PAPER

EVALUATION OF FRUIT LEATHER MADE FROM TWO CULTIVARS OF PAPAYA

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ABSTRACT

Two papaya cultivars were used to manufacture fruit leather. The objective of this study was to formulate papaya leather from locally grown papaya using natural ingredients like pectin, honey and citric acid. The fresh fruits were pureed and mix with natural ingredients, and dried in an oven at 60°C for 12 hours. The physicochemical properties and antioxidant activity were determined. The results showed that fruit leather made from Hongkong cultivar is significantly ($P<0.05$) higher in sensory parameters as well as physicochemical properties and antioxidant activity. The phenolics content and antioxidant activity increased by process of drying the fruit leather compared to fresh fruits in both papaya cultivars. Therefore, the consumer requirements for healthy and safe food products were respected.

- Keywords: fruit leather, antioxidant activity, phenolic content, sensory evaluation -

INTRODUCTION

Like numerous fruits and vegetables, papaya is a rich source of antioxidants. Antioxidants have a neutralising effect on free radicals, which are unstable molecules that can trigger a range of diseases, including cancers, cardiovascular and neurodegenerative diseases (PRIOR *et al.*, 1998). Naturally occurring antioxidants have been examined by (PRAKASH, 2010), who discerned that disease risk is reduced by such antioxidants as vitamin C, vitamin E, carotene, phenolic acids, phytate and phytoestrogens. Similarly, epidemiological research has emphasised the important role of antioxidants derived from fruits and vegetables in preventing degenerative processes (AMES *et al.*, 1993). Papaya fruit can be eaten fresh or as part of different processed foods, including baked products, beverages, cereals, confectionery, dairy snacks and sauces (USHBC, 2010). The demand for papaya as dried fruit is also high, alongside sultanas, peaches and apricots (LOHACHOOMPOL, 2007). Healthy products with dried papaya include breakfast cereals, energy bars and fruit snacks. In addition, there is a range of other papaya-based products, such as jam, jelly, papaya toffee, papaya bar, papaya squash, papaya soft drinks, papaya pulp powder, and others SWAMY and PREMNATH (2010). Fresh papaya is a seasonal fruit with a shelf life between one and two weeks. To respond to consumer demand, with fresh substitute is necessary to ensure year-round availability and drying is the most commonly used preservation method. As explained by (TESHOME, 2010), the drying process entails eliminating as much water as possible from the fresh fruit in order to inhibit enzyme and bacterial activity, thus halting decomposition. There are various types of drying processes, including sun drying, oven drying, cabinet drying, dehydrator drying and freeze drying. Based on food type, from 2 to 30% of water is left in the dried foods. In addition to prolonging product shelf life, water content reduction ensures that the product is stable from a microbiological perspective and minimises deteriorating chemical reactions. Fruit leathers are referred to the dried sheets of fruit pulp that taste sweet and have a soft, rubbery texture. Their production involves the dehydration of fruit puree to a leathery sheet (RAAB and OEHLER, 1999). In this regard, the study had two goals: (a) to use locally grown papaya to make fruit leathers based by using on natural ingredients like pectin, honey and citric acid, as well as to determine the cultivar most suitable for the production of papaya fruit leather; (b) to analyse the extent to which the drying process affects fresh and processed papaya in terms of antioxidant content, physic-chemical properties and sensory evaluation.

Ripe Papaya
↓
Washing
↓
Pulping
↓
Addition of honey + citric acid + pectin
↓
Mixing
↓
Cooking
↓
Spreading on trays
↓
Drying
↓
Cutting into slabs
↓
Packing
↓
Labeling

A process flow chart of papaya leather production.

MATERIALS AND METHODS

Samples collection and preparation

Papaya (*Carica papaya* L. cv. Hongkong and Eksotika) fruits at the mature stage of ripening were collected from Pusat Flora Cheras, Jabatan Pertanian, and Hulu Langat Semenyih in Selangor, Malaysia. The fruits were selected to ensure uniformity in size (800 g to 1000 g) and color as well as to ensure freedom from diseases and infection. The selected fruits were transferred on the same day to the University Kebangsaan Malaysia food laboratory, Bangi. The other three major ingredients used in the trials were honey (Polleney honey, Chaina), pectin (Germany) and citric acid (USA).

Procedure for making papaya fruit leather

For each cultivar, frozen papaya cultivars were thawed at 4^{0}C overnight in the fridge. Six hundred grams of thawed papaya cultivars were weighed. Honey 10% (v/v), 2% (v/v) of citric acid and % 6 (v/v) of pectin were weighed and mixed with papaya fruits. A Cascade blender model CE071BR (Japan) was used to mix all these ingredients for 2 minutes to make a puree. Cooking oil was lightly sprayed over trays made of stainless steel before 200 g of puree was spread uniformly over the trays with a metal spreader. The drying of the leather was done in the middle section of the cabinet dryer, which had been preheated to 60° ± 2°C. Throughout the drying interval, the dryness of the leather was closely monitored. Two batches were made for every cultivar each of them has three trays. The trays were dried for 12 hours for both papaya cultivars.

Physiochemical properties of papaya fruits

Moisture content was measured by drying sample at 105°C overnight in Memmert Oven (Germany). Titratable acidity (TA) was determined from 10 ml of sample diluted with 50 mL of water, titrated with 0.1 N NaOH and calculated as percent citric acid. Total soluble solids (TSS) were measured with an abbe refractometer at 20°C and pH was determined using pH meter using juice extracted directly from pulp.

Humidity content

The moisture content was determined by drying samples of approximately 1 g at 105°C in an forced air oven (Watson Victor Ltd, NZ) for 24 hours. The textural of papaya leather were conducted with a Stable Micro System TA-EZtest/AGS-H- Japan).

Texture analyzer

The procedures for operating the texture analyzer were stated in the Standard Operating Procedure (SOP). The following parameters were determined: hardness (g/f). The pulp color was longitudinally determined on four points of each flat side of the fruit using a Minolta CR-300 colorimeter. The (L*) value represented the luminosity of the fruit, where 0 = black and 100 = white but the (a*) value ranged from the negative (green) to the positive (red) scale and the (b*) value ranged from negative (blue) to positive (yellow), (AOAC 1998).

Antioxidants extraction

Papaya were peeled, cut into 1 cm slices and crushed in a food processor to produce uniform slurries. The mixture was prepared fresh to preserve the extracted antioxidant compounds. In the extraction process, about 1 g of papaya slurries were weighed in universal bottles and 10 ml solvent was added. Solvents used were 50% aqueous methanol; samples (papaya slurries with solvents) were then homogenized using homogenizer (T 250, IKA, Germany) at 24,000 rpm for 1 min. All extracted samples were centrifuged by using tabletop centrifuge (MLX 210, Thermo-line, China) at 4750 *g* for 10 min. The supernatants were collected for further analysis.

Total phenol content (TPC)

Antioxidant activity was determined using TPC based on the method of (MUSA *et al.* 2011). Approximately 0.4 mL distilled water and 0.5 mL diluted Folin-Ciocalteu reagent were added to 100 μL papaya extracts. The samples (papaya extracts with Folin-Ciocalteu reagent) were set aside for 5 min before 1 mL 7.5% sodium carbonate (w/v) was added. The absorbances were taken at 765 nm wave length using a spectrophotometer after 2 h. The calibration curve of gallic acid (GA) was used for the estimation of sample activity capacity. The result was recorded in terms of mg of GA equivalents per 100 g of fresh sample (mg GA/100 g of FW).

Total flavonoid content (TFC)

The TF content was determined by the colorimetric method as described by (ABU BAKAR *et al.*, 2009). A total 0.5 mL of the extract was mixed with 2.25 mL of distilled water in a test tube, followed by the addition of 0.15 mL of 5% (w/v) $NaNO_2$ solution. After 6 min, 0.3 ml of a 10% $AlCl_3 \cdot 6H_2O$ solution was added, and the reaction was allowed to stand for another 5 min before 1.0 ml of 1 M NaOH was added. The mixture was mixed well by vortexing, and the absorbance was measured immediately at 510 nm using a spectrophotometer (Epoch, Biotek, USA). The results were expressed as milligrams of quercetin equivalents (QE) per 100 g of fresh sample (mg QE/100 g of FW).

Ferric reducing antioxidant power (FRAP)

First, 300 mM acetate buffer FRAP reagent was prepared fresh as follows: pH 3.6 (3.1 g sodium acetate trihydrate plus 16 mL glacial acid made up to 1:1 with distilled water); 10 mM 2,4,6-tris (2-pyridyl)-*s*-triazine (TPTZ) in 40 mM HCl; and 20 mM FeCl3·6H2O in the ratio of 10:1:1 to provide the working reagent. In addition, approximately 1 mL FRAP reagent was added to 100 μL papaya extracts, and the absorbances were taken at 595 nm wavelength using a spectrophotometer after 30 min. The calibration curve of Trolox was established to approximate sample activity capacity. The result was recorded as mg of Trolox equivalents (TEs) per 100 g of fresh sample mg (TE/100 g of FW) (MUSA *et al.*, 2011).

DPPH Radical scavenging activity

Based on the method of (Musa *et al.* 2011) the antioxidant activity was assessed using a 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging system. The stock solution was obtained by dissolving 40 mg DPPH in 100 mL methanol, which was stored at -20°C until further use. Approximately 350 mL stock solution was mixed with 350 mL methanol to obtain the absorbance of 0.70±0.01 unit at 516 nm wavelength by using a spectrophotometer (Epoch, Biotek, USA). In the dark, approximately 100 μL papaya extracts with 1 mL prepared methanolic DPPH solution was stored overnight for scavenging reaction. The percentage of DPPH scavenging activity was determined based on the following equation:

$$\text{DPPH scavenging activity (\%)} = [(A_{blank} - A_{sample}) / A_{blank}] \times 100,$$

where A is the absorbance.

ABTS assay

The ABTS radical cation (2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) was generated by the interaction of ABTS (250 μM) and $K_2S_2O_8$ (40 μM). After the addition of 990 μL of ABTS solution to 10 ml of fruit extract, the absorbance at 734 nm was monitored. The percentage decrease of the absorbance was calculated and plotted as a function of the concentration of the extracts and Trolox for the standard reference data (Özgen *et al.* 2006). The following formula was used:

$$\text{Percentage (\%) of reduction power} = [(A_{blank} - A_{sample}) / A_{blank}] \times 100,$$

where A is the absorbance.

Oxygen radical absorbance capacity (ORAC)

The ORAC assay was conducted according to (HUANG *et al.*, 2002). The ORAC assay was carried out on a fluorescence microplate reader (FLUOstar Omega, BMG LABTECH, Multi-Detection Microplate Reader, Germany). Peroxyl radicals were generated by AAPH, and fluorescence microplate reader was used at an excitation wavelength of 485 nm and an emission wavelength of 525 nm. Trolox was used as standard (50, 25, 12.5, 6.25, 3.12 mM). Proper dilutions of papaya extracts were made with ORAC buffer (potassium phosphate buffer, pH 7.4). For each ORAC run, a micro plate was prepared containing 25uμ of Trolox standards, buffer control, and sample dilutions, as well as 150ul of fluorescein (FL) solution. All ORAC analyses were performed at 37°C with a 20 min incubation and 60 min run time. After the incubation, 25ul of AAPH was added to each well for a final volume of 200 uL. The results were calculated using the differences of areas under the FL decay curves between the blank and a sample and were expressed as micromole Trolox Equivalents per gram of sample (μmol TE/g).

Sensory evaluation

A consumer acceptability sensory trial was conducted at University Kebangsaan Malaysia in the sensory evaluation laboratory. Panellists comprised 30 volunteers who were staff or students at the University. Each panellist was asked to taste two samples, one from both cultivar (2 x 2 cm square). Attributes selected for the papaya fruit leather were colour, sweetness, sourness, flavour, texture and overall appearance. In this study, the hedonic scale was implemented; on a scale of 1 to 7 there were tabulations of scores, where 1 indicates “extremely dislike” and 7 represents “extremely like” (AMINAH, 2004). For reliability purposes, distilled water was given to the panelists for them to rinse the mouths between evaluations.

Statistical analysis

Data were expressed as the means values ± standard deviation. Mean of minimum three measurements were compared by analysis of variance (ANOVA). Significant differences between means were determined by Duncan ($P<0.05$). Correlation analysis was performed using Pearson’s. The software used was SPSS ver.19. (BRYMAN and CRAMER, 2012).

RESULTS AND DISCUSSION

Physicochemical properties of papaya

The pH, titratable acidity and TSS for the two papaya cultivars are shown in Table 1. The cultivars exhibited considerable differences in terms of pH ($P<0.05$). The Hongkong cultivar had a higher level of pH (5.47), while the Eksotika cultivar had a lower pH (5.34). In comparison to fresh fruit, drying caused a substantial decline in the pH of all fruit leathers ($P<0.05$). Furthermore, there were significant discrepancies between the average pH of the Hongkong cultivar (3.93) and that of the Eksotika cultivar (3.82). Likewise, (HARSIMRAT, 1998) demonstrated that acidity has a positive effect on shelf life. By contrast, (BABALOLA *et al.*, 2002) found that papaya leather stored in a cool environment for 30 days had a higher pH compared to other samples. Similar findings were obtained in the case of pineapple leather (PHIMPHARIAN *et al.* 2011), mango leather (AZEREDO *et al.*, 2006) papaya and guava leathers (BABALOLA *et al.*, 2006). The present study revealed that the titratable acidity differed substantially between the cul-

Table 1 - Effect of processing on pH, TA and TSS of two papaya cultivars. Result showed mean ± standard deviation.

Cultivars	pH		TA		TSS	
	Fresh	Leather	Fresh	Leather	Fresh	Leather
Hongkong	5.47±0.02[a]	3.93±0.01[b]	0.15±0.01[b]	1.63±0.02[a]	11.74±0.52[b]	68.50±0.57[a]
Eksotika	5.34±0.03[a]	3.82±0.01[b]	0.17±0.02[b]	1.48±0.03[a]	12.46±0.14[b]	70.50±0.60[a]

[a-b] Mean with different letters within each raw are significantly different (P< 0.05).

tivars of both fresh and dried papaya. Hongkong and Eksotika had the highest average total acid content in fresh fruit, with 0.15% and 0.17%, respectively, of citric acid (reference). In the case of all fruit leathers, drying determines a considerable increase in the titratable acidity. As shown in Table 1, the highest acidity among fruit leathers was shown by the cultivar Hongkong (1.63%), while the lowest was exhibited by Eksotika (1.48%). In keeping with BEAUDRY *et al.* (1992), the results of this study indicated that the titratable acidity (TA) of fresh papaya is between 0.3 ± 0.1 to 0.7 ± 0.1% of citric acid equivalent. The addition of 4% of citric acid to the fruit leather puree increased the TA of the two papaya leather cultivars. In addition, drying contributes to concentration in the fruit's natural acidity, leading to a significant increase in the acidity of the fruit leather. Among all cultivars, Eksotika displayed the highest levels of titratable acid (0.17%). However, after drying, TA was highest in leathers with concentrations between 1.48 and 1.63 %. The high levels of acidity in fruit leather not only inhibit bacterial growth, but also protect the colour and flavour of the fruit. Hence, in terms of processing or manufacturing, papaya cultivars with high acidity should be used. This study also found that Hongkong cultivars is most appropriate for fruit leather production. VAIDYA *et al.*, (2007) reported the acidity of fruit leather made from kiwifruit which was found to be 3.8% but the reason for the high acidity was not discussed. Vega Galvez *et al.* (2009) reported an acidity of 2.2 ± 0.12% (monohydrated citric acid), pH of 2.7 ± 0.09, and soluble solids of 15.0 ± 0.07 °Brix in dried O'Neil blueberries. The two cultivars also differed greatly with regard to TSS (P<0.05). The TSS of Hongkong cultivar fresh fruit was 11.74 while Eksotika fruit cultivar was 12.46. Although there is a substantial increase in the °Brix of all fruit leathers after drying, with a TSS of 68.50 and 70.50 respectively for both papaya cultivars (Hongkong and Eksotika). The two cultivars did not display noticeable discrepancies. All processed papaya leathers had higher TSS than fresh fruit. The higher levels of °Brix in fruit leathers compared to fresh fruit, particularly sweet fruit, had already been noted in earlier research. For example, the addition of ingredients, such as pectin, glucose, syrup, and sugar, to raw pineapple puree increased the TSS of the latter between 66.4 and 75.3 °Brix. The pineapple fruit leather had a final TSS of between 82.4 and 86.9 after drying (PHIMPHARIAN *et al.*, 2011). In the case of kiwi fruit, (VAIDYA *et al.*, 2007) observed that the addition of 15% sugar increased its °Brix, which became even higher (68 °Brix) after the fruit was dried in a cabinet drier for 15 hours at a temperature of 45° ± 2° C. The present study used honey as an added sweetener. In this research, creamed honey (83 °Brix) was added as a sweetener. The °Brix found in creamed honey was similar to that found by ANUPAMA *et al.* (2003). The °Brix of blueberry fruit leathers increased due to the addition of 15% of honey. The high °Brix of blended papaya leather was explained by (KUMAR *et al.*, 2008) in terms of a high carbohydrate content, making it a good energy source.

Humidity content of fresh fruit

As illustrated in Fig. 1, the moisture content of two papaya leathers were 14.31% and 15.42%, (Hongkong and Eksotika) respectively. The fruit leathers from different cultivars exhibited discrepancies with respect to moisture content levels (P<0.05). In this study, given the relative reduced moisture content (22%-24%), all cultivar leathers can be classified as concentrated or intermediate moisture foods. Although the product thickness may be one of the reasons for high moisture content in this product. Nevertheless, the final product thickness was decreased from 4 mm to 1 mm. Based on their research on hot air drying of grape leather, MASKAN *et al.* (2002) argued that drying of the product surface occurs rapidly at high temperatures, particularly in the case of thinner samples. The moisture content of jackfruit leather, papaya leather and blended papaya leather was determined to be 11-17% (CHE MAN *et al.*, 1992), 12-13% (CHAN and CAVALETTO, 1978) and 20.80% (KUMAR *et al.*, 2008), respectively. However, IRWANDI *et al.* (1998) emphasized that, despite suppressing bacterial development and extending shelf life, a low moisture content of fruit leathers may have an adverse effect on texture quality. HUANG and HSEIH (2005) found that increasing the pectin concentration (from 1 to 1.5%) affected the hardness of the sample and decreased moisture content and aw of pineapple fruit leathers had an a_w value of < 0.55. Similarly, PHIMPHARIAN *et*

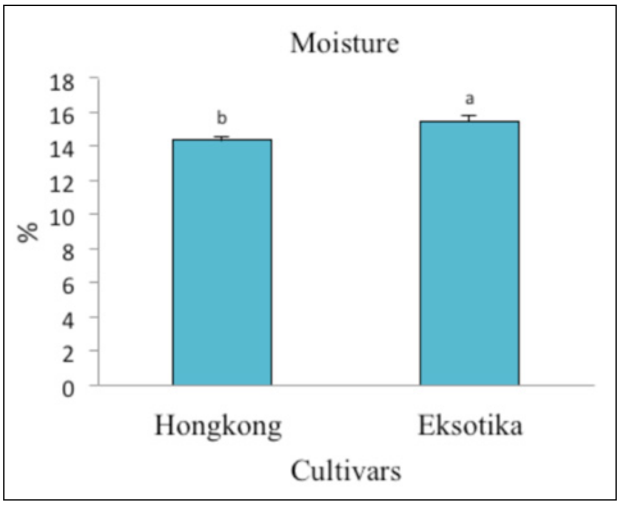

Fig. 1 - Effect of processing on moisture of two papaya cultivars.
[a-b] Mean with different letters are significantly different (P < 0.05).

al. (2011) reported that both moisture content and water activity were influenced by the pectin concentration. What is more, the pectin concentration also affected aw on pear fruit leather.

Texture of papaya leather

The papaya leather cultivars in Hongkong and Eksotika had a range texture (Fig. 2) of 490.48 - 483.60 respectively. A possible cause for the high texture was the pectin, which generated a firm gel structure followed by a tough texture. The high texture due to the 6% pectin concentration used in this study was combined with the reduced moisture content of the papaya leather. Reduced moisture content and harder texture are the outcome of higher temperatures and extended drying periods (CHE MAN, 1995) and (OKILYA *et al.*, 2010). A comparison was difficult to achieve due not only to the different genetic structure of this fruit (BABALOLA *et al.*, 2002), but also to extra ingredients that influenced the texture quality. GUJRAL and KHANNA (2002) found that

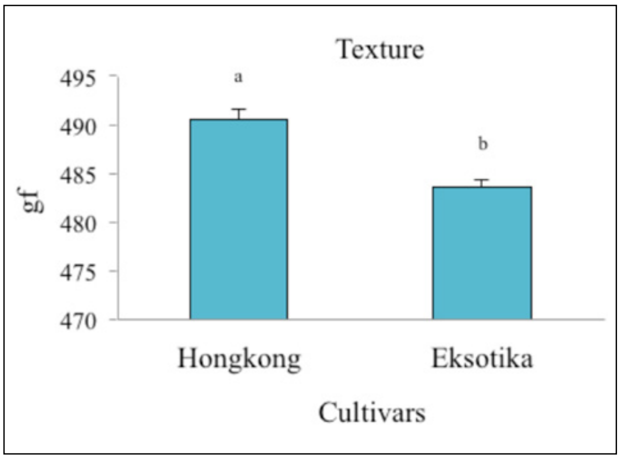

Fig. 2 - Effect of processing on texture of two papaya cultivars.
a-b Mean with different letters are significantly different (P < 0.05).

the tensile force in the mango leather was reduced by increased levels of sucrose (ranging from 4.5% to 9%). The texture decreased even more when skim milk powder was added, in comparison to soy protein concentrate. In this study, it is probable that the texture or extensibility of papaya leathers was affected by the pectin, honey and citric acid that were added. HUANG and HSIEH (2005) obtained a hardness value for pear fruit leathers of between 4420 and 13200 g (18 formulations with various water, pectin and corn syrup ratios). There were also differences in terms of ingredients, while the texture of the leathers may have been influenced by water absorption and the protein content of the fruit (BABALOLA *et al.*, 2002). By contrast to the results of HUANG and HSIEH (2005), the values obtained in this study were considerably lower.

Colour measurements

The final fruit leather product (Table 2) was lighter in colour (L* mean value of 32.10 and 30.70) less than the fresh fruit (L* mean value of 48.52 and 45.43). All cultivars decreased in brightness (L*) indicating that fresh papaya had a lighter colour compared to the fruit leathers. This was expected as the drying and addition of pectin, honey and citric acid to papaya puree can have significant effects on the colour of the papaya fruit. For example, citric acid is a strong acid and the addition of citric acid in the papaya puree may have impacted the stability of the anthocyanins. Anthocyanins are highly unstable and very susceptible to degradation. Anthocyanins are oxidised in the absence of oxidase enzymes and subsequent condensation reactions can lead to brown pigment formation (Singleton, 1987). This reaction may have led to colour changes in the papaya fruit leather but the addition of citric acid was necessary in the production of papaya fruit leather as it protected the natural colour and helped destroy bacteria during drying. Pectin concentration has also been found to affect the colour of the product as the absorbance intensity was decreased in the production of jam, which suggested a relationship between pectin and anthocyanin degradation (DERVISI *et al.*, 2001). Significant increases in L* values after drying were also observed by YANG and ATALLAH (1985). The authors suggested that in both forced air and micro-convection dried papaya increased L* values indicated a higher loss of anthocyanin from thermal degradation. However, for a* values a significant decrease was found in both papaya cultivars after drying, which may be due to anthocyanin oxidation as well as heat degradation during dehydration. In this study, papaya fruit leather also showed lower a* (13. 21 and 11.61) than fresh fruit (from 27.24 and 20.34) for two papaya cultivars Hongkong and Eksotika respectively. The b* values in C. papaya (Hongkong) were higher (10.25) compared to C. papaya (Eksotika). The extra added ingredients and the drying process had an effect on the b* value. The leather cultivars in Hongkong and Eksotika had an average b* value of 10.25 and 8.84 respectively. Similar results were also observed in previous studies with jackfruit leather (CHE MAN and SIN, 1997; OKILYA *et al.*, 2010) and blended papaya leather (KUMAR *et al.*, 2010). After drying, these fruit leathers became darker. This was especially prevalent in light coloured fruit leather (RAAB and OEHLER, 1999). Other factors that can also affect papaya anthocyanins are: pH, storage, temperature, light, light, oxygen, concentration and structure of anthocyanins, other flavonoids, protein and miner-

Table 2 - Effect of processing on colour of two papaya cultivars. Result showed mean ± standard deviation.

Cultivars	L*		a*		b*	
	Fresh	Leather	Fresh	Leather	Fresh	Leather
Hongkong	48.52±1.02[a]	32.1±0.71[b]	27.24±0.51[a]	13.21±0.20[b]	31.71±0.50[a]	10.25±0.41[b]
Eksotika	45.42±1.13[a]	30.7±1.01[b]	20.34±0.42[a]	11.61±0.18[b]	29.41±0.15[a]	8.84±0.65[b]

[a-b] Mean with different letters within each raw are significantly different (P< 0.05).

Table 3 - The effect of processing on the total phenolics content and total flavonoids content of two papaya cultivars. Result showed mean ± standard deviation.

Phenolics	Fresh		Leather	
	Hongkong	Eksotika	Hongkong	Eksotika
TPC	49.61±1.03 [a]	62.59±1.09 [b]	104.71±2.50 [b]	121.4±1.79 [a]
TFC	40.01±1.26[b]	45.40±0.82 [a]	91.43±1.54 [b]	108.78±1.77 [a]

[a-d] Mean with different letters within each raw are significantly different (P< 0.05).

als. These factors were associated with colour changes in papaya fruit. In this study, during the development of fruit leather the interactions between heat and the food ingredients may have significantly affected the anthocyanins' stability and this could have resulted in the colour change of the fruit. Ingredients such as honey contain antioxidants as well as hydrogen peroxide, which may cause degradation of anthocyanins by oxidation mechanism or by indirect oxidation (LOHACHOOMPOL, 2007). Also, it is noted that under high concentrations of oxygen and ascorbic acid increased pigmentation loss occurred which resulted in change to the colour of papaya. Other major factors mentioned by IRWANDI *et al.* (1998) that influenced the colour of fruit leathers were: processing condition, storage time and temperature.

Phenolics content and antioxidant activity

A comparison between fresh fruit and fruit leathers in terms of the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity (FRAP, DPPH, ABTS and ORAC) were illustrated in Tables 3 and.4. The fresh fruit showed different trends with regard to total phenolic content and total flavonoid content. The TPC and TFC were higher in Eksotika (62.59 mg GAE/100g DW and 45.40 mg QE/100g DW, respectively) than in Hongkong (49.61 mg GAE/100 g DW and 40.01 mg QE/100g DW, respectively). Also an antioxidant activity (FRAP, DDPH, ABTS and ORAC) was higher in Eksotika (197.41 mg TE/100g DW, 71.48%, 73.89% and 13.62 μmol TE/g DW, respectively) than in Hongkong (127.74 mg TE/100g DW, 49.62%, 61.84% and 11.50 μmol TE/g DW, respectively).

Antioxidant capacity and phenolic concentration were found to differ according to the types of papaya cultivars. The reason for this may be differences in regions, climate, as well as in the solvents employed for extraction. Furthermore, antioxidant activity may also be affected by lipid composition, antioxidant concentration, temperature, pH, oxygen, and water. Compared to earlier research carried out by (CONNOR *et al.*, 2002), (EHLENFELDT and PRIOR, 2001) and (PRIOR *et al.*, 1998), this study reported higher levels of antioxidant activity. Although dried fruit leathers showed comparable trends, fruit leather had higher TPC, TFC and antioxidant activity (FRAP, DPPH, ABTS, and ORAC) than fresh fruit. Drying determines increase in the levels of antioxidant activity and phenolics in both cultivars. However, Eksotika exhibited a greater increase in antioxidant activity than Hongkong. The fruit leathers showed different trends with regard to total phenolic content and total flavonoid content. TPC and TFC were higher in Eksotika (121.41 mg GAE/100g DW and 108.78

Table 4 - The effect of processing on antioxidant activity (FRAP, DPPH, ABTS and ORAC) of two papaya cultivars. Result showed mean ± standard deviation.

Antioxidant activity	Fresh		Leather	
	Hongkong	Eksotika	Hongkong	Eksotika
FRAP	127.74±1.88[b]	197.41±2.50[a]	231.51±3.87[b]	284.32±1.10[a]
DPPH	49.62±108[b]	71.48±0.87[a]	76.11±0.13[b]	89.47±102[a]
ABTS	61.84±0.86[b]	73.89±1.79[a]	84.97±0.60[b]	92.12±1.52[a]
ORAC	11.50±0.72[b]	13.62±0.96[a]	29.54±0.24[b]	34.40±1.91[a]

[a-d] Mean with different letters within each raw are significantly different (P< 0.05).

mg QE/100g DW, respectively) than in Hongkong (104.71 mg GAE/100 g DW and 91.43 mg QE/100g DW, respectively). Also, an antioxidant activity (FRAP, DDPH, ABTS and ORAC) was higher in Eksotika (284.32 mg TE/100g DW, 89.47%, 92.12% and 34.40 μmol TE/g DW, respectively) than in Hongkong (231.51mg TE/100g DW, 76.11%, 84.97% and 29,54 μmol TE/g DW, respectively).

As previously shown, in both cultivars, drying causes increase in phenolics and antioxidant activity within the range of 50% to 53%. This increase is due to loss of moisture from the samples and thus reflected in the weight, leading to an increased concentration, as well the addition of honey and lemon contributed to the increase in phenols and antioxidants.

Total phenolic contents assay is known to overestimate the content of phenolic compounds, because other agents present in food, such as carotenoids, amino acids, sugars and vitamin C, can interfere (BAHORUN *et al.*, 2004; LUXIMON-RAMMA *et al.*, 2003). Furthermore there may be a contribution of millard reaction products to the total phenolic and antioxidant activity (ZHUANG and SUN, 2011). Oxidation produces free radicals which are taken up by the vitamins and polyphenols. Reports that the antioxidant activity of partially oxidised polyphenols is higher compared to that of non-oxidised phenols have prompted further research. As highlighted by GARAU *et al.* (2007), there are other factors that may contribute to a reduced antioxidant activity; these include extended drying intervals. Despite the use of identical cultivars, it is difficult to generate a comparison between the antioxidant activity results of this study and those of earlier ones, due to differences in the assays, extraction techniques and standards (TE, GAE) employed. Moreover, apart from fruit quality, antioxidant activity is also influenced by factors such as geography, environment, climate and harvesting practices. The analysis of the impact of drying on total phenolic content revealed that, in contrast to fresh fruit cultivars, there was a reduction in total phenolic content. Thermal deterioration is the likely cause for the increase in the total phenolic content of the two cultivars. Furthermore, DI SCALA *et al.* (2011) specified that the total phenolic content may also decline due to dehydration, during which polyphenols bind to other compounds, such as proteins, or their chemical structure undergoes changes that existing techniques are unable to extract or identify. In the present study, although the increase was significant, papaya fruit leathers exhibited higher antioxidant activity and phenolics content than fresh fruit.

Table 5 - Correlation coefficients of antioxidants activities of different papaya cultivars.

Correlation coefficient (R2)	FRAP	DPPH	ABTS	ORAC
TPC	0.95	0.80	0.87	0.98
TFC	0.92	0.86	0.85	0.98

Correlation of TPC and TFC with FRAP, DPPH, ABTS and ORAC assays

A correlation analysis among phenolic compounds (TPC and TFC) assays, and antioxidant activity (FRAP, DPPH and ABTS) was performed regardless of the extraction cultivars. A high correlation (Table 5) was found between TPC, TFC and antioxidant activity (FPAP, DPPH ABTS and ORAC) for both cultivars (Hongkong and Eksotika). Thus, it can reasonably be concluded that in the extract, antioxidant activity is related to the active component. Findings of researches of correlation analyses among TPC, TFC, and antioxidant activities (FRAP, DPPH, and ABTS) are high (MAHATTANATAWEE *et al.*, 2006). There have been significant effects on the antioxidant activities of papaya fruit.

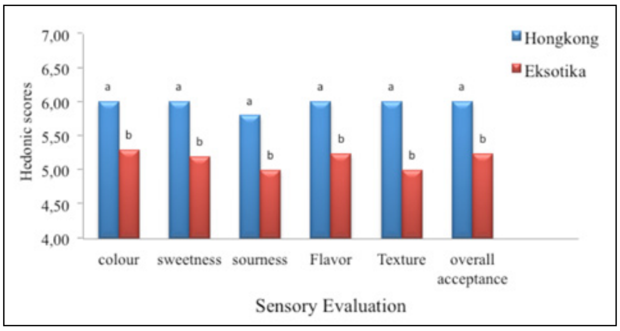

Fig. 3 - The effect of processing on texture of two papaya cultivars.
a-b Mean with different letters are significantly different (P < 0.05)

Sensory evaluation

The statistical analysis of the sensory evaluation was conducted on the basis of 30 responses. The average scores for six properties of all fruit leathers are presented in Fig. 3. A score of 1 signified 'dislike extremely', while a score of 7 signified 'like extremely'. The cultivars differed significantly (P<0.05) in terms of colour, sweetness, sourness, flavour, texture, and general product acceptance. Of the two types of cultivars, Eksotika achieved the lowest acceptability scores of colour. This implied the importance attributed to the visual appearance of the product. There was a greater preference for the papaya leather cultivar Hongkong, due to its reddish colour, than for the dark coloured Eksotika. Surprisingly, the results for fresh papaya were different. In a study undertaken by (SAFTNER *et al.*, 2008), the highest scores among all cultivars were obtained by the Highbush cultivars Coville and Hannah's Choice for the intense blue colour, acceptable appearance, colour, fruit size, sweet/tart balance, flavour and overall eating quality. In a different study, GUJRAL and KHANNA (2002) increased the sucrose level in order to enhance the colour, flavour and texture of mango leather. Such approaches should be applied in the case of blueberry fruit leathers as well, to improve the darker colour of certain varieties of blueberry. Similarly, the colour of the papaya leather could be enhanced by adding other colourless fruit (DERVISI *et al.*, 2001).

The fruit leathers obtained an average sweetness score of 6.00. This meant that the panelist 'liked' the product sweetness and thus it was necessary to add honey. However, as warned by KUMAR *et al.* (2008), the overall taste rating may decline due to an excessive increase in the amount of sugar. The sourness of the papaya leather was 'moderately liked' by a panelist, with an average score of 5.6. Moisture content and duration of drying have an impact on the texture of fruit leather. The moisture content is reduced and the texture is hardened by higher temperatures and extended drying intervals (OKILYA *et al.*, 2010). Furthermore, the texture quality of the end-product may also be affected by the addition of flavour and colour-enhancing ingredients like pectin, honey, sugars, nuts, salt and other fruits (RAAB and OEHLER, 1999). Eksotika cultivars obtained a lower flavour score (5.2) than Hongkong (6.0). OKILYA *et al.* (2010) explained that the amount of sugar within the fresh pulp affects how the fruit leather tastes. The taste of papaya fruit leather was enhanced in this study by adding honey and citric acid. Similarly, KUMAR *et al.* (2008) noted that papaya and guava fruit leather were affected by the addition of extra ingredients. Compared to individual scoring, the overall score for sensory attributes was considerably improved by the addition of 60% papaya and 40% guava, the nutritional and textural quality of the fruit leather remained unaffected. It was necessary to make this addition in order to enhance the low scent of the papaya fruit, which constituted a major obstacle to the commercial use of this fruit. As specified by (Raab and Oehler 1999), the taste of fruit leather could also be improved by using additional ingredients like leaf oregano and garlic salt. The blueberry fruit leather achieved an average overall score of 5.0, indicating that the panelists 'moderately liked' it. Theoretically, the overall reception of all sensory attributes of the papaya fruit leather was the reason for its overall acceptability. The Hongkong cultivar obtained an overall acceptable score of 6.00 making it the best liked fruit leather. The colour, appearance, sweetness, sourness, texture and flavour of the cultivar determined the preference of the panelists for it. Furthermore, Hongkong received an overall acceptability score of 6 out of 7. On the other hand, Eksotika obtained the lowest score, being 'moderately liked' by the panelists for its colour, general appearance and flavor.

CONCLUSIONS

Fruit leather was successfully developed from two different papaya cultivars using three additional ingredients - honey, pectin and citric acid. This processed product was intended to preserve or enhance the nutritional value and sensory quality of the papaya fruit. The moisture content of the fruit leather derived from the two cultivars was reduced (14.31% and 15.42%), signifying that they were safe from a bacterial viewpoint and could be classified as an intermediate moisture food. The phenolics content and antioxidant activity were increased using the process of drying the fruit leather. Substantial discrepancies in colour, sweetness, sourness, texture, flavour and overall acceptability were reflected in the consumer sensory assessment. 'Like moderately' was the average overall acceptability score. However, according to the results of the sensory evaluation, panelists expressed a low preference for the Eksotika fruit leather, which received a 'moderately liked' score. The results of the present study have great significance for producers of papaya leathers. Among the main factors that determined the acceptability of the fruit leathers were colour, sweetness, sourness, texture and flavour. The end-product can be considered natural, as only small amounts of honey, citric acid and pectin were added in this study. Hence, the consumer requirements for healthy and safe food products were respected

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