Quality Characteristics and Acceptability of Three Types of Pitaya Fruits in a Consumer Acceptance Test

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ABSTRACT

Three types of pitaya fruits Hylocereus polyrhizus, Hylocereus undatus and Selenicereus megalanthus were subjected to colour evaluation, proximate test, physicochemical analysis and consumer acceptance test. Morphologically, red pitaya have red violet pulp while white pitaya and yellow pitaya both have white pulp. The other significant difference is the peel colour; yellow pitaya are differentiated from the other two pitaya by their significant yellow peel as compared to red and white pitaya which have red peel. L, a and b* values for the pitaya pulp are 25.3, 27.8 and -1.1 for red pitaya, 54.9, 0.5 and 2.3 for white pitaya and 21.9, 30.9 and -2.1 for yellow pitaya. Red pitaya peel had 37.9, 40.0 and 10.7 for its L, chroma and hue value. Seeds contained the highest protein and fat ($p < 0.05$) with value of 23.1 to 28.6% and 18.8 to 22.8% respectively. Pitaya peel contained the highest ash content ranging from 15 to 28.8% while pulp contained the highest carbohydrate ranging from 86.3 to 90.6%. pH value for pitaya fruits pulp and peel range between 4.6 to 4.7 and 5.3 to 5.5. White*

ISSN 1985-8914

pitaya pulp showed significant ($p < 0.05$) titratable acidity with 26.8 g/L while red and yellow pitaya had 19.3 g/L and 17.9 g/L respectively. Hedonic sensory analysis indicated that red pitaya was preferred in terms of its sweetness and overall liking. Red pitaya fruit showed potential to be developed into other food products due to its distinct red colour and was the most preferred choice in overall sensory hedonic tests.

***Keywords**: pitaya fruits, quality characteristics, sensory evaluation, Hylocereus polyrhizus, Hylocereus undatus, Selenicereus megalanthus*

INTRODUCTION

Pitaya, locally known as dragonfruit is a new crop being cultivated in Malaysia commercially, although it has been grown in Vietnam for at least 100 years after being introduced by the French (Mizrahi et al., 1997). This climbing cactus is known as red pitaya in Latin America, with medium-large berry bearing large green or red scales (Nerd and Mizrahi, 1997) which resembles a dragon, hence the name Thanh Long or green dragon in Vietnam (Hoa et al., 2006) . The peel is usually red, and the pulp varies from purple red to white. The pulp is delicate and juicy containing many small soft seeds (Nerd et al., 1999). These cactus plants are grown openly in tropical areas with good water flow and lots of sun. Scientifically the red pitaya is known as *Hylocereus polyrhizus* and the white pitaya, *Hylocereus undatus*.

Yellow pitaya (*Selenicereus megalanthus*), a related cactus which originated in the northern part of South America (Mizrahi et al., 1997) is also being cultivated in Columbia and Israel (Nerd and Mizrahi, 1998). The fruit is a medium-sized oblong berry with yellow peel bearing tubercles and thorns that are shed during ripening. The pulp is white and delicate and contains numerous small digestible black seeds (Nerd and Mizrahi, 1997). Yellow pitaya has a different duration of fruit development which depends on seasonal temperatures, and the fruits reach their optimal flavour close to the full colour stage (Nerd and Mizrahi, 1998). It is a nonclimateric fruit and has the best quality when picked close to the full colour stage (Nerd and Mizrahi, 1998).

Pitaya cultivation in Malaysia which started in 1999 in Kuala Pilah, Negeri Sembilan and Kluang, Johor has now reached more than 600 acres in plantation area with fruit yielding more than 16,000 metric tonnes/year (FAMA, 2006). Although all three pitaya are found in Malaysia, only red pitaya with red-violet pulp is cultivated for sale in the local market and exported overseas. The white-pulp pitaya is not cultivated commercially because of its lower market value while yellow pitaya needs a longer time to bear fruit. Therefore, it is the intention of this study to compare the characteristics of these three types of pitaya found in Malaysia and their sensory evaluation as perceived by the panelists.

MATERIALS AND METHODS

Samples

Red and white pitaya were hand picked from the Dragon Plantation, Malacca, immediately transported to the laboratory and fruits were sorted for the analyses. Both types of pitaya were picked based on Federal Agricultural Marketing Authority (FAMA) maturity index Grades 3 and 4. Yellow pitaya were also hand picked from the Tropical Agro Farm Sdn Bhd, Teluk Bahang, Penang and brought to the laboratory immediately for processing. The peels were removed and kept separated from the pulp. Ten fruits from a batch of fruits were chosen for the physical and chemical tests. The other fruits were used for the sensory test.

Morphology Measurement and Colour

The weight and length of the fruits were taken using a measuring scale and vernier calipers. Colour was measured using a Minolta Chromameter CR-300 (Atago, Japan). The peel colours of the fruits were taken at three different points and measurements were taken from 10 fruits. Inside colours were measured by cutting the fruits in half and measurements were taken from the middle and at each different end. The Minolta Chromameter was standardized using a white plate before being used (L,a and b; 96.97, -0.12 and +1.95). L value (bright/dark), a (red/green) and b (yellow/blue) were measured and chroma and hue were calculated according to the formula below;

$$Chroma = (a^2 + b^2)^{1/2}$$
$$Hue = \arctan (b^*/a^*)$$

Proximate Analyses

Proximate analysis was conducted according to AOAC (1990). Carbohydrate was calculated from the difference with the value of the moisture, protein, fat and ash with 100 percent.

Physicochemical Analyses

Physicochemical characteristics were determined for brix, pH and titratable acidity. The fruits were cleaned, separated from their peel and cut into small cubes and macerated (waring blender). Twenty grams of pulp sample were set aside and brix (Refractometer, Atago, Japan) and pH value (Mettler Toledo, FE20, France) were taken from the sample. The samples were later titrated using 0.01 N sodium hydroxide (NaOH). The same test was repeated for the peels, 10 gm of macerated peels were added with 50 ml of water. Percent acid weight/volume was calculated based on formula (3).

$$\text{Percent acid weight/volume} = \frac{\text{ml titrant x 0.01 NaOH x Equivalent weight of acid (64) X 100}}{\text{Sample (gm) x 1000}}$$

Sensory Evaluation

The sensory hedonic test was conducted with 40 member panels consisting of students and staff of the Department of Food Technology in the Faculty of Science and Technology, Universiti Kebangsaan Malaysia. Fruit samples were cleaned and the fruit pulp cut into 1 x 1 cm cubes and put into small glass containers. Each panel received the three types of pitaya fruits, 3 cubes for each fruit coded with a three digit number and permutated randomly. The fruits were evaluated on a 7 point hedonic scale (Abdullah, 2004) anchored with either "least" on one end and "most" on the other. Variables evaluated were colour, seed ratio, seed size, sweetness, liking of sweetness, sourness, liking of sourness and overall acceptability.

All data were analyzed using SAS version 9 (SAS 2002), ANOVA were used to determine significance difference ($p < 0.05$) and DUNCAN were used to compare fruits.

RESULTS AND DISCUSSION

Morphology Characteristics and Colour of Three Types of Pitaya

The red pitaya (*Hylocereus polyrhizus*) and white pitaya (*Hylocereus undatus*) weights were 475 gm and 493 gm; while their lengths were 13.2 cm and 13.3 cm respectively. Both were similar in size while the yellow pitaya (*Selenicereus megalanthus*) weighed 302 gm and was 10.0 cm long. It was the smallest in size of the three pitaya. The major differences between the pitaya were the shape and peel colour. The red pitaya was round while the white and the yellow pitaya are oblong. The morphology of the three types of pitaya is shown in Table 1. Both red and white pitaya had red peel colour but red pitaya was a deeper red compared to the white pitaya. The yellow pitaya is recognized based on its yellow peel colour and the thorn that is shed during ripening (Lichtenzveig et al., 2000).

When the peel was removed, the red pitaya pulp was red-violet in colour, while the white and yellow pitaya had white pulp. All pitaya had small black seeds fully dispersed in the fruits. According to Lichtenzveig et al., (2000), the major differences between pitaya are that the red pitaya has red-violet pulp as opposed to white and yellow pitaya which have white pulp. There is a significant difference ($p < 0.05$) in the colour of the pitayas. The L value which shows the lightness or darkness of colour showed that the pulp of the white pitaya is the lightest with a value of 54.9. White pitaya pulp is white and so is the yellow

Table 1: Mean (n = 10) morphology characteristics of three types of pitaya

Characteristics	Cultivar		
	Red pitaya *Hylocereus polyrhizus*	White pitaya *Hylocereus undatus*	Yellow pitaya *Selenicereus megalanthus*
Fruit weight	475 gm[a]	493 gm[a]	302 gm[b]
Fruit length	13.2 cm[a]	13.3 cm[a]	10.0 cm[b]
Shape	Round	Oblong	Oblong
Peel colour	Red	Red	Yellow
Pulp colour	Red-violet	White	White

A different letter on the same row shows the significant difference ($p < 0.05$)

pitaya pulp however, yellow pitaya pulp is transparent and thus the seeds are clearly visible and this affects the L value of yellow pitaya pulp.

There was a significant difference ($p < 0.05$) in the chroma value of all three types of pitaya pulp and peel. Chroma intensity for red pitaya peel and white pitaya peel showed no difference with values of 40.0 and 38.4 respectively, while yellow pitaya peel showed significant difference ($p < 0.05$) in colour intensity with chroma value 34.1. Yellow pitaya peel had a different colour tone from the other two types of pitaya. Hoe et al. (2006) found a C value for white pitaya peel (*Hylocereus undatus*) between 27.5 and 31.3. The C value in this study was lighter compared to the value found by Hoa et al. (2006) that is 38.4. Hue value was between 25.8 and 31.8 for white pitaya in the study by Hoa et al. (2006). In comparison, the pitaya fruit used by Hoa et al. (2006) were redder and darker than the ones used in this study. There are a variety of pitaya

Table 2: Mean (n = 10) pulp and peel colour of pitaya fruits

Characteristics	Cultivar					
	Red pitaya *Hylocereus polyrhizus*		White pitaya *Hylocereus undatus*		Yellow pitaya *Selenicereus megalanthus*	
Colour*	Peel	Pulp	Peel	Pulp	Peel	Pulp
L	37.9[c]	25.3[d]	40.8[b]	54.9[a]	41.6[b]	21.9[e]
a	39.3[a]	27.8[c]	38.0[a]	0.5[d]	32.9[b]	30.9[bc]
b	7.9[b]	-1.1[e]	5.6[c]	2.3[d]	8.8[a]	-2.1[e]
Chroma	40.0[a]	27.8[c]	38.4[a]	2.3[d]	34.1[b]	30.8[bc]
Hue	10.7[c]	3.1[e]	8.5[c]	77.8[a]	14.9[b]	4.5[c]

and their ripening stages also influence their colour intensity. Red pitaya pulp showed a deeper colour intensity with a red-violet colour (27.8) while white pitaya pulp had the least (2.3) intensity. Chroma value for yellow pitaya pulp (30.8) was high due to its transparent white colour and thus the black seeds are visible and influence its a* and b* values.

Proximate Composition

The seeds contained a significant percentage of protein ($p < 0.05$) with 28.6% for yellow pitaya followed by red pitaya seeds 26.3% and white pitaya seeds 23.1%. Protein content in pitaya peel was between 6.2 and 7.9% while the protein content for pitaya pulp ranged between 5.2 and 9.5%. The protein content in this study was higher than that reported by Jaafar et al. (2009) with a value of 0.16 to 0.23%.

Fat in the white pitaya seeds was most significant ($p < 0.05$) with a value of 27.5% followed by red pitaya seeds (22.8%) and yellow pitaya seeds (18.8%). Pitaya seeds contain a higher percentage of fat than *Opuntia ficus indica* which is another type of cactus fruits with values between 10.9 and 11.1% (Ennouri et al., 2005). Fat from the pitaya pulp was low, between 0.1 and 1.1%, and this is in agreement with Jaafar et al. (2009) with a value of 0.21 to 0.61%. Yellow pitaya pulp was the highest in fat of all the pitaya owing to the seeds content which are bigger in size compared to the other two types of pitaya seeds.

Table 3: mean (n = 3) proximate (%) and physicochemical analysis of three types of pitaya

Fruits	Red pitaya *(Hylocereus polyrhizus)*			White pitaya *(Hylocereus undatus)*			Yellow pitaya *(Selenicereus megalanthus)*		
	Peel	Pulp	Seeds	Peel	Pulp	Seeds	Peel	Pulp	Seeds
Protein	7.9^{e}	5.2^{g}	26.3^{b}	6.2^{f}	7.7^{e}	23.1^{c}	7.6^{e}	9.5^{d}	28.6^{a}
Fat	0.4^{e}	0.1^{e}	22.8^{b}	2.7^{d}	0.1^{e}	27.5^{a}	0.3^{e}	1.1^{de}	18.8^{c}
Ash	28.8^{a}	4.1^{d}	6.1^{cd}	15.0^{bc}	2.6^{d}	3.1^{d}	20.0^{ab}	3.0^{d}	3.8^{d}
Carbohydrate	63.0^{c}	90.6^{a}	44.8^{d}	76.2^{b}	89.6^{a}	46.3^{d}	72.2^{bc}	86.3^{a}	86.3^{a}
pH	5.5^{a}	4.7^{c}	ND**	5.3^{b}	4.7^{c}	ND	5.3^{b}	4.6^{d}	ND
Titratable acidity (%)	0.18^{c}	0.19^{b}	ND	0.19^{b}	0.26^{a}	ND	0.20^{b}	0.18^{c}	ND
Soluble solid (Brix)	1.0^{e}	8.2^{b}	ND	0.6^{d}	8.7^{b}	ND	0.9^{d}	15.0^{a}	ND
Brix/acid ratio	5.7^{c}	42.9^{b}	ND	5.3^{c}	33.1^{b}	ND	4.6^{d}	89.6^{a}	ND

A different letter on the same row shows a significant difference ($p < 0.05$); Carbohydrate determined by difference. **Not determined

Ash content in red pitaya peel was most significant ($p < 0.05$) with a value of 28.8% as compared to white pitaya (15%) and yellow pitaya (20%). All the three types of pitaya studied showed the same trend with the ash content which was higher in peel than in pulp. The high ash content showed that peels and seeds had some potential to supply the minerals needed for body development. The ash content in pitaya seeds was in agreement with the study by Habibi et al. (2008).

Physicochemical

There was significant difference ($p < 0.05$) in the physicochemical content in the pitaya fruits. pH for pitaya fruit was between 4.6 and 4.7, with a higher pH value for peel between 5.3 and 5.5. Titratable acidity of white pitaya pulp showed a significant difference ($p < 0.05$) at value 0.26% followed by red pitaya pulp 0.19 and yellow pitaya pulp 0.17% respectively. The brix value of yellow pitaya pulp was most significant ($p < 0.05$) with a value of 15 as compared to red pitaya pulp with a value of 8.2 and white pitaya 8.7. Brix and acid ratio showed yellow pitaya pulp had the highest ratio ($p < 0.05$) with 89.6. Pitaya peel had pH higher than its brix, that is between 0.6 and 1, thus resulting in a low brix acid ratio.

Hoa et al. (2006) found that white pitaya (*Hylocereus undatus*) had brix between 11.3 and 11.6 while its brix value was between 2.7 and 4.3. Nerd et al. (1999) also found that the brix value of red pitaya was 6.3 and 6.6 for white pitaya. Titratable acidity, pH and soluble solids contents are indicators of fruit

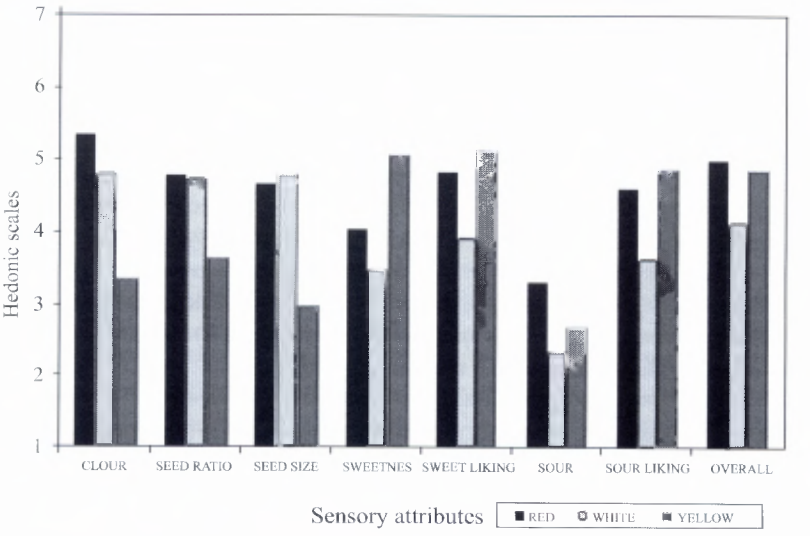

Figure 1: Mean (n = 40) scores of hedonic acceptance of three types of pitaya.

maturity. As a comparison, strawberry maturity is at a brix value of 8.1, pH 3.44 and titratable acidity at 0.74% (Zheng et al., 2007). The balance between pH and its soluble sugar content will determine the acceptability of the fruit consumed. The different results from the studies were probably due to the different fruit maturity used in each study. The maturity of the fruit chosen for this study was according to the quality index set by FAMA (2006) for local market distribution and consumption.

Consumer Sensory Evaluation

The sensory hedonic test was carried out using 40 consumer panelists consisting of students and staff at the School of Chemical Science and Food Technology, Universiti Kebangsaan Malaysia. Panelists selected were between the ages of 24 and 50 years of age (14 males, 26 females). Seven point hedonic scales were used (1 – least like; 7 – most like). Eight attributes were assessed; the fruit colour, the size of the seeds, dispersed seeds ratio, fruit sweetness, the panel's degree of liking of the sweetness, fruit sourness, panel's degree of liking of the sourness and overall liking of the fruits.

Colour was the first perceived attribute seen by panelists. The liking of the fruit colour will eventually influence panelists to like the fruit. Among the three types of fruit, red pitaya was most liked ($p < 0.05$) with a mean score of 5.3 followed by white pitaya 4.8 and yellow pitaya 3.4.

Panelists liked ($p < 0.05$) the seeds ratio for red (4.7) and white pitaya (4.7) followed by yellow pitaya seeds (3.6). The seeds size for red and white pitaya were more preferred ($p < 0.05$). In comparison, red and white pitaya seeds size are smaller than the yellow pitaya seeds. The ratio of pulp volume and the seeds was also obvious because of its smaller fruit size (10 cm) as compared to red pitaya size (13.2 cm) and white pitaya (13.3 cm). Thus the seeds ratio and the size of yellow pitaya seeds were found to influence the degree of liking by the panelists.

When the three pitaya were compared, the sweetness in yellow pitaya was the most preferred ($p < 0.05$) (brix: 15%) with a mean score of 5.1, followed by a red pitaya hedonic value of 4.1 and brix value of 8.2% and a white pitaya score (3.5) with a brix value of 8.7%. When panelists were asked to perceive their liking for sweetness, they liked the sweetness in yellow pitaya fruit ($p < 0.05$) with a mean score 5.1 as opposed to red pitaya (4.8). White pitaya fruit sweetness was least liked with a mean score of 3.9.

The sourness in red pitaya was the most liked by the panel with a mean score value of 3.3 while the white pitaya was the least liked (2.4) and yellow pitaya had a mean score of 2.7. Liking for sourness for yellow pitaya as perceived by panelists was at a mean score of 4.9 while the red pitaya score was 4.6. The lowest score was for white pitaya with a score of 3.6. This shows that panels do not like the sour taste in white pitaya. The sourness score between 2.7 to

3.3 means "Not like" in the real hedonic scales. Although the brix values for red and white pitaya were almost the same, the white pitaya titratable acidity was high (0.26%) as compared to red pitaya with 0.19%.

Overall panelists liked red pitaya with a mean score of 5.0 and yellow pitaya with a mean score of 4.9. White pitaya were less like when compared to other two pitaya with a mean score of 4.2. Panelists' degree of liking white pitaya was most probably influenced by the fruit's sourness as white pitaya fruit was the most sour of the pitaya fruits studied. The correlation between the sweetness and overall likeness of the fruits showed that there is a good relationship (R^2 = 0.74) between red pitaya sweetness and the panel's overall liking for the fruit while white pitaya had R^2 = 0.68 and yellow pitaya R^2 = 0.55. This shows that the sweetness found in red pitaya (Brix 6.3) is most suitable and most liked by the consumer panels. Although the panelists liked the sweetness in yellow pitaya the correlation was found to be weak. Probably panelists preferred the sweet taste of yellow fruit but for overall attributes yellow pitaya were probably not acceptable due to the large seeds. The fruits chosen for the hedonic test were considered to be matured and ripe for immediate consumption. Nerd et al. 1999 reported that changes during maturing gave an advantage to the red pitaya taste and the same effect could be seen in yellow pitaya (Nerd and Mizrahi, 1998. Thus it is important to pick and consume pitaya when it is fully ripe.

CONCLUSION

Red pitaya was found to possess good nutritional potential and was more preferred by the consumers than the white and yellow pitaya. It has the advantage of its bright red violet colour, acceptable sweetness and small seeds that are fully dispersed in the fruit. White pitaya were not well perceived maybe owing to its sourness and yellow pitaya have a higher seeds ratio and bigger seeds size even though it has the sweetest taste. Therefore, red pitaya has potential as compared to the other types of pitaya to be developed into another food product with bigger scope for market value.

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