpaw (*Carica papaya* Linn, solo variety) and mature unripe cooking banana (*Musa cardaba* AAB) with colour index No. 1 (Osman and Abu-Goukh, 2008) was procured at Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Oyo state in Western Nigeria. Processing of the fruit leather was done at Food Processing laboratory, Food Science Department, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Methods

Preparation of Fruit Leather

Freshly harvested pawpaw and bananas were selected. Defective fruits were removed while selected good fruits were washed, peeled and pawpaw seeds were removed manually with knife and placed in a clean bowl. Peeled fruits were cut into smaller pieces, 80g of each sample was weighed and steamed for 10 - 15 min until the fruit is soft. Steamed fruits were removed from the heat and were blended separately. Different proportions of pawpaw and banana puree was measured and mixed (Table 1). Mixed fruit puree was poured and evenly spread in the oven tray and dried at 60ºC for 8-12h. Fruit leather was checked frequently until it became non sticky to the finger. The fruit leather was removed and allowed to cool and packed in high density polyethylene bag. The flow chart for the preparation of the fruit leather is presented in Figure 1.

Table 1: Pawpaw-banana mixed fruit leathers formulation

Sample	Pawpaw puree (%)	Banana puree (%)
90%Pawpaw-banana	90	10
80%Pawpaw-banana	80	20
70%Pawpaw-banana	70	30
60%Pawpaw-banana	60	40
Plain pawpaw	100	0

Chemical Analysis of the Fruit Leather

Moisture content determination

Moisture dish was placed in thermostatically controlled air oven at 103 °C, for about 30 mins, it was cooled in the desiccators and weighed. 5 g of sample was weighed into the dish. The dish containing the sample was placed in the oven for one hour, it was returned into the oven and the process was repeated until a constant weight was obtained (AOAC, 2010). All experiments were performed in triplicate. The moisture content was estimated using the formula below:

$$\% \text{ moisture content } = \frac{W_2 - W_3}{W_2 - W_1} x100$$

Where W_1 = weight of dish; W_2 = weight of dish + sample weight; W_3 = weight of dish + sample weight after drying.

Chemical Analysis of the Fruit Leather

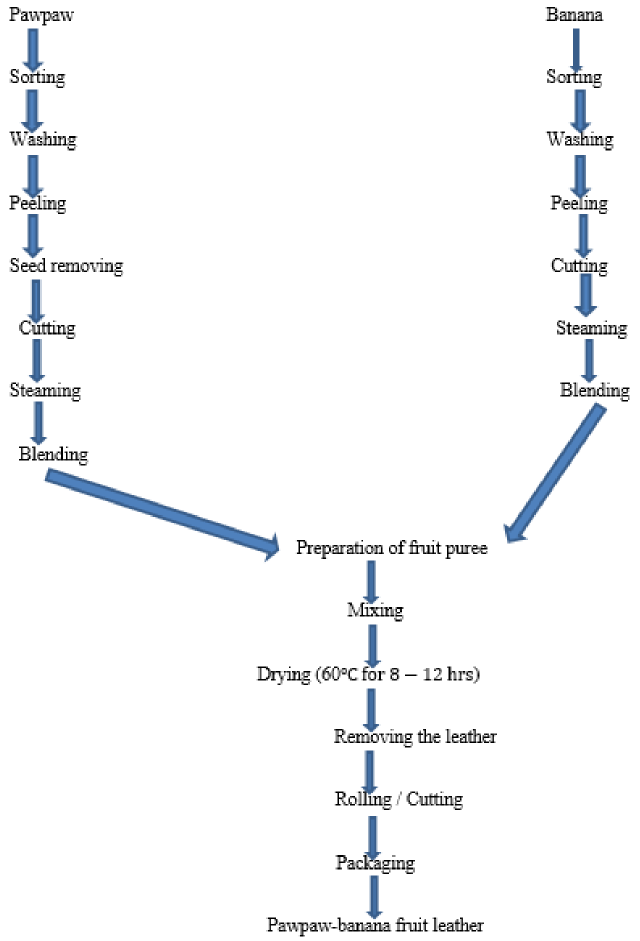

Figure 1: Production of pawpaw-banana fruit leathers.

Determination of Carotenoids Contents

Lycopene analysis

Spectrophotometric determination of lycopene content was carried out by using Spectrophotometer (Uv-vis Specord Analytik Jena, Germany) as described by Alda *et al.* (2009). Lycopene in the fruit leather samples were extracted by adding 8.0 ml of the mixture of hexane–acetone–ethanol (2:1:1, v/v/v) wrapped with aluminum foil. The Lycopene levels in the hexane extracts was calculate as follows:

$$Lycopene\ (mg/100g) = (A503 \times 537 \times 8 \times 0.55)\ (0.10 \times 172)$$

Where: The molecular weight of lycopene = 537g/mole, The volume of mixed solvent = 8 ml, The volume ratio of the upper layer to the mixed solvent = 0.55, The weight of added tomato = 1.0 g, The extinction coefficient for lycopene in hexane = 172 mM-1, The Spectrophotometer at 503nm = A503.

β-carotene determination

The β-carotene contents of the fruit leathers were determined following the method described by Bolarinwa *et al.* (2021) with slight modifications. Ten grammes (10g) of each fruit leather was ground and extracted with a mixture of 20 ml of acetone and 30 ml of hexane (4/6 v/v). The mixture was poured into a separatory funnel and shaken until the content became homogenous. The mixture was allowed to separate and, also protected from light; after which the top layer was taken with a pipette and the optical density was measured at 452 nm for β-carotene. The β-carotene was calculated as follows:

$$\beta - carotene\ (\mu\frac{g}{100}) = \frac{OD\ \times 13.9\ \times 10000 \times 100}{Weight\ of\ sample\ \times\ 560\ \times\ 1000}$$

Vitamin C

The method described by Okwu and Josiah, 2006 was used. Exactly 10g of the sample was extracted with 50ml EDTA/TCA (50 g in 50 ml of water) extracting Solution for I hour and filtered through a Whatman filter paper into a 50ml volumetric flask and made up to the mark with the extracting solution. Twenty (20ml) of the-extract was pipette into a 250ml conical flask and 10ml of 30 % K.I was added and, also 50ml of distilled water added. This was followed by 2 ml of 1% starch indicator. This was titrated against 0.0ml $CuSO_4$ solution to a dark end point.

$$\text{Vit C } (\frac{mg}{100g}) = 0.88\times\frac{100}{5}\times\frac{Vf}{20}\times\frac{T}{1}$$

Where: Vf = Volume of extract
T = Sample titre – blank titre.

Determination of Antioxidant activity of the Fruit Leather
Ferric reducing antioxidant power (FRAP)

The assay was based upon the methodology of Benzie and Strain (1996). The FRAP reagent consisted of 10 mM TPTZ in 40 mM HCl, 250 mM sodium acetate buffer (pH 3.6) and 20 mM $FeCl_3$. The reagent was freshly prepared by mixing TPTZ solution, $FeCl_3$ solution and acetate buffer in a ratio of 1:1:10. An extract solution (100 µl) was mixed with 900 µl of FRAP reagent. The mixture was incubated at 37 °C for 4 minutes and the absorbance was estimated at 593 nm. BHT was used as a standard. The results were expressed as µg BHT equivalent/mg sample.

Total Phenolic Content

The total phenolic content was measured using the Folin Ciocalteu reagent Kupina *et al.* (2017). An aliquot of the extract (100 µl) was mixed with 250 µl of Folin Ciocalteu's reagent and incubated at room temperature for 5 minutes. 1.5 ml of 20 % sodium bicarbonate was added to the mixture and incubated again at room temperature for 2 h. Absorbance was measured at 765 nm using a UV-Vis spectrophotometer. The results were expressed in terms of µg gallic acid equivalents (GAE)/ mg dry extract (Soni *et al.*, 2014).

Microbiological Analysis
Total Viable Count of Bacteria (TVC)

The microbiological analysis was carried out according to Harrigan (1998). Plate count agar was used for enumeration of bacteria. A well homogenized sample was serially diluted with 0.1% peptone water up to 10-6. One ml aliquot from a suitable dilution was transferred aseptically into sterile petri dishes. To each plate about 15ml of melted and cooled PDA (Potato Dextrose Agar) was added. The inocula was evenly mixed with media by rotating the plates and allowed to solidify. The inverted plate was incubated for 48h. The TVC (cfu/ml) was determined using a colony counter.

Total Coliform Bacteria

Mac Conkey broth was used for the detection of coliform bacteria by the multiple tube technique. The medium was distributed in 9 ml quantities standard test tubes with inverted Durham tube and was autoclaved for 20 mins at 121°C.Well homogenized samples was serially diluted (10^{-1}, 10^{-2}, 10^{-3} and 10^{-4}) with 0.1 % peptone water.1 ml from each dilution was aseptically inoculated into triplicate of 9 ml sterile Mac Conkey broth in standard test tube and incubated for 48 h at 37°C. Positive tests gave gas in the Durham tubes and changed the color of the medium (Harrigan, 1998).

Total Fungi Count

Potato dextrose agar (PDA) was used for enumeration of yeast and mould. Well homogenised samples were serially diluted with 0.1 % peptone water up to 10^{-6}. Aliquots (0.1 ml) from a suitable dilution were transferred acseptically into solidified PDA plates. Samples were spread all over the surface of the plates using sterile bent glass rod. The plates were incubated for 48 to 72 h at 28 °C. The colony (cfu/ml) was counted out by using colony counter (Harrigan, 1998).

Colour Measurement

Color values of fruit leather were obtained using a hand-held Konica Minolta Chroma Meter (Model CR-410, Konica Minolta Sensing, Inc., Japan). Values was reported as Hunter color values where $L*$ values denote lightness, $a*$ values signify redness, and $b*$ values determine yellowness (Hanis-Syazwani *et al*., 2018).

Sensory Evaluation

Descriptive test was used to evaluate the sensory attributes of the fruit leather using 50 untrained panelist who are fruits consumers and familiar with its quality selection based on their interest and availability. The fruit leather was served with random coded plates, and the panelists were asked to rate the samples based on a 9-point hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely) for different parameters (colour, flavor, sweetness, texture and overall acceptability).

Statistical Analysis

The results of the experiment were subjected to analysis of variance (ANOVA) and the mean was separated using Duncan's multiple range test to detect significant difference ($p<0.05$) among the sample values using the statistical package for the social science (SPSS) version 20.

3. Results and Discussion

Chemical and Physiochemical Properties of Pawpaw-Banana Fruit Leather

The chemical and physiochemical properties of the fruit leather are shown in Table 2. The moisture content of the fruit leather ranged from 14.43 to 23.67 % with plain pawpaw leather having the lowest value while the 60% pawpaw-banana leather had the highest value. The result showed that there was variation (14.43 - 23.67%) in the moisture content of fruit leather with increase in banana puree inclusion. The average moisture content varies significantly, but there were no significant differences ($p<0.05$) between the moisture content of the fruit leathers produced with higher proportion of banana puree**.** It has been reported that moisture content at or below 15% (wet base) for most fruit is safe indicator that the product will not be susceptible to microbial contamination or mould growth, and the rate of several other deteriorative factors such as sugar crystallization, non-enzymatic browning, flavor deterioration, lipid oxidation will be low (Zambrano *et al.*, 2019).

The vitamin C is important water-soluble vitamin already implicated in most of the life processes but principally functions as an antioxidant. The vitamin C contents of the fruit leather ranged from 7.66 to 13.76 (mg/100g). Addition of banana puree decreases the vitamin C contents of the fruit leather. The result showed that there was variation (7.658 - 13.758 mg/100g) in the vitamin C content of fruit leather with increase in banana puree inclusion. The average vitamin C content varies significantly ($p<0.05$). Comparatively, the difference in vitamin C contents is lower than other values recorded for pawpaw-guava leathers (23.81 %) using the oven dryer (Ashaye *et al.*, 2005).

Table 2: Chemical and Physiochemical Properties of Pawpaw-Banana Fruit Leather

Sample	Moisture (%)	Vitamin C (mg/100 g)	pH	TTA (%)	Brix (° brix)
90%Pawpaw-banana	20.20±1.39^{ab}	7.69±0.77^{a}	4.09±0.012^{a}	0.35±0.01^{c}	11±0.02^{b}
80%Pawpaw-banana	19.83±1.52^{ab}	10.49±0.37^{b}	4.19±0.01^{b}	0.22±0.01^{a}	10±0.02^{a}
70%Pawpaw-banana	22.83±6.35^{b}	13.07±0.68^{cd}	4.02±0.02^{a}	0.56±0.00^{e}	12±0.02^{c}
60%Pawpaw-banana	23.67±3.51^{b}	11.82±0.77^{bc}	4.07±0.01^{a}	0.39±0.01^{d}	11±0.03^{b}
Plain pawpaw	14.43±3.00^{a}	13.76±1.10^{d}	4.46±0.02^{b}	0.28±0.00^{b}	12±0.03^{c}

Means with different superscript(s) along the same column are significantly different ($P < 0.05$).

The pH of the fruit leather ranged from 4.02 to 4.46. There was variation in the pH content of fruit leather with increase in banana puree inclusion. However, there were no significant differences ($p>0.05$) between the pH content of the fruit leathers produced at sample A (90: 10% pawpaw-banana puree) and sample D (60: 40% pawpaw-banana puree)**.** The titratable acidity of the fruit leather is between 0.22 and 0.56. The results indicate that the fruit leather was fairly acidic. The low pH value in the fruit leather might be due to the organic acids such as citric and tartaric acids existing in the pawpaw puree. Fruit acids influence the flavor, brightness of color, stability, consistency and keeping quality of the product (Adedeji *et al*., 2006). Thus, the acidity of the fruit leather will protect the samples from microbial contamination and extend the shelf-life of the fruit leathers. The pH and acidity values of the pawpaw-banana fruit leather is similar to the pH (3.57-3.98) and acidity (0.42-0.48) for guava (Jain et al, 2003), and the pH value of tamarind pulp (4.17 - 4.2) reported by Jittanit *et al*. (2011) and Joshi *et al*. (2012).
The brix level of the fruit leather ranged from 10 to 12 ° brix. Addition of banana puree had significant effect on the brix level of the fruit leather up to 20% inclusion, however at 30% banana puree inclusion, the brix level was the same as that of 100% pawpaw leather. This could be due to synergistic effects of the sweetness of the two fruits at this mixing ratio. The brix values of the fruit leather reported in this study is within the range of brix level (7-14° brix) reported for kokam and pineapple blended fruit leather (Sawant *et al*., 2009).

Antioxidant activity of Pawpaw-Banana Fruit Leather
The antioxidant activity of the fruit leather is shown in figure 2. The total phenolic compound of fruit leather ranges from 0.61 to 0.86 mg/GAE g. Addition of banana puree increased the phenolic contents significantly ($p<0.05$) up to 30% inclusion, after which a decrease in the total phenolic value was recorded. This could be due to interaction of the chemical composition of the fruit leather at higher concentration of the banana puree. The total phenolic contents recorded for the mixed fruit leather in this study is however lower than that of roselle leather (2.59 mg GAE/g) (Dangkrajang, 2011). This could be due to differences in the phenolic contents of the plants.

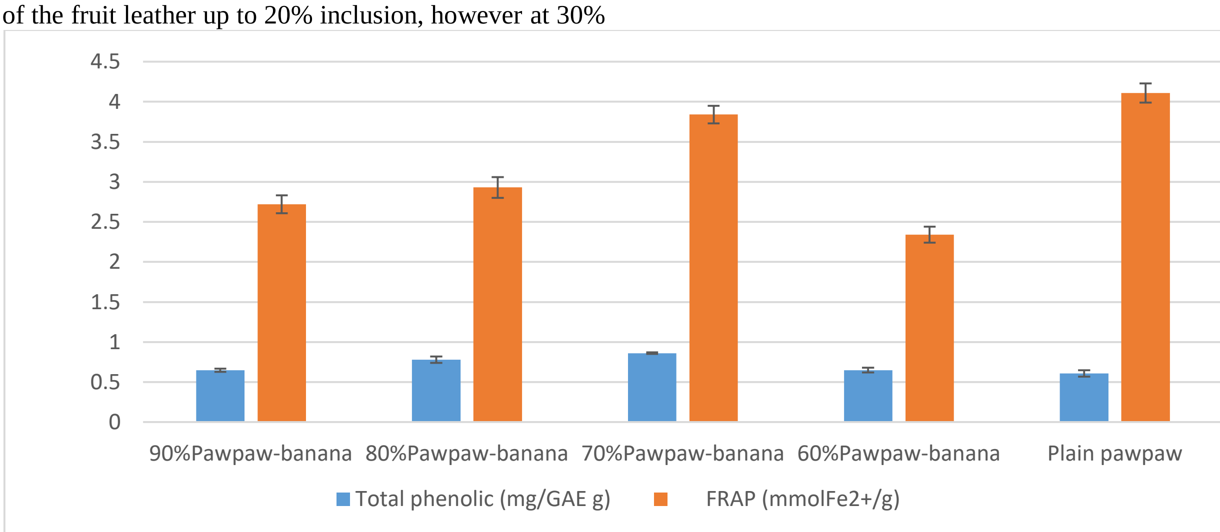

Figure 2: Antioxidant activity of Pawpaw-Banana Fruit Leather

The reduction in total phenolic content of fruit leathers might be due to its losses during the heating process (100 °C). Sharma *et al*. (2016) observed the decrease in total phenolic content of fruit leather with increasing temperature, and reported that this could be due to the decarboxylation of phenolic acids. Heating process caused an increment in the concentration of mixtures containing maltodextrin and hydrocolloids; in which the reacting molecules becomes closer once the mixture is concentrated, accelerating the degradation of the compounds (Patras *et al*., 2010).

The potential of the antioxidant's component present in the pawpaw-banana leathers to reduce ferric ion (Fe3+-TPTZ to a blue coloured Fe2+-TPTZ) was determined using FRAP assay (Azizah *et al*., 2007: Hajimahmoodi *et al*., 2008). The Ferric Reducing Antioxidant Power (FRAP) compound of the fruit leather is between 2.34 to 4.11 mmolFe^{2+}/g. The FRAP contents of the mixed fruit leather decreases with the addition of banana puree. However, there was no significant difference in the FRAP value of the plain pawpaw leather and the 70%pawpaw leather. The lower level of FRAP in the mixed fruit leather could be due to the low concentration of total phenolic in the fruit leather. Previous research has showed that low FRAP activity relates to the low phenolic content in the fruit (Azizah *et al*., 2007).

Carotenoid Contents of Pawpaw-Banana Fruit Leather
The total carotenoid content of the fruit leather is shown in figure 3. The β–carotene content of the fruit leather decreases significantly ($p<0.05$) with the inclusion of banana puree in the mixed fruit leather. Similarly, the lycopene contents of the mixed fruit leather also followed the same trend as the β–carotene.This could be due to high level of β–carotene and lycopene in pawpaw fruit (Dimitrovski *et al.*, 2010; Bolarinwa *et al*., 2021). However, the lycopene content of 70%pawpaw leather was not significantly different ($p>0.05$) from that of the plain pawpaw leather. This indicate that mixed fruit leather from 70%pawpaw will have high antioxidant activity and could have free radical scavenging properties and help in prevention of cancer. As indicated in the results on the antioxidant activity of the fruit leather among all the mixed fruit leather, 70%pawpaw leather had the highest antioxidant activity. This is a confirmation of high carotenoids in the 70% pawpaw leather.

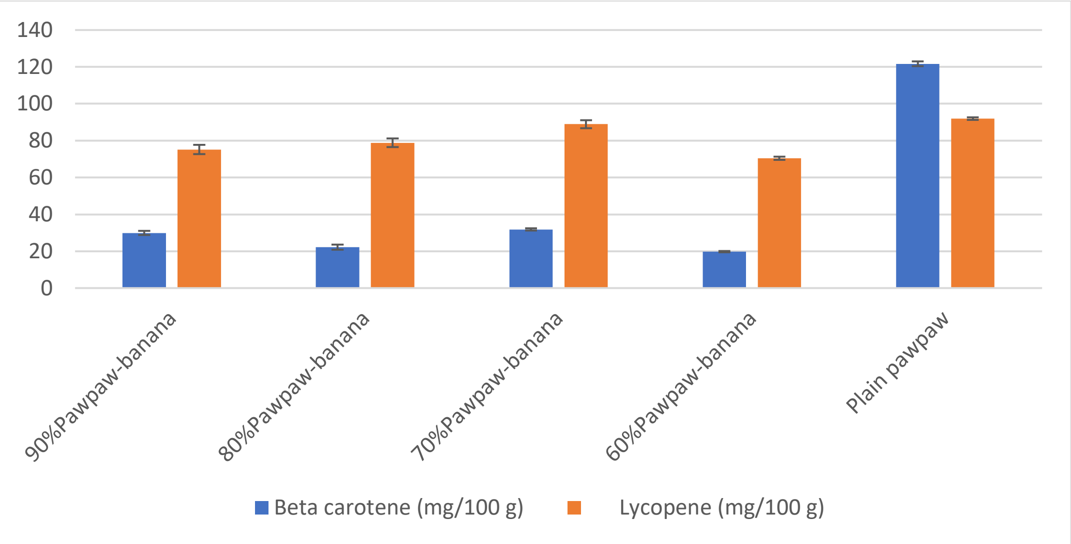

Figure 3: Total carotenoid content of Pawpaw-Banana Fruit Leather

Microbial Characteristics of the Pawpaw-Banana Fruit Leather
The microbial results of the fruit leather are shown in Table 3. The total bacterial count of the fruit leather ranged from 0.5 x 10^3 to 10.0 x 10^3. These values are within the safe level for food. Prior to processing, most fruit contains bacterial counts of 1 X 10^5 CFU/ml (Al-Jedah and Robinson, 2002). The low total bacterial count obtain in our study is similar to that of the report of Rathnayaka (2006) on the quality and acceptability mixed fruit leathers produced from pineapple, mango and papaya mixes. The total coliform count and total fungi count of the fruit leather showed no growth. The absence of coliform in the products confirms the products processing under hygienic condition and its conformity to standards.

Table 3: Microbial Analysis of Pineapple-Banana Fruit Leather

Sample	Total Bacteria Count (cfu/ml)	Total Coliform Count (cfu/ml)	Total Fungi Count (cfu/ml)
90%Pawpaw-banana	10.0 x 10^3	Ng	Ng
80%Pawpaw-banana	3.4 x 10^3	Ng	Ng
70%Pawpaw-banana	1.6 x 10^3	Ng	Ng
60%Pawpaw-banana	0.7 x 10^3	Ng	Ng
Plain pawpaw	0.5 x 10^3	Ng	Ng

Ng= No growth

Colour Attributes of Pawpaw-Banana Fruit Leather

The results of the colour attributes of the fruit leather are presented in Table 4. The lightness (*L*)* value of the fruit leather decreases with the increased addition of banana puree in the fruit leather. The 80% pawpaw leather had the highest *L**value (31.55) followed by the 90% pawpaw leather (31.22). This could be due to higher anthocyanin content in fruit puree (Escribano-Bailón *et al*., 2006). On the other hand, the 30%pawpaw leather had the lowest *L**value (26.63). Oliver *et al*. (1993) attributed the decrease in brightness to higher ash content in fruit. Diamante *et al*. (2014) also reported a variation of 12.37 - 15.62% in the colour of fruit leather from mango puree and banana puree. The 30% pawpaw leather with the lowest *L**value is likely to be more acceptable to consumer in terms of lightness. This is because consumers prefer bright yellow translucent fruit leather products (Ugarcic-Hardi *et al*., 2003).

The redness (*a**) value of the fruit leather does not follow a particular pattern (Table 4). However, the addition of banana puree to pawpaw puree had significant impact on the *a** values of the mixed fruit leathers. In general, there was an increase in the redness values of the mixed fruit leather was observed as the proportion of the banana puree increased in the mixed fruit leather. A similar increase in a* colour coordinates was noted when red acid calyx of roselle (*Hibiscus sabdari*), rich in anthocyanin (Castaneda-Ovando *et al*., 2009) was added to pineapple fruit leather (Ahmad *et al*., 2018).

Table 4: Colour Attributes of Pawpaw-Banana Fruit Leather

Sample	*L**	*a**	*b**	ΔE
90%Pawpaw-banana	31.22±0.05^{c}	0.69±0.01^{a}	5.28±0.03^{a}	18.47±0.06^{c}
80%Pawpaw-banana	31.55±1.52^{c}	4.69±0.17^{e}	10.20±0.62^{e}	21.86±0.20^{e}
70%Pawpaw-banana	26.63±0.22^{a}	2.75±0.04^{d}	5.81±0.03^{b}	14.37±0.20^{a}
60%Pawpaw-banana	28.91±0.06^{b}	2.48±0.05^{c}	6.53±0.01^{c}	16.71±0.04^{b}
Plain pawpaw	30.98±0.30^{c}	1.85±0.03^{b}	7.60±0.03^{d}	18.95±0.28^{d}

Means with different superscripts along the same column are significantly different ($P < 0.05$).
*L** = lightness*a** = redness*b** = yellownessΔE = hue angle

The yellowness (*b*)* of the fruit leather also does not follow a particular trend. However, the 80% pawpaw leather had the highest *b**value (10.20) followed by the plain pawpaw leather which had *b**valueof7.60. This variation in yellowness may be due to the leaching and or degradation of color pigments, such as carotenoids and xanthophylls during processing. The yellowness (b* values) of the fruit leather in this study (5.28 to 10.2%) is within the range of b* values (4.76-9.35%) reported for mango fruit leather (Eyarkai-Nambi *et al*., 2016).

The hue angle (ΔE) of the 80% pawpaw leather was the highest among the mixed fruit leather. This could be due to its high b* value and low a* value.According to Ugarcic-Hardi *et al.* (2003), bright yellow fruit leather is achieved by having both high *b** values and low *a** values. In general, the variation in the hue angle of the fruit leather can be attributed to the carotenoids and xanthophylls present in the pawpaw (Cremer and Eichner, 2000).

Sensory Evaluation of the Fruit Leather

The results of the sensory evaluation showed that the 90%Pawpaw-banana was highly rated for colour (8.70) and flavor (7.66). However, the 70%Pawpaw-banana had the highest sensory scores in terms of flavor (7.50), taste (7.20), texture (7.26) and overall acceptance (7.48) among the mixed fruit leathers. On the other hand, the plain pawpaw leather was highly rated for flavor (7.92), taste (7.60) and overall acceptance (7.58). This could be because of the inherent flavour of pawpaw and its natural sweetness. The flavour of the products results from volatile substances in the fresh food such as esters, ketones, terpenes, aldehydes and others (Cremer and Eichner, 2000). In terms of colour, plain pawpaw leather had the lowest score (5. 60). This could be due to browning reaction that occur during the drying of the fruit leather. In general, the 80%Pawpaw-banana was the most preferred mixed fruit leather by the panelists.

Table 5: Sensory Analysis of Fruit Leather

Sample	Colour	Flavour	Taste	Texture	Overall acceptance
90%Pawpaw-banana	8.70^{d}	7.66^{bc}	6.78^{b}	6.88^{a}	7.00^{a}
80%Pawpaw-banana	7.56^{d}	7.50^{b}	6.44^{a}	7.12^{b}	7.26^{b}
70%Pawpaw-banana	6.66^{b}	7.50^{b}	7.20^{c}	7.26^{b}	7.48^{ab}
60%Pawpaw-banana	6.82^{c}	7.28^{a}	7.40^{c}	7.24^{b}	7.40^{ab}
Plain pawpaw	5.60^{a}	7.92^{c}	7.60^{c}	6.91^{a}	7.58^{c}

Means with different superscript(s) along the same column are significantly different ($P < 0.05$).

4. Conclusion

This study has been able to establish the production of mixed fruit leather from pawpaw and banana puree. The addition of 30% banana puree to pawpaw puree produced a mixed fruit leather with high vitamin C, beta carotene, lycopene, and antioxidant activity. Sensory evaluation results revealed that 70%pawpaw leather was highly rated for flavor, taste, texture and overall acceptance. Hence, pawpaw-banana fruit leather produced from 770%pawpaw is recommended due to their high nutritional value and sensory attributes. In general, the production of mixed fruit leather from pawpaw and banana will add value to the fruits, reduce their post-harvest losses, and prevent micronutrient deficiency in developing nations. There is need for further study on the storage stability of the mixed fruit leather.

Declarations

Competing Interest

The authors declare no competing of interest.

References

Adedeji, A.A., Gachovska, T.K., Ngadi, M.O., Raghavan, G.S.V. (2006). Effect of Pretreatment on the Drying Characteristics of Okra. Dry. Tech., 26, pp. 1251-1256

Ahmad, N.; Shafi'I, S.N.; Hassan, N.H.; Rajab, A.; Othman, A. (2018). Physicochemical and sensorial properties of optimised roselle-pineapple leather. Malays. J. Anal. Sci., 22, 35–44.

Ahmed J., Shivhare U.S. and Sandhu, K.S. (2002). Thermal degradation kinetics of carotenoids and visual color of papaya puree. Journal Food Science. 67: 2692-2695.

Alda LM, Gogoasa I, Despina-Maria B, Gergen I, Alda S, Camelia M, Nita L (2009). Lycopene content of tomatoes and tomato products. J. Agro-alimentary Process. Technol. 15(4):540-542.

Al-Jedah, J.H and Robinson, R.K (2002). Nutritional Value and Microbiological Safety of Fresh Fruit Juices sold through Retail Qutlets in Qatar. Pakistan J. Nutr. 1(2):79-81.

Anon (2010) Yeast. Encyclopedia Britannica. Ultimate Reference Suite. Chicago. Encyclopedia Britannica. Journal Science Food Agricultural, 41:79-187.

AOAC. (2010) Official methods of Analysis, 15th edition; AOAC, Washington, DC, USA.

Ashaye, O., Babalola S.O, Babalola, A.O, Aina J.O., Fasoyiro, S. (2005). Chemical and Organoleptic Characterization of Pawpaw and Guava Leathers. World Journal of Agricultural Sciences. 1.

Azeredo M.C., Brito S.E, Moreira E.G, Frarias L.V and Burno M. (2009). Effect of drying and storage time on the physico-chemical properties of mango leather International Journal of Food Science and Technology 41:635-638.

Azizah, O., Amin, I., Nawalyah, A. G. and Ilham, A. (2007). Antioxidant capacity and phenolic content of cocoa beans. Food Chemistry, 100: 1523 – 1530.

Azizah, O.; Amin, I.; Nawalyah, A.G.; Ilham, A. (2007). Antioxidant capacity and phenolic content of cocoa beans. Food Chem., 100, 1523–1530.

Benzie, I.F.F., Strain, J.J. (1996). The ferric reducing ability of plasma as a measure of antioxidant power: The FRAP assay. Journal of analytical Biochemistry**, 293**, 70-76.

Boeing H, Bechthold A, Bub A, Ellinger S, Haller D, et al. (2012) Critical review: vegetables and fruit in the prevention of chronic diseases. Eur J Nutr 51(6): 637- 663.

Bolarinwa, I. F., Aruna, T. E., Ajetunmobi, R. I., Adejuyitan, J. A. and O. W. Alawode (2021). Pawpaw enriched soymilk beverage. Bangladesh J. Sci. Ind. Res. 56(2), 105-114.

Castaneda-Ovando, A.; de Lourdes Pacheco-Hernández, M.; Elena Páez-Hernández, M.; Rodríguez, J.A.; Galán-Vidal, C.A. (2009). Chemical studies of anthocyanins: A review. Food Chem., 113, 859–871.

Cremer, D.R. and Eichner, K. (2000). Formation of volatile compounds during heating of spice paprika (Capsicucum annum) powder. J Food Chem 48 (6), 2454-2460.

Damodaran, S., Parkin, K.L. and Fennema, O.R. (2010). FENNEMA Quimica de los Alimentos. Acribia, Zaragoza, Espain.

Dangkrajang, S. (2011). Development of roselle leather from roselle (Hibiscus sabdariffa L.) by-product. Thesis of Master Degree, Prince of Songkhla University.

Dimitrovski, D., Bicanic, D. and Lutarotti, S. (2010). The concentration of trans-lycopene in post-harvest watermelon; An evaluation of analytical data obtained by direct methods.

Journal of Postharvest Biology and Technology, 58(1): 21-28

Dreher ML (2018) Whole Fruits and Fruit Fiber Emerging Health Effects. Nutrients 10(12): E1833

Escribano-Bailón, M.T.; Alcalde-Eon, C.; Muñoz, O.; Rivas-Gonzalo, J.C.; Santos-Buelga, C. (2006). Anthocyanins in berries of Maqui (Aristotelia chilensis Mol. Stuntz). Phytochem. Anal., 17, 8–14.

EyarkaiNambi, V.; Thangavel, K.; Shahir, S.; Chandrasekar, V. (2016). Color Kinetics during Ripening of Indian Mangoes. Int. J. Food Prop., 19, 2147–2155.

Hajimahmoodi, M., Oveisi, M. R., Sadeghi, N., Jannat, B., Hadjibabaie, M., Farahani, E., Akrami, M. R. and Namdar, R. (2008). Antioxidant properties of peel and pulp hydro-extract in ten Persian pomegranate cultivars. *Pakistan Journal of Biological Sciences*, 11: 1600 – 1604.

Hanis-Syazwani, M., Bolarinwa, I.F., Lasekan, O. and Kharidah Muhammad. (2018). Influence of starter culture on the physicochemical properties of rice bran sourdough and physical quality of sourdough bread. Food Research, 2 (4): 340 – 349.

Harrigan, W.F. (1998). Laboratory methods in Microbiology Academics Press, Califonia, USA.

Herforth A, Arimond M, Alvarez Sanchez C, Coates J, Christianson K, *et al.* (2019) A Global Review of Food-Based Dietary Guidelines. Adv Nutr 10(4): 590-605.

Jain, N., Dhawan, K., Malhotra, S. P., Singh, R. (2003). Biochemistry of fruit ripening of guava (Psidium guajava L.): Compositional and enzymatic changes. Plant Foods for Human Nutrition 58: 309–15.

Jittanit, S., Komutarin, T., Azadi, S., Butterworth, L., Keil, D., Chitsomboon, B., Suttajit, M. and Meade, B.J. (2011). Extract of the seed coat of Tamarindusindica inhibits nitric oxide production by murine macrophages in vitro and in vivo. Food and Chemical Toxicology. Pergamon Press, Oxford, UK, 42(4): 649-658.

Joshi A.A, Kshirsagar R.B, Sawate and A.R (2012). Studies on Standardization of Enzyme Concentration and Process for Extraction of Tamarind Pulp, Variety Ajanta. J Food Process Technol, 3:141

Kupina, S., Fields, C., Roman, M. C., Brunelle, S.L. (2017). Determination of Total PhenolicContent Using the Folin-C Assay: Single-Laboratory Validation, First Action 2017.13. J AOAC Int. 1;101(5):1466-1472. doi: 10.5740/jaoacint.18-0031. Epub 2018 Jun 12. PMID: 29895350.

Okwu, D.E., Josiah, C. (2006). Evaluation of the chemical composition of two Nigerianmedicinal plants. African Journal of Biotechnology Vol. 5 (4), pp. 357-361.

Osman, H. E., Abu-Goukh, A. A. (2008). Effect of Polyethylene Film Lining and Gibberellic Acid on Quality and Shelf-Life of Banana Fruits. U. of K. J. Agric. Sci. 16(2), 242-261.

Patras, A., Brunton, N. P., O'Donell, C. P. and Kumar, T. B. (2010). Effect of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. Trends in Food Science and Technology, 21: 3 – 11.

Rathnayaka, R.M.D.N.K. (2006), Study on Quality and Acceptability of Mixed Fruit Leathers (Unpublished Master's Thesis). University Of Sri Jayewardenepura, Nugegoda.

Rodríguez, J.A.; Galán-Vidal, C.A. (2009). Chemical studies of anthocyanins: A review. Food Chem., 113, 859–871.

Ruiz, N., Demarchi, Silvana, Massolo, Juan., Rodoni, Luis., Giner, Sergio. (2012). Evaluation of quality during storage of apple leather. LWT - Food Science and Technology. 47. 485–492.10.1016/j.lwt.2012.02.012.

Sawant, A. A., Kad, V. P. and Thakor, N. J. (2009). Preparation of kokum-pineapple blended fruit leather. *Beverage and Food World*, 36(12): 28-30.

Sharma, P., Ramchiary, M., Samyor, D. and Das, A. B. (2016). Study on the phytochemical properties of pineapple fruit leather processed by extrusion cooking. Original Research Article LWT - Food Science and Technology, 72: 534 – 543.

Singh, R., Kaushik, R., and Gosewade, S. (2018). Bananas as Underutilized Fruit Having Huge Potential as Raw Materials for Food and Non-Food Processing Industries: a brief review. The Pharma Innovation Journal, 7:574-580.

Ugarcic-Hardi, Z., Hackenberge, D., Subaric, D. and Hardi, J. (2003). Effect of soy, maize and extruded maize flour addition on physical and sensory characteristics of pasta. Italy Journal Food Science, 15:277–8.

Zambrano, M., Dutta, B., Mercer, D., Maclean, H., Touchie, M. (2019). Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. Trends in Food Science & Technology. 88. 10.1016/j.tifs.2019.04.006.