International Food Research Journal 19(1): 167-174 (2012)

Chemical composition changes of two water apple (*Syzygium samaragense*)

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Abstract: Changes in physical properties (weight, size, colour and weight loss) and chemical properties (proximate analysis, TSS, pH, freezing point, total acidity and sugar content) of two water apple (*Syzgium samaragense*) cultivars, Semarang Rose and Kristal Taiwan were evaluated during ripening at 10°C and 50% RH. The results showed that the Kristal Taiwan cultivar was larger in size and weight but smaller in length compared to Semarang Rose. The Semarang Rose cultivar was sweeter than Kristal Taiwan. In this study, data obtained suggests that the water apple fruit can be stored at cold storage until 19 days.

Keywords: Water apple, chemical composition, cold storage

Introduction

Water Apple (*Syzygium samarangense*) is a species in the Myrtaceae, native to Philippines, Indonesia and Malaysia. Common names include wax apple, love apple, java apple, Chomphu (in Thai), Bellfruit (In Taiwan), jambu air (in Indonesian), water apple, mountain apple, jambu air ("water guava" in Malay), wax jambu, Rose apple, bell fruit, makopa, tambis (Philippines), and chambekka in Malayalam and jumbu (Sri Lanka). There are many varieties of water apple. The most popular varieties of water apple in Malaysia are *Syzvgium javanica* (*Eugenia javanica*), buah jambu lilin (*Eugenia aquem*), buah jambu semarang, buah jambu air and buah jambu mawar. In Malaysia, two forms are recognized which are white-fruited or red-fruited. The shapes of water apples are different according to the species. Its pulp is crisp and watery, hence the name watery apple. However, not much part of the fruit is edible: the centre is filled with woolly fibers, within which brown seeds are located, they may be 3 to 6 small seeds, but generally the fruits are seedless (Morton, 1987). The flavours are varies from a thin, slightly acid flavor to a full and fruity apple flavour.

Semarang Rose and Kristal Taiwan are the most well-known water apple in Malaysia. Kristal Taiwan is pear-shaped with a narrow neck and broad apex which is 4-5 cm long, and 5-8 cm wide. The apex is concave: bears the thick calyx segments and the protruding, slender, bristle-like style. Its color varies from white to bright pink (Lee, 2008). Semarang Rose is mainly distributed in Indonesia, Thailand and Taiwan. The fruit quality is better than Kristal Taiwan. It is bell-shaped edible berry, with red colors. It is longer but smaller in size than that of Kristal Taiwan (Rukayah, 1992). In the past literature, many researches on physical properties of liquid foods have been reported (Bayindirli, 1993) but no much literature of water apple juice especially on these two cultivars.

The objective of this study was to determine physico-chemical properties of water apple juice from cultivar Semarang Rose and Kristal Taiwan. The properties such as size, weight, weight loss, colour, proximate analysis, TSS, pH, freezing point, total acidity and sugar content of water apple juice were determined during ripening at 10°C and 50% relative humidity (RH); to compare the best quality between two different cultivars. Beside plants, fruits also have become the main subject for researchers to be investigated since their bioactive compounds close related with herbs, commonly referred as phytochemicals such as carotenoids, polyphenols and anthocyanins that are abundantly present in fruits and vegetables such as tomatoes, grapes, pomegranates and strawberries are gaining lot of interest due to their functional property (Jayaprakasha *et al*., 2001; Li *et al*., 2006; Rao and Rao, 2007). Furthermore, natural compounds in fruits and vegetables such as polyphenols such as flavonoids and tannins have shown very promising results in combating bacteria, fungus and viral (Ahmad and Beg, 2001; Cushnie and Lamb, 2005).

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Materials and Methods

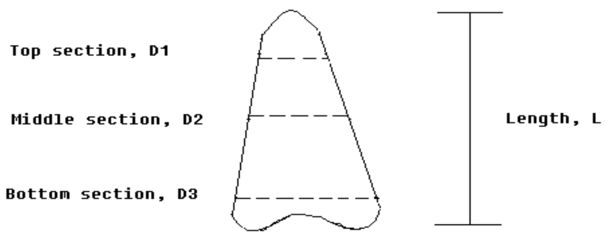
Preparation of sample and juice

Fruit at maturation growing stages of water apple cultivars Semarang Rose and Kristal Taiwan were collected throughout the growing season, November 2008 from farm in Perak, Malaysia. Harvested fruit were immediately transported on the same day to the laboratory. Fruits were stored in an Incubator (TD-1600, Protech Incubator, Malaysia) at 10°C and 50% RH. Analyses were carries out for fruits harvested from the farm, at the second day after storage. 25 fruits were used for sampling. The experiments were conducted every 3 days during ripening at 10°C. Fruit were selected at random for physical properties analysis. After the physical properties analysis, the selected fruits were cut into small pieces, fruit bulbs were removed and the fruits were extracted using a juice extractor (Model 800, Breville, Japan). All experiments were conducted at room temperature in three replications.

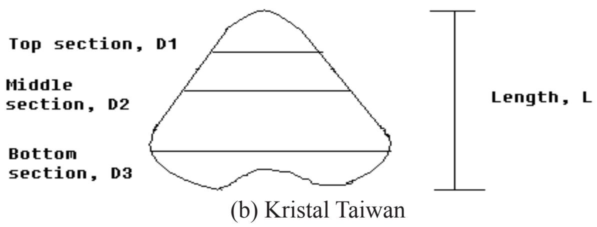
Physical properties

Shape, size and weight of fruit

The length and width of the whole fruits were measured on its most stable position. The size of the sample was determined using Digital Vernier Caliper. The diameter and length of samples were recorded at four different locations of the whole fruit as shown in Figure 1. The top is defined as the end of the stem of water apple. The weight of each fruit was measured by using electronic balance (Model B204-S Mark2, Mettler Teledo, Switzerland). The average values of three replications were reported.



(a) Semarang Rose



(b) Kristal Taiwan

Figure 1. Longitudinal sections of water apple cultivar (a) Semarang Rose and (b) Kristal Taiwan

Weight loss

10 fruits were randomly selected and labeled. After labeling, the samples were weighed using electronic balance (Seven Multi, Mettler Teledo, US). The labeled samples were weighed again every 3 days during storage at 10°C until day 16.

Colour

Colour was measured on the surface of the fruit with Colour Reader (CR10, Konica Minolta, Japan). Colour measurement was done in terms of the Commission Internationale de L'Eclairage (CIE) 'Lab' color space coordinates (Ranganna, 1986). The fruit was placed on the light port of Colour Reader. Each value represents a mean of triplicate determination of three different positions for each fruit sample. The values were reported as the average of individual value as L (lightness), a (+a is red, -a is green) and b (+b is yellow, -b is blue). Before measuring the colour, the Colour Reader was standardized with black and white calibration tiles supplied with the instrument.

Chemical properties

Proximate analysis

Twenty fruits were sliced into small portions, and were arranged on an aluminum foil, then; the samples were placed inside the oven (OF-22GW, Lab Companion, Korea) at 63°C for 48 hours. After 48 hours, the fruits were dried. The dried fruits were then blended into a powder form using a blender (Multipro, Kenwood, Japan). The powder was used for ash, fat, protein and fiber analysis. The moisture content was measured using an oven method according to Association of Official Analytical Chemists (AOAC International) standard. The Kjeldahl method was used for protein determination and the Soxhlet method was used for the fat content. The determination of fiber was based on the method by Lees (1968). For ash content, the sample was weigh and transfer to a muffle furnace at 550°C until a white or light grey ash is obtained. Three replications of all of these measurements were carried out.

Total soluble solid (TSS)

The total soluble solid (TSS) of water apple juice (°Brix) was determined using a Digital refractometer (AR 2008, Kruss, Germany) at 25°C. All experiments were conducted at room temperature and the average values of three replications were reported.

pH

pH is a measure of the acidity or basicity of a solution. It is defined as the cologarithm of the activity of dissolved hydrogen ions (H^+). pH was measured at room temperature using a pH meter (Seven Multi, Mettler Toledo, Switzerland). The pH meter was fully immersed in the juice to give the correct data prior to measurement. Buffers of pH 4.0 and 7.0 were used to calibrate the equipment. All experiments were conducted at room temperature and were carried out in three replications.

Freezing point

Freezing Point of the juice was determined using freezing point apparatus (Cryo Star 1, Funke Gerber, Germany). Buffers of pH 4.0 and 7.0 were used to calibrate the equipment. All experiments were conducted at room temperature and were carried out in three replications.

Total acidity

Total acidity of water apple juice was determined using a autotitration apparatus (Model 785 DMP Tritino, Metrohm, Switzerland). 10 ml of sample juice was treated with 40 ml distilled water. The electrode was pushed into the sample and measured under stirring. All experiments were conducted at room temperature and the average values of three replications were reported.

Sugar

Major carbohydrate constituents in water apples juice are glucose, fructose, and sucrose. The amount of these sugars was determined by High Pressure liquid Chromatography (HPLC). The HPLC was equipped with a Jasco RI-1530 detector and a Jasco PU-1580 pump. The column used to analyze the sample was a 10 um uBondapak *TM*-NH2 column (3.9 x 300 m) with NH2 polar bonded stationary phase. Degassed 80% acetonenitrile was used as a mobile phase. Forty microliters of the extracted sample was injected. Sugars in the samples were quantified by comparing peak areas of the samples with standards. The standards comprised glucose, fructose and sucrose at concentrations of 0.5, 1.0, 1.5 and 2.0%. A calibration curve was obtained for each of these sugars.

About 40 g of sample was heated with methanol (85%, 100ml) in a water bath for 30 min at 80ºC. Then filtered through a filter paper (Whatman No.1) and the residue was re-extracted twice with methanol (85%, 100 ml). Then, the filtrate was evaporated using a rotary vacuum evaporator at 50ºC until final volume 10 ml. The evaporated sample was filtered through a Sep-pek (C-18 cartridge, US) and a 0.45 um filter membrane (Avantak, Japan) using a syringe and stored in vials for further HPLC analysis. Three replications of this determination were carried out. (DMSO). The final concentrations of all extracts were standardized at 10 mg/mL.

Results and Discussion

Physical properties

Weight and size

The weight of Kristal Taiwan varies between 89.85 g and 125.13 g with an average value of 103.87 g; while, the weight Semarang Rose varies between 55.35 g and 87.94 g with an average value of 68.93 g. The length, L of Kristal Taiwan ranges from 64.37 mm to 69.79 mm with an average value of 67.09 mm. The length of Semarang Rose ranges from 65.79 mm to 72.05 mm with an average value of 68.93 mm. The maximum and minimum observed diameters for Kristal Taiwan were 76.39 mm and 33.6 mm respectively. These values for the Semarang Rose were 50.66 mm and 28.13 mm respectively. The diameters of both cultivars were at maximum at the bottom portion and minimum at the top portion. Both cultivars of water apple were different in shape, size and weight. The results showed that the Kristal Taiwan was larger in size and weight but smaller in length compared to Semarang Rose cultivar. .

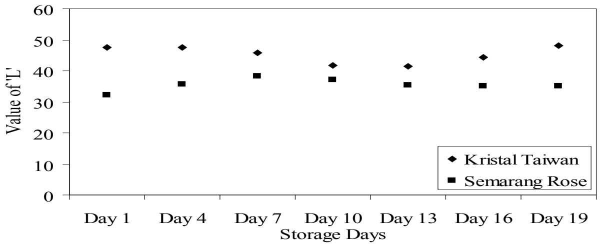
Weight loss

The weight of the water apple decrease due to the evaporation of moisture inside the fruits during ripening process. This loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and weight loss (Wills *et al*., 1981). The result shows that the weight loss ranges from 3.80 to 18.48 % (Kristal Taiwan) and 2.46 to 21.69% (Semarang Rose). The weight loss of Kristal Taiwan and Semarang Rose increase significantly ($p<0.001$) during storage. Normally, the weight loss occurs during the fruits storage due to its respiratory process, the transference of humidity and some processes of oxidation (Ayranci and Tunc, 2003). Temperature and relative humidity of the product and its surrounding atmosphere, and air velocity affected the amount of water lost from fresh fruits, vegetables, and flowers.

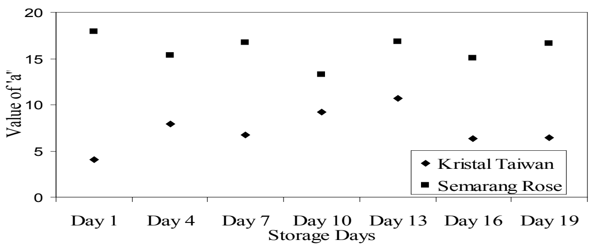
The results show that Kristal Taiwan exhibited greater weight loss, however the amount of weight loss is lower than Semarang Rose at day 16. This may due to the different in sizes and weight in both cultivars. Kristal Taiwan with large weight and size has higher moisture content than Semarang Rose. At Day 16, Semarang Rose experiences a great reduction in weight loss because of its perishables. This was proved by Wills *et al.* (1981), which reported that mechanical damage to tissue is another factor that can greatly accelerate the rate of water loss from fruits.

Colour

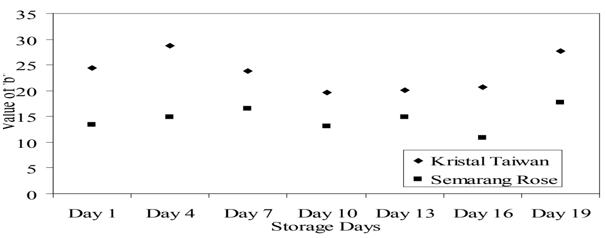
Colour is the most obvious change and the major important characteristic used by consumers to evaluate whether the fruit is ripe or unripe (Wills *et al*., 1981). Therefore, colour is a primary indicator of maturity or ripeness of fruit (Pantastico, 1975). It is also an important parameter to distinguish between cultivars. The experimental results for the colour changes in the skin of Kristal Taiwan and Semarang Rose during ripening at 10°C and 40-50% RH storage temperature are shown in Figure 2(a)-(c). The value of 'L' ranged from 41.57 to 48.03 (Kristal Taiwan) and 32.03 to 38.23 (Semarang Rose). The value of 'a' or greenness ranged from 4.10 to 10.70 (Kristal Taiwan) and 13.27 to 17.9 (Semarang Rose). The value of 'b' or yellowness ranged from 19.60 to 28.77 (Kristal Taiwan) and 10.93 to 17.67 (Semarang Rose).



(a) 'L' values



(b) 'a' values



(c) 'b' values

Figure 2. Changes in skin colour of the water apple cultivars Kristal Taiwan and Semarang Rose during storage at 10°C and 40-50% RH

The result also shows that there is no significant difference of 'L', 'a' and 'b' values between Kristal Taiwan and Semarang Rose during storage. It means that there are no colour changes of the fruits during storage and colour of the fruits during harvesting remain the same as in their storage. This may be because of the ripening process of the fruit was slow at low temperature. The trend was similar to oranges (Singh and Reddy, 2006). According to Rukayah (1992), which indicated that the water apple is non-climacteric fruits, it undergone little or no desirable change in composition after harvest and must be harvested until its fit for consumption. The fruits harvested from the same tree will not undergone ripening process at the same time.

The Skin of Kristal Taiwan has higher 'L' or lightness values the Semarang Rose. The results show that 'a' or redness values of skin Semarang Rose is higher than Kristal Taiwan. That's mean the skin Semarang Rose is red in colour, while, the skin Kristal Taiwan is green in colour. From Figure 2 (c), the results show that 'b' or the yellowness values of the skin of Semarang Rose is lower than Kristal Taiwan. This is because the yellowness of skin of Kristal Taiwan is higher than Semarang Rose. In conclusion, the skin of Kristal Taiwan is light and green in colour while the skin of Semarang Rose is red in colour.

Chemical properties

Proximate analysis

The result shows that the moisture content values are similar for both cultivars, 90.54 to 92.58% (Kristal Taiwan) and 90.66 to 92.41% (Semarang Rose). The moisture content of both water apple cultivars was decreased during storage. These values were close to those values reported by Salah and Dilshad (2001). The decreasing trend of the moisture content may due to the degenerative changes of the skin resulting from both respiration and transpiration sources (Aina, 1990).

The result shows that the ash content varies between 2.84 to 3.41% (Kristal Taiwan) and 2.77 to 3.26% (Semarang Rose). The fat content varies between 0.12 to 0.07% (Kristal Taiwan) and 0.10 to 0.08% (Semarang Rose). The fiber content value ranges between 4.68 to 5.61% (Kristal Taiwan) and 3.92 to 5.21% (Semarang Rose). The results show that ash, fat and fiber experience a very small change during storage. This can be explained by Rukayah (1992), as reported previously. Both cultivars have similar content of ash, fat and fiber content during storage. The protein content ranges between 4.11 to 5.61% (Kristal Taiwan) and 4.00 to 5.12% (Semarang Rose). There were no significant different between both cultivars. The protein contents of both cultivars decrease significantly ($p<0.05$) during storage. The decline of protein content in fruits was explained as the breakdown of protein during senescence, which supported the idea that proteins in ripening fruits are enzymes required for the ripening process (Frenkel *et al*., 1968). Ripening changes of protein have been previously reported in other fruits (Marin and Cano, 1992; Salah and Dilshad, 2001).

Total soluble solid

Figure 3 shows that the results of total soluble solid (TSS) of Kristal Taiwan (5.9-9.6°Brix) and Semarang Rose (5.2-9.0°Brix).The result indicates that the values of TSS of Kristal Taiwan were slightly higher than that of Semarang Rose. The high maximum total soluble solid content indicates that the fruit is at the ripe stage and similar as those reported previously for banana (Munash and Mendoza, 1990), guava (Bashir and Abu-Goukh, 2003) and sweet peppers (Tadesse *et al*., 2002).

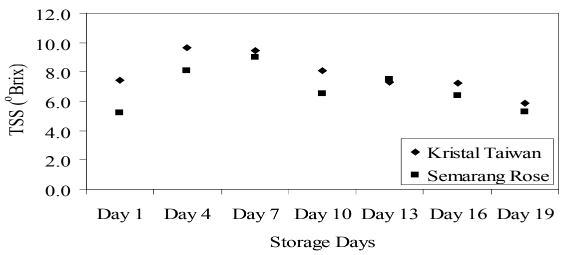


Figure 3. The Total soluble solid of the water apple cultivars Kristal Taiwan and Semarang Rose during storage at 10°C and 40-50% RH

The TSS of Kristal Taiwan is increases from 7.4 to 9.6 °Brix during early storage but it starts to decrease at day 4. For Semarang Rose, the TSS increased from 5.3 to 9.0 °Brix during early storage but it started to decrease at day 7. Both cultivars undergone ripening process at an early storage period, hence, the TSS is increasing during the early storage. This can be proven by Drake and Fellman (1987), which reported that the TSS of the fruit depends upon the stage of maturity and the degree of ripening. Sharaf and El-Sundany (1987) also indicated that the increase in the soluble solids content could be attributed to the conversion of starch into sugars. The decomposition of the cell wall will release the water-soluble components causing the increase in the soluble solid content (Rees *et al*,. 1981). While, the drop in total soluble solids may be due to the conversion of sugar in the pulp to alcohol as reported by Dadzie *et al*. (1997).

According to Dadzie *et al*. (1997), in some hybrids, the soluble solids contents increase to a peak and then decline. This increase and decrease in total soluble solids are directly correlated to the hydrolytic changes in starch and conversion of starch to sugar being an important index of ripening process in mango and other climacteric fruit and further hydrolysis decreased the total soluble solids during storage (Kays, 1991; Kittur *et al*., 2001). The observed results are similar to the explanation from Rodrigues (1971) in guava fruit. From Figure 3, the total soluble solid of Kristal Taiwan started to decrease at day 4 while Semarang Rose started to decrease at Day 7. This may be because Kristal Taiwan ripens faster than Semarang Rose therefore, it is perishable earlier.

pH value

Figure 4 shows that the pH values of Semarang Rose (4.44 to 4.63) were higher than Kristal Taiwan (3.84 to 4.12). A lower pH fruit indicates a more sour fruit with high acidity. It can be concluded that the Kristal Taiwan is less sour than Semarang Rose. The pH value of both varieties of water apple was increased with storage period significantly ($p<0.01$). According to Cemeroglu *et al*. (1992), pH is related to the acidic taste of juice. The pH value of water apple increased with the decrease of titratable acidity during storage.

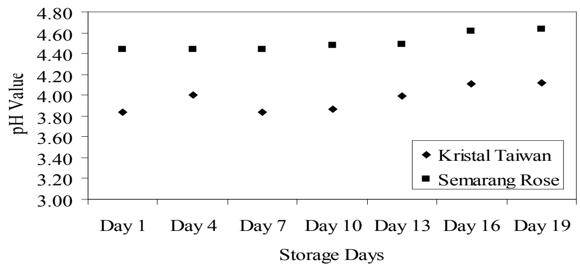


Figure 4. The pH value of water apple cultivars Kristal Taiwan and Semarang Rose during storage at 10°C and 40-50% RH

Freezing point

The freezing point of Kristal Taiwan is in the range of -0.89 to -1.13°C, while for Semarang Rose is in the range of -0.8 to -0.95°C. The freezing points of both cultivars decreased significantly ($p<0.001$) during storage. This may be due to the total soluble solids variation in the water apple during storage. According to Hartel (1992), the higher the level of dissolved solids; the greater the extent of the freezing point depression and the lower the freezing point. Low molecular weight solutes in foods like sugar and salt caused a thermodynamic change in the freezing point of liquid. Hence, it can be concluded that the decrease in the freezing point is due to the decrease in the total soluble solids during storage. Kristal Taiwan exhibited higher freezing point because it contains higher total soluble solids than Semarang Rose. This may be because of the different variety of fruit, maturity stages, water content and TSS content. Freezing points of fruit juices are different from the freezing point of fresh fruits (Wang Jie *et al*., 2003).

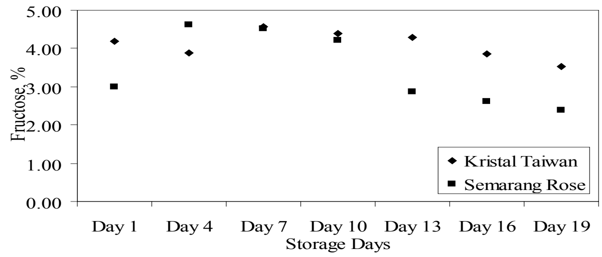
Total acidity

The total acidity of Kristal Taiwan ranges between 0.2-0.25%, while the total acidity of Semarang Rose are between 0.07-0.1%. The Total acidity of Semarang Rose and Kristal Taiwan are slightly decreases during storage ($p<0.001$). According to Wills *et al*. (1989), organic acids usually decline during ripening as they are respired or converted to sugar. Reduction in acidity was mainly due to the result of a decrease in citric acid. Both citric acid and malic acid contents declined during cold storage (Kawada and Kitagawa, 1986). Habib Ahmed Rathore *et al*. (2007) also reported that the decrease in total acidity might be due to the degradation of citric acid. Also the reduction in acidity may be due to their conversion into sugars and their further utilization in metabolic process in the fruit. The lowest total acidity value is found in the Semarang Rose, this explained that Semarang Rose was sweeter than Kristal Taiwan. The acidity content is related to pH value.

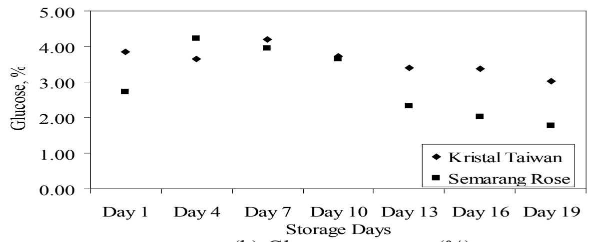
Sugar content

The sweetness of fruit depends to a large extent on its sugar to acid ratio. Hence, an increase in the content of the simple sugar generally brings about a sweeter fruit especially if this is accompanied by a decrease in the organic acid and phenolics content to minimize acidity and astringency (Tung and Nir, 1980). Mowlah and Hoo (1982) showed that glucose, fructose and sucrose were the main sugars in the white- and pink-fleshed guavas. The fructose content was highest in the water apple juice in the range of 7.05 to 9.15% (Kristal Taiwan) and 4.77 to 9.25% (Semarang Rose) as shown in Figure 5(a). That's means; the fructose content is the major sugar contributing to water apple sweetness followed by glucose and sucrose. The glucose content varies between 6.74 to 8.37% (Kristal Taiwan) and 3.53 to 8.26% (Semarang Rose) while the sucrose content varied between 0.19 to 0.36% (Kristal Taiwan) and 0.38 to 1.51% (Semarang Rose) as shown in Figure 5(b) and 5(c), respectively. Fructose, being sweeter than sucrose and glucose, has a desirable influence on the taste of fruits.

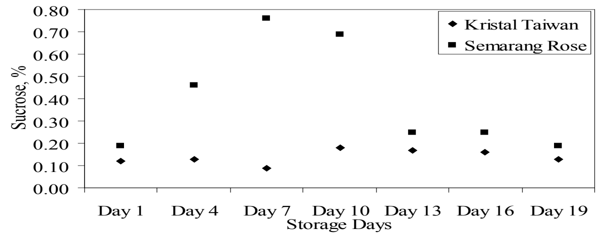
Fructose, glucose and sucrose of Kristal Taiwan and Semarang Rose increased slowly at early storage period but start decreased at day 7. This estimated that water apple ripens at the early stage and start perishable at day 10. These phenomena was proven by Le-Riche (1951), which reported that the level of fructose increased during guavas ripening and then decreased in the over-ripe fruits. Subramanyam and Archarya (1957) also found that the reducing sugars increased during guava ripening and then decreased. According to Bashir and Abu-Goukh (2003), increase in total sugar in guava was attributed to an increase in the activity of enzymes. Starch and sucrose change into glucose during fruit ripening (Wills *et al*., 1981).



(a) Fructose contents (%)



(b) Glucose contents (%)



(c) Sucrose content (%)

Figure 5. Changes in sugar content of water apple cultivars Kristal Taiwan and Semarang Rose during storage at 10°C and 40-50% RH

Fructose and glucose of both water apple cultivars are same, but the sucrose of Semarang Rose is higher than Kristal Taiwan. Total sugar in water apple cultivar Semarang Rose is higher than water apple cultivar Kristal Taiwan (Figure 6). These indicated that the Semarang Rose is sweeter than the Kristal Taiwan.

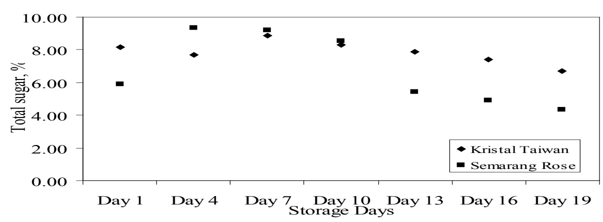


Figure 6. Total sugar content of the water apple cultivars Kristal Taiwan and Semarang Rose during storage at 10°C and 40-50% RH

Conclusion

Physico-chemical changes that occurred in two water apple cultivars at different storage period were analyzed to provide useful information in determining optimum quality of water apples. The main compositional differences between the water apple cultivars were weight, size, colour, total acidity, total sugar content and density. Kristal Taiwan is larger in size and weight but smaller in length compared to Semarang Rose. Peel of Kristal Taiwan is green, yellowish and light in colour; while Semarang Rose is red in colour. Kristal Taiwan is sourer, because it total acidity is higher than Semarang Rose. In addition, its total sugar content is lower than Semarang Rose. In conclusion, Semarang Rose is more sweets and provides a better palatability.

Acknowledgement

We thank to Fundamental Research Grant Scheme (FRGS) for their financial support (Project No: 03-11-08-671FR).

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