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Short communication

Physicochemical Characteristics and Sensory Evaluation of Mixed-Fruit Leather

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Abstract

The objective of the present study was to investigate the physicochemical characteristics and sensory acceptance of mixed-fruit leather prepared from bananas, pineapples, and watermelons. Four different compositions of mixed-fruits (Control = 33 g banana + 33 g pineapple + 33 g watermelon; 50B = 50 g banana + 25 g pineapple + 25 g watermelon; 50P = 50 g pineapple + 25 g banana + 25 g watermelon; 50W = 50 g watermelon + 25 g banana + 25 g pineapple) were produced. The results from the proximate analysis showed that mixed-fruit leather 50B contained higher moisture, crude protein, and crude fat compared to other samples. The highest carbohydrate content was recorded in sample 50P. Water activity of all mixed-fruits leathers were lower than 0.5. The lowest pH (4.01) and the highest total titratable acidity (0.14) were recorded in sample 50P. A 50P mixed-fruit leather possessed the highest *L** and *b** values whereas 50W had the highest *a** value. The textural properties of all samples were not significantly different. All mixed-fruit leathers were accepted by the panellist. The results obtained from the present study showed that mixed-fruit leather has the potential to be produced as a healthy snack.

Keywords: *Bananas; Fruit leather; Physicochemical; Pineapples; Sensory evaluation; Watermelons*.

1. Introduction

Fresh fruits are known to be excellent sources of energy, vitamins, minerals, and fibres. The nutritional value of fruits greatly depends on the quality and quantity of its nutritive substances. Fruits are produced in considerable quantities and consumed locally but are seldom processed [1]. Most fresh fruits have a short harvest season and are sensitive to deterioration despite being stored under refrigerated conditions, therefore making fruit leather is an effective way to preserve fruits [2]. Demands on processed fruit increase every year; the trend of consumers spending on processed fruits shows significant increases over the past five years up until 2015 [3].

Fruit leather is the dehydrated restructured fruit pulp-based products prepared by mixing of sugar, acid, and high-methoxyl pectin [4]. Fruit leather is nutritious and organoleptically acceptable to customers [5]. It is chewy and flavourful, naturally low in fat, sugar, and high in fibre and carbohydrate. It is also lightweight, easily stored and packed [6].There are large numbers of fruit leathers available in the market; such as mango, apricot fruit, grape, berry, and jackfruit leathers [5]. Che Man and Sanny [7] reported that there might be a good market for fruit leather among teenagers in Malaysia. Al-Hinai et al. [8] prepared fruit leather from dates and tamarind in order to study the effect of different hydrocolloids on texture profile analysis of the fruit leather. Nasution et al. [9] studied the effect of pectin concentration and drying conditions on physicochemical properties and sensory acceptance of roselle leather. The study of physicochemical properties of mixed fruit leather prepared from banana, pineapple, and apple had previously been conducted by Offlia-Olua and Ekwunife [1].

According to Offlia-Olua and Ekwunife [1], pineapples are low in calories and rich in vitamin C, minerals, fibre, and carbohydrate. Pavan et al. [10] reported that pineapple has a good source of bromelain, which contains many health benefits due to the presence of phytomedical properties. However, recent production of pineapple has been solely for commercial use focusing on canned pineapple, yet there are many areas of pineapple-based products that have the potential to be developed [11]. Bananas are the source of carbohydrates, fibre, and polyphenols with antioxidant capacity [12]. Odenigbo et al. [13] reported that banana is classified among low glycemic index food. Banana is a fruit with abundant minerals and functional nutrients, yet it is underutilized [14]. Hence, optimization of banana processing for bioavailability and utilization of nutrients available in this fruit should be scaled up. Watermelon belongs to the Cucurbitaceae family and is a source of multiple minerals, vitamins, and proteins that are present in the skin, pulp, and seed [15, 16]. Watermelon is traditionally used in folk medicine due to its abundance of bioactive compounds [17]. However, watermelon is often consumed fresh by consumers and seldom processed, thus development of value-added products from watermelon is desirable [18]. The objective of the present study is to determine the physicochemical properties and sensory acceptance of mixed fruit leather prepared from pineapple, banana, and watermelon.

2. Materials and methods

2.1. Materials

Materials used in this study were ripe pineapple, banana, watermelon, and sugar. All of these materials were purchased at a supermarket located in Jerteh, Terengganu, Malaysia. The fruits were selected according to the guidelines described by Sapii and Muda [19].

2.2. Preparation of mixed-fruit leather

The preparation of mixed fruit leather was divided into two stages. The first stage aimed to obtain the pulp from the fruit and the second stage was the drying process. All of the fresh fruits were washed under running water to discard dirt and unwanted materials. Next, these fruits were peeled using a knife. After that, the fruits were cut into small pieces before going through the blending process to obtain puree. For the second stage, the specific composition of fruits puree (Table 1) was well mixed. A thin layer of mixed fruits puree was spread on aluminium foil and dried in a hot-air cabinet dryer at a temperature of 60 °C for seven hours.

Table 1: Formulation of mixed-fruit leather.

	Weight of ingredients (g)			
	Banana	Pineapple	Watermelon	Sugar
Control	33.33	33.33	33.33	10
50B	50.00	25.00	25.00	10
50P	25.00	50.00	25.00	10
50W	25.00	25.00	50.00	10

Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

2.3. Proximate analyses

Proximate analyses were conducted according to the AOAC [20] method. Analyses on moisture, ash, crude fat, crude protein, and crude fibre were carried out based on oven-drying, muffle furnace, Soxhlet, Kjeldahl, and Gerhardt Fibretherm Automated Fibre methods, respectively.

2.4. Determination of total carbohydrate

The percentage of total carbohydrate in the sample was calculated by subtracting 100% with the percentage of crude protein, crude fat, ash, and moisture (Carbohydrate % = 100% - (crude protein + crude fat + ash + moisture)).

2.5. Determination of calories

The calorie content of the sample was determined by calculating the amount of crude protein, crude fat, and carbohydrate in the sample according to the multiplying factor; Calorie = (crude fat × 9) + (crude protein × 4) + (carbohydrate × 4).

2.6. Determination of pH

The pH was determined using the method as prescribed by Mamade et al. [21]. The pH was measured using a pre-calibrated pH meter (Orion 2 Star pH Benchtop, Singapore). The pH meter was calibrated using buffers at pH 4, pH 7, and pH 10. Approximately 10 g of mixed fruit leather were suspended in 10mL of distilled water and stirred for 3-4 minutes. The readings were taken in triplicate.

2.7. Determination of total soluble solid

The total soluble solid of the mixed fruit leather was determined using the method prescribed by Shakoor et al. [22]. The total soluble solid was measured using Master 2-M Refractometer. 10 g of sample were suspended in water at the ratio 1:5 (sample:water) and a few drops of the mixture were placed onto the reading crystal, then a sheet was used to assure distribution of the juice over the whole crystal. The triplicates of every sample were made to ensure better accuracy of the reading.

2.8. Determination of total titratable acidity

The total titratable acidity of the mixed fruit leather was determined by redox titration with sodium hydroxide (NaOH) using the method prescribed by Mamade et al. [21]. Approximately 100 g of sample were weighed and ground with icy-cold water using a food processor for 1 min. The solution was filtered using muslin cloth to obtain the juice. A 20 mL of the juice was then mixed with 150 mL of distilled water and 6 drops of phenolphthalein indicator were added into the juice. The juice mixture was titrated with 0.1 M of NaOH until the mixture changed to a pinkish colour. The acid content was expressed as malic acid.

2.9. Analysis of vitamin C

The determination of vitamin C of the samples was performed using the titrimetric method [23]. Approximately 100 g of the sample was weighed and ground with 100 mL of icy-cold water using a food processor (Panasonic MKF800, Selangor, Malaysia) for approximately 1 min. The solution was filtered using muslin cloth. 20 mL of the solution was mixed with 150 mL of distilled water and 1 mL of starch indicator which was also added. The mixture was titrated with iodine solution until the colour changed to blue-black. The vitamin C content was calculated according to the formula; Vitamin C = Molarity of iodine × titration volume × molecular weight of vitamin.

2.10. Measurement of water activity

Water activity of the mixed fruit leather was determined using a water activity meter (AquaLab Dew Point Water Activity Meter 4TE, USA). All measurements were performed at room temperature. The water activity meter was calibrated using distilled water before each series of test. Samples were placed into a sample cup and the reading was recorded.

2.11. Texture Profile analysis

The texture profile of the mixed fruit leather in terms of their hardness, fracturability, adhesiveness, cohesiveness, gumminess, and chewiness were determined using a Texture Analyzer (TA-XT2, United Kingdom). The probe used was spherical probe with 0.5 mm diameter. The pre-test speed was set at 1 mm/s. Test-speed and post-test speed were set at 5 mm/s.

2.12. Determination of colour

The determination of the colour of the samples was performed using Konica Minolta CR-400 Chromameter (Japan). The colour of the samples were measured according to the L^*, a^*, b^* scale. The colours that attribute lightness (L^*), redness (a^*), and yellowness (b^*) values were recorded. L^* defines the lightness (0^o = black, 100^o = white), a^* denotes the red/ green value (+ value = redness, - value = greenness), and b^* the yellow/ blue value (+ value = yellowness, - value = blueness).

2.13. Sensory evaluation

The sensory evaluation was conducted based on a 7-point hedonic scale (1 = dislike very much, 2 = dislike slightly, 3 = dislike moderately, 4 = neither like nor dislike, 5 = like moderately, 6 = like slightly, 7= like very much). Thirty semi-trained panels from UniSZA, Besut Campus were employed during the sensory evaluation. The tested attributes were colour, aroma, fracturability, chewiness, sweetness, sourness, tartness, and overall acceptability. Each sample was coded using a three-digit random number system to avoid bias. The samples were presented to the panellist in a white plate and a glass of water was provided to cleanse the palate before or during the evaluation.

2.14. Statistical analysis

The statistical analysis was conducted using SPSS. All the data were reported as mean ± standard deviation using One-Way ANOVA method. The significant differences among the samples were compared using Duncan multiple test at significance level ($p<0.05$).

3. Results and discussion

3.1. Proximate composition

Foods show extended variability in composition (mainly water, proteins, carbohydrates, fat, ash, and fibre) and structure. These compositions can turn into more complex composite materials when heated [24]. The results of proximate compositions for mixed-fruit leather are shown in Table 2. All mixed-fruit leather has the moisture content below 20%. This finding was similar to previous report on fruit leather made from papaya [25]. The moisture content for 50B fruit leather did not have a significant ($p>0.05$) difference with the control sample but differed significantly with 50P and 50W fruit leather. The highest moisture content was recorded on the 50B fruit leather (17.06%), whereas, fruit leather 50W had the lowest moisture content (14.96%). Higher moisture content in fruit leather 50B may be attributed to the higher percentage of banana in the sample. Joardder et al. [26] reported that banana has a good moisture holding capacity. High pectin (*i.e.* a soluble dietary fibre) content in banana may contribute to this finding. The higher moisture content in 50B contributed to higher water activity of 50B fruit leather compared to other samples.

Protein whose basic function is to supply adequate amounts of required amino acids for nutrition, is an essential diet component needed for survival of animals and human beings [27]. The crude protein content of mixed-fruit leather ranged from 2.51 to 3.88%. The crude protein content of mixed-fruit leather obtained from the present study was slightly higher than results reported by Effah-Manu et al. [28] where the protein content of mango-sweet potato leather and mango leather were 2.30 and 2.25% respectively. Different types of fruits used for fruit leather may lead to variation in protein content. There was no significant difference for crude protein content between mixed-fruit leather 50P and the control. The variations of protein content in mixed-fruit leather samples could be attributed to the different percentage of fruits used, where there are variable nitrogen containing compounds in the fruits [1]. Fruit leather 50B has the highest protein percentage compared to others. Higher percentage of banana in fruit leather 50B may contribute to the higher protein content in fruit leather 50B compared to other samples. This is in agreement with a study conducted by Ekpete et al. [29] where banana has higher protein content compared to pineapple and watermelon.

Table 2: Proximate composition of mixed-fruit leather.

Composition (%)	Control	50B	50P	50W
Moisture	$16.78±0.67^{b}$	$17.06±0.92^{b}$	$14.96±0.15^{a}$	$15.36±0.16^{a}$
Ash	$1.16±0.14^{a}$	$1.49±0.22^{ab}$	$1.39±0.35^{ab}$	$1.55±0.23^{b}$
Crude protein	$2.51±0.03^{a}$	$3.88±0.18^{c}$	$2.61±0.08^{a}$	$2.86±0.11^{b}$
Crude fat	$0.32±0.12^{a}$	$0.72±0.12^{b}$	$0.32±0.18^{a}$	$0.33±0.17^{a}$
Crude fibre	$1.40±0.08^{a}$	$1.45±0.30^{ab}$	$1.73±0.03^{b}$	$1.57±0.05^{ab}$
Total carbohydrate	$79.06±0.34^{b}$	$76.84±1.31^{a}$	$80.72±0.42^{c}$	$79.89±0.19^{bc}$
Calories (kcal)	$329.09±1.38^{a}$	$327.67±5.93^{a}$	$333.72±4.79^{a}$	$333.87±1.35^{a}$

Means in the same row with different superscript are significantly ($p<0.05$) different

Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

The proximate results indicated that all mixed-fruit leather samples contained a crude fat value below 1%. The result also indicated that 50B had the highest crude fat content and most significant difference from other samples. According to Ekpete et al. [29], banana contains the highest amount of fat as compared to watermelon and pineapple. Thus, the high percentage of banana in 50B fruit leather may have contributed to the highest fat content in that sample compared to other samples. The results from proximate analysis recorded that the fibre content of 50P fruit leather was significantly different from the control. In a previous study on the composition of crude fibre by Gopalan et al. [30] revealed that pineapple has slightly higher crude fibre compared to banana and watermelon.

Carbohydrate was the highest constituent in all samples (Table 2). An addition of 10% of sugar during the preparation of fruit leather may have contributed to this finding. Carbohydrate composition of 50B fruit leather was the lowest among the sample and was significantly different from other samples. The result was in agreement with a previous study by Offlia-Olua and Ekwunife [1] who reported that fruit leather samples containing the highest amount of banana has the lowest carbohydrate value. However, a study by Ekpete et al. [29] on proximate composition of fresh fruits showed that banana contained the highest amount of carbohydrate followed by pineapple and watermelon. Higher moisture content, crude protein content, and crude fat content in fruit leather 50B may reduce the percentage of carbohydrate in the sample. The calorie values of mixed-fruit leather ranged from 333.87 to 327.67 kcal. There was no significant difference in the calorie content of mixed-fruit leather. Therefore, it can be concluded that the calorie content of mixed-fruit leather was not affected by the percentage of fruits used.

3.2. Biochemical composition and vitamin C content

Results for biochemical analyses and vitamin C were recorded in Table 3. Based on the statistical analysis conducted, there was a significant difference ($p<0.05$) in the water activity of 50B and 50W fruit leather. Higher moisture content in 50B resulted in higher water activity of 50B leather. This finding was similar to Huang and Hsieh [31] on pear fruit leather. This result indicated that higher moisture content increased the water activity of fruit leather. For dried products such as fruit leather, water activity is important since at low-levels of water activity, most of the chemical and biological reactions; including microbiological growth can be inhibited [32]. The minimum water activity required for microbial growth is 0.6 [33]. The water activity of fruit leather samples ranged from 0.46 to 0.48. At this level of water activity, most microbial growth, especially bacterial are inhibited except for some Europhilic moulds and Osmophilic yeast [34]. This suggested that all samples of the mixed-fruit leather produced could not allow bacterial growth but may have mould or yeast growth (minimum water activity 0.61) with the increase of storage time. However, the spoilage of the leathers could be mostly caused by the action of Europhilic moulds and Osmophilic yeast [35].

Results obtained from the pH analysis showed that there was a significant difference among mixed-fruit leathers except for sample 50W and 50B. Fruit leather 50P showed the lowest pH reading. The result implicated that pineapple lowered the pH of the mixed-fruit leather. A study conducted by Offlia-Olua and Ekwunife [1] on mixed-fruit leather prepared from pineapple, apple, and banana showed that samples containing 40% pineapple had the lowest pH value compared to other samples. All of the samples had pH values lower than 5, and this indicated that the fruit leathers fell into the category of slightly acidic food (pH≤4.6). Total titratable acidity (TTA) of mixed fruit leather ranged from 0.09 to 0.14. Higher TTA value was recorded in the 50P sample. This was in accordance with the lower pH value of the 50P sample compared to other samples.

Table 3: Water activity, pH, total titratable acidity, total soluble solid, and vitamin C of mixed-fruit leather.

Parameter	Control	50B	50P	50W
Water activity	0.47±.01^{ab}	0.48±0.01^{b}	0.46±0.01^{ab}	0.46±0.01^{a}
pH	4.21±0.02^{b}	4.34±0.04^{c}	4.01±0.00^{a}	4.32±0.01^{c}
Total titratable acidity (%)	0.11±0.01^{ab}	0.09±0.01^{a}	0.14±0.03^{b}	0.09±0.01^{a}
Total soluble solid (^{0}Brix)	41.00±.80^{a}	41.70±.44^{a}	41.03±0.15^{a}	40.73±0.64^{a}
Vitamin C (mg/100g)	14.97±0.89^{a}	16.73±0.88^{a}	16.73±4.57^{a}	18.49±1.52^{a}

Means in the same row with different superscript are significantly (p<0.05) different
Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

Statistical results of total soluble solid in mixed-fruit leather showed that all samples were not significantly different (40.73-41.70 ^{0}Brix). This showed that total soluble solid of mixed-fruit leather was not affected by the different percentages of fruits used in preparing the fruit leather. In a study conducted by Nasution et al. [9] on mango-sweet potato leather, the total soluble solid obtained was 18.2 ^{o}Brix. Another study conducted by Karki [36] on blueberry leather with added pectin and honey obtained overall total soluble solid range from 85.3 to 89.3 ^{o}Brix. Rahman [37] reported that the total soluble solid of tamarind leather ranged between 5.19 to 8.03 ^{o}Brix. The variation of total soluble solid content in fruit leather was affected by the types of fruits used in making the leather and ingredients added in the preparation of the mixed fruit leather.

There was no significant difference recorded in the vitamin C content of mixed-fruit leather. The vitamin C in the control, 50B, 50P, and 50W were 14.97, 16.73, 16.73, and 18.49 mg/100 g, respectively. The result indicated that the level of vitamin C in mixed-fruit leather was lower than the vitamin C contained in fresh fruit. The loss of vitamin C content was mostly due to oxidation and hydrolysis that took place during drying. In addition, losses in vitamin C may also be contributed by storage and handling as well as preparation steps of leather processing [38, 39]. According to Muhammad et al. [40] vitamin C losses will increase with increasing storage time.

3.3. Colour properties

Chromaticity (*L**, *a**, and *b**) values of mixed-fruit leather are shown in Table 4. The results showed that the lightness value of mixed-fruit leather 50P was significantly higher than the other samples due to the high amount of pineapple in 50P fruit leather. Among the samples, 50P fruit leather had the lowest moisture content. According to Hartel and Hartel [41], at very low moisture content, fruit leather may reach glassy state, which is similar to hard candy. Therefore, lightness value is increased when sample is more glassy and transparent.

Table 4: Colour properties of mixed-fruit leather.

Parameter	Control	50B	50P	50W
*L**	29.38±0.72^{a}	31.18±0.75^{b}	34.42±0.36^{c}	30.56±0.58^{b}
*a**	9.62±0.92^{b}	7.24±0.34^{a}	10.93±0.70^{c}	14.15±0.42^{d}
*b**	9.93±0.60^{a}	9.20±0.11^{a}	12.39±0.51^{c}	11.24±0.43^{b}

Means in the same row with different superscript are significantly (p<0.05) different
Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

The *a** value of all samples was significantly different from each other. Table 4 shows that sample with highest amount of watermelon (50W) has the highest *a** values (redness). The presence of red pigment (carotenoid) in watermelons may contribute to this finding. Zhao et al. [42] reported that carotenoids are responsible for the different flesh colours in watermelon fruit, where in red flesh watermelon, lycopene constitutes the major pigment and β-carotene constitutes the secondary pigment. Therefore based on this result, fruit leather 50W is assumed to contain higher amount of lycopene compared to other samples. It could be observed from Table 4 that fruit leather 50P possessed the highest *b** values (yellowness) and was significantly different from other samples. According to Yano et al. [43], pineapple contains a substantial amount of ß-carotene (yellow-coloured pigment). Therefore, the high yellowness value for 50P fruit leather may be contributed to the higher percentage of pineapple in that sample as compared to other samples. The result from *L***a***b** analysis indicated that the percentage of fruit used in preparing mixed-fruit leather gave a significant effect to the colour of the end product.

3.4. Texture profile

The results of hardness, fracturability, adhesiveness, cohesiveness, gumminess, and chewiness of mixed-fruit leather are presented in Table 5. Hardness is defined as the force needed to attain a given formation, adhesiveness as the work needed to overcome the attractive force between food and plate surface, fracturability as the force of food fracture, and cohesiveness as the internal integrity of the sample [44]. Rahman and Al-Mahrouqi [44] also defined gumminess as the multiplication of hardness and cohesiveness; while chewiness is the multiplication of gumminess and cohesiveness.

Table 5: Texture profile of mixed-fruit leather.

Parameter	Control	50B	50P	50W
Hardness (g)	5.65±0.18^{b}	4.88±0.07^{a}	5.09±0.24^{a}	6.21±0.18^{c}
Fracturability (g)	5.42±0.51^{a}	6.02±0.58^{a}	5.44±1.01^{a}	5.91±0.16^{a}
Adhesiveness (g.sec)	-52.43±16.38^{a}	-65.3±20.25^{a}	-46.87±24.76^{a}	-37.14±1.86^{a}
Cohesiveness	0.13±0.02^{a}	0.15±0.03^{a}	0.15±0.04^{a}	0.13±0.01^{a}
Gumminess	0.78±0.08^{a}	0.75±0.14^{a}	0.89±0.36^{a}	0.80±0.10^{a}
Chewiness	0.50±0.07^{a}	0.52±0.10^{a}	0.72±0.43^{a}	0.50±0.04^{a}

Means in the same row with different superscript are significantly (p<0.05) different
Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

Although the percentages of fruit used had given a significant effect to the hardness of the fruit leather, there was no significant effect found between percentages of fruit used on the fracturability, adhesiveness, cohesiveness, gumminess, and chewiness properties of mixed-fruit leather. Fruit leather 50B possessed the lowest hardness (4.88 g) value and was significantly different from fruit leather 50W (6.21) and the control sample (5.65). Vijayanand et al. [45] reported that hardness of mango and guava leathers decreased with the increase of moisture content. In addition, watermelon has higher fructose content when compared to banana and pineapple

[46]. Therefore, 50W fruit leather is assumed to contain higher amounts of fructose due to the higher percentage of watermelon present in that formulation. According to Perera [32], sugar is subjected to crystallization during the drying process. The crystallization of sugar may contribute to higher hardness value in 50W fruit leather.
Several authors have reported that high moisture content of fruit leather (*i.e.* jackfruit and pear) might increase its cohesiveness value [31, 47]. However, the results obtained from the present study showed that the difference in moisture content of fruit leather did not give a significant effect on the cohesiveness of fruit leather. In addition, Huang and Hsieh [31] also reported that higher amounts of pectin contributes to the higher value of chewiness. In another study, Nasution et al. [9] mentioned that the addition of pectin also increases adhesiveness of roselle fruit leather. Based on the results obtained from instrumental texture profile analysis, different compositions of fruits (*i.e.* banana, pineapple, and watermelon) used in preparing mixed-fruit leather did not significantly affect the textural properties (fracturability, adhesiveness, cohesiveness, gumminess, chewiness) of the end product.

3.5. Sensory evaluation

Results from sensory evaluation are presented in Table 6. Colour is one of the quality parameters of fruit leather because of its aesthetic appeal to the customer. From the statistical analysis conducted, fruit leather 50W received the best score and was moderately liked by the sensory panellists. Based on the $L^*a^*b^*$ result, fruit leather 50W had the highest value of a^*. This was attributed to the reddish colour of the sample which contained a high composition of watermelon. This can be assumed that the panellists preferred the red colour of the mixed-fruit leather. The aroma of food is an essential component of sensory evaluation. Generally, aroma of the mixed-fruit leather is slightly liked (5.53-5.90) by the panellist and was not significantly different from each other.
Fracturability and chewiness were used in this sensory test to describe the hardness of the mixed-fruit leather. The fracturability of mixed-fruit leather was not significantly different from each other (Table 6). This result was in agreement with the results obtained from instrumental texture profile analysis of mixed-fruit leather which recorded that the fracturability of mixed-fruit leather also did not differ significantly among the samples (Table 5). Although the chewiness value obtained from instrumental texture profile analysis showed insignificant difference, the result of sensory evaluation showed that the chewiness of fruit leather sample, and the control had received a lower score (5.20) than the other samples (5.87-5.90).

Table 6: Sensory evaluation of mixed-fruit leather.

Parameter	Control	50B	50P	50W
Colour	5.17±1.34^a	5.23±1.33^a	5.47±1.04^a	6.27±0.91^b
Aroma	5.57±0.82^a	5.57±1.10^a	5.53±1.04^a	5.90±1.00^a
Fracturability	5.53±1.14^a	5.57±0.94^a	5.73±0.94^a	5.70±0.92^a
Chewiness	5.20±1.10^a	5.87±1.04^b	5.90±0.96^b	5.87±0.86^b
Sweetness	5.57±0.97^a	5.53±0.90^a	6.10±0.80^b	5.70±1.15^{ab}
Sourness	5.47±0.94^a	5.40±0.97^a	5.97±0.62^b	5.27±1.08^a
Tartness	5.67±0.96^{ab}	5.27±1.23^a	5.87±1.04^b	5.80±0.85^{ab}
Overall acceptability	5.90±0.76^a	5.53±1.01^a	5.93±0.87^a	5.97±0.93^a

Means in the same row with different superscript are significantly ($p<0.05$) different
Control: 33 g banana + 33 g pineapple + 33 g watermelon; 50B: 50 g banana + 25 g pineapple + 25 g watermelon; 50P: 50 g pineapple + 25 g banana + 25 g watermelon; 50W: 50 g watermelon + 25 g banana + 25 g pineapple

Three parameters which are sweetness, sourness, and tartness were used in this sensory test to describe the taste of the fruit leather. The sweetness of the mixed-fruit leather is mainly influenced by the percentage of sugar added and sugar that is naturally present in the fruit. Based on the results obtained from the sensory evaluation, the fruit leather 50P received the highest score for sweetness and was significantly different from 50B and control samples. The percentage of acid in fruits may affect the sourness and tartness of mixed-fruit leather. As referred to the Table 6, fruit leather 50P received the highest score for both sourness and tartness. From this sensory evaluation, a higher percentage of pineapple added in preparing mixed-fruit leather is assumed to increase the acceptance of the panellists towards the taste of the fruit leather. As shown in Table 3, the pH of mixed-fruit leather 50P was the lowest (4.01) and total titratable acidity of 50P was the highest (0.14). Based on the pH and total titratable acidity of mixed-fruit leather 50P, the panellists were assumed to prefer the sour taste of the mixed-fruit leather. The overall acceptability for mixed-fruit leather was not significantly different among the four samples. All formulations were acceptable as they received scores higher than 4, ranging from 5.53 to 5.97. This indicated that all mixed-fruit leather samples were well accepted by the most of the panellists.

4. Conclusion

Transforming fresh fruits into leather is an alternative method to preserve perishable fruit commodity. All mixed-fruit leather samples made from banana, pineapple, and watermelon had low water activity ($aw<0.6$) and moisture content less than 20%. This level indicated that the mixed-fruit leather should be microbiologically stable. The mixed-fruit leather can be classified as an acidic food due to the pH value ranges from 4.01 to 4.34. The acidic condition of mixed-fruit leather is expected to prolong the shelf life of the leather. Based on proximate composition results, all mixed fruit leathers are mainly composed of carbohydrates. Only a small percentage of fat was recorded in all samples. Overall acceptability of sensory panellists towards mixed-fruit leather showed no significant difference (score>5.0). Based on the panellists' acceptability, the mixed-fruit leather may have potential to be commercialized. However, further studies on storage stability of mixed-fruit leather are needed.

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