Physico-chemical compositions of the red seedless watermelons (*Citrullus Lanatus*)

[1]Yau, E. W., [1*]Rosnah, S., [1]Noraziah, M., [1]Chin, N. L. and [2]Osman, H.

[1]*Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang Selangor, Malaysia*
[2]*Department of Food and Science Technology, Faculty of Science, Universiti Kebangsaan Malaysia, 43600 Bangi Selangor, Malaysia*

Abstract: Changes of physico-chemical properties such as size, weight, moisture content, total soluble solid (TSS), colour, pH, total acidity and sugar content of red seedless watermelon during storage at room temperature (± 28ºC; 70-80% RH) were investigated. The average weight, diameter and length of red seedless watermelon were 5.94 kg, 22.0 cm and 21.8 cm respectively. The length to diameter ratio was 1.02. The statistical analysis indicated that total soluble solids of fruit decreased significantly ($p<0.01$), but no significant changes were found in pH and total acidity during ripening. Weight loss, moisture content and freezing point was found to be increased significantly ($p<0.01$) during ripening. Colour L* was found no significant changes but colour a* and b* increased significantly ($p<0.1$) throughout the ripening process. For sugar analysis, significant changes ($p<0.1$) in fructose and glucose were obtained, but no significant changes were observed in sucrose content during storage time. From the observation, the optimum eating quality of watermelon stored in room temperature (± 28ºC; 70-80% RH) was within one week after harvest, although they can be stored up to 2 weeks. The data obtained is vital in order to apply in different field, purpose and application.

Keywords: Watermelon; size, weight, total soluble solid, colour, sugar

Introduction

Watermelon (*Citrullus Lanatus*) is a rather popular fruit among Malaysians. Watermelon is native to Africa, and it has been cultivated in the Middle East for thousands of years. Watermelon is a warm-season crop and is grown worldwide, usually in regions that have a long warm growing season (Snowdon, 1990). The plants have weak stems and climb by tendrils. Unlike other Malaysian fruits, which hang from tree as tall as 20 to 60 feet, the watermelon fruit ripens on the ground. The fruits are very juicy, with a moisture content of over 90%. Although watermelons are not a rich source of Vitamin C, the level of this nutrient in the fruit comparable to that in imported pears and grapes. The red flesh of watermelon also contains some vitamin A (Anon, 2008).

There is no way of determining with certainty when watermelons are ripe, and harvesting is based on the experience of the growers. Some believe that when the fruit is thumbed and gives forth a dull sound, it is mature. Other criteria are the colour of that part of the fruit that touches the ground, which takes a yellow tinge as maturity approaches. The drying of the tendril at the point of attachment the fruit stem to the vine is also considered a sign of maturity (Avgi Soteriadou, 1969). Because of consumer demand for sweet, flavorful watermelons, total sugar content is an important quality factor. One way to determine field maturity before harvest is to cut a few melons taken from random parts of the field and test their sugar level using a hand refractometer. High quality watermelon should have a sugar content (measured as soluble solid) of 10 percent or more in the flesh near the center of the melon (William, 1999).

There are many watermelon cultivars that vary in shape, colour of the rind, and flesh, and some are seeded and other seedless. The shape of the fruit varies from globular to oblong, whereas the colour of the rind varies in shades of green from a pale yellowish-green to a deep blackish-green. Watermelon has a thin, firm external rind, a layer of white-fleshed internal rind that varies in thickness, and an interior edible flesh. Seeded watermelons have dark brown or black oval seeds, whereas seedless varieties may contain no seeds at all or only very small and thin,

*Corresponding author.
Email: *rosnahs@eng.upm.edu.my*
Tel: +603-89466366; Fax: +603-89464440

jelly-like white seeds. The colour of the flesh varies from yellow, orange, pink, or red in most commercial varieties (Rushing, 2004).

Generally, there are few research and study about watermelon especially the seedless cultivars watermelon. Moreover, there is very little data or information related to changes of watermelon properties during storage time. The storage changes study is important in the designing of equipment for harvesting and post-harvest technology, and in improving the quality and processing characteristic in watermelon processing industry. Thus, the present study is to determine the physico-chemical properties changes of red seedless watermelon during storage at room temperature (± 28ºC; 70-80% RH) and optimum eating quality and storage day at this storage condition.

Materials and Methods

Juice preparation

Red seedless of watermelons was purchased from Selangor, a middle state in Malaysia. They were harvested 65 days after planting which was approximately 30 days after pollination. Harvested fruit were carefully packed and transported immediately to the laboratory and stored at room temperature (± 28ºC; 70-80% RH). At intervals during storage period, three fruits were randomly sampled and analyzed for compositional changes. Each fruit was considered as a replication. Three watermelons were cut and each watermelon was divided into four quadrants. The two quadrants which are opposite each other were diced into cubes and were extracted using juice extractor (Power juicer, Smart Shop^{TM}, US). The juice was prepared to determine the physico-chemical properties of watermelon. Three replications were used for these tests.

Shape, size and weight of fruit

The diameter and length of the watermelon fruit were determined by digital vernier calipers. Watermelon was placed vertically at its most stable position. The diameter of the fruit was recorded at two different locations, which are D_1 and D_2. D_1 was measured at the position as shown in Figure 1 and D_2 was measured at the position after the fruit was rotated 90° around its longitudinal axis. While the length of the fruit, L was determined by measuring the distance between the top portion and the bottom portion. The top portion is the tendril end, whereas the bottom portion is the crown surface of fruit (Figure 1).The weight of the whole fruit was recorded using the electronic balance (HW 200KGL, A and D Platform Scale, Japan). The total numbers of watermelon used for this experiment were 20 pieces. The average values of three replications were reported.

Weight loss

Weight loss of fruit was determined as it is correspond to the amount of water loss in the watermelon. Three watermelons were labeled and weighed prior to storage at room temperature (± 28ºC; 70-80% RH) for 16 days and were weighed again when it is retrieved for calculating percentage of weight loss.

Moisture content

The watermelon flesh was first diced into cubes of about 5mm x 5mm x 5mm size. Moisture content was measured using an oven method according to Association of Official Analytical Chemists (AOAC International) standard (Pearson, 1976). Three replications of all measurements were carried out.

Total soluble solid (TSS)

The total soluble solids content was determined using a digital refractometer (Model AR2008, Kruss, Germany) and the results expressed as ^{o}Brix. All experiments were conducted at room temperature (± 28ºC; 70-80% RH) and three replications of all of these measurements were carried out.

Colour

Colour measurement of watermelon flesh was done in terms of the Commission Internationale de L'Eclairage (CIE) 'Lab' colour space coordinates, where *L* represents the degree of lightness (the light to dark spectrum), *a* represents the green to red spectrum, and *b* represents the blue to yellow spectrum (Ranganna, 1986). The colour of the watermelon flesh was measured at three different locations for each fruit sample. The colour reader (CR-10 Konica Minolta, Japan) was standardized with black and white calibration tiles provided with the instrument before started the experiment. The average values of three replications were reported.

Total acidity and pH

The total acidity and pH of juices were measured using a digital Autotitrator (Model 785 DMP Titrino, Metrohm, Switzerland). 10 ml of sample juice was treated with 40 ml distilled water. The electrode was simply pushed into the sample and measured under stirring. When the

Table 1. Constituents of red seedless watermelon fruit

	Weight (kg)	L (cm)	D_1 (cm)	D_2 (cm)	D_{ave} (cm)	L/D ratio
Maximum	7.64	24.30	23.60	23.40	23.50	1.03
Minimum	3.97	20.70	20.80	20.20	20.50	1.01
Average	5.94	22.75	22.22	21.78	22.00	1.02
Standard deviation	1.00	1.00	0.83	0.85	2.12	0.01

drift value set on the titrator has been reached, the pH value is shown automatically. The mixture is then titrated in the SET mode with c (NaOH) = 0.1 mol/ L to pH=8.5. The titratable acid content up to endpoint (pH=8.5) was recorded and calculated as per cent citric acid. All the experiment was conducted at room temperature (± 28ºC; 70-80% RH) and the average values of three replications were reported.

Freezing point

Freezing point of the juice was determined using a digital freezing point apparatus (Model CryoStar 1, Funke Gerber, Germany). All experiments were conducted at room temperature (± 28ºC; 70-80% RH) and the average values of three replications were reported.

Sugar analysis

Sugar content which includes glucose, fructose and sucrose were determined using High Performance Liquid Chromatography (HPLC) using a Jasco RI-1530 detector and a Jasco PU-1580 pump. The column used to analyze the sample was a 10 um uBondapak ᴹ -NH_2 column (3.9 x 300 m) with NH_2 polar bonded stationary phase. Degassed 80% acetonenitrile was used as a mobile phase. The average values of two replications were reported.

Statistical analysis

Data collected were analyzed using the Microsoft Excel and SPSS statistical software (Version 13, USA).

Results and Discussions

Shape, size and weight of fruit

Table 1 shows that the weight of red seedless watermelon fruit ranges from 3.97 to 7.64 kg and the average weight was 5.94 kg. The average diameter between D_1 and D_2 of red seedless watermelon was 22 cm. The average length of watermelon was 21.8 cm and the average length to diameter ratio is 1.02. According to Modolo and Costa (2004), fruit shape with length to diameter ratio value close to 1 indicate round shape while values higher than 1 indicate elongated shape. Since, the average length to diameter ratio of watermelon is approach to 1, thus, it can be concluded that the watermelon was in a round-shaped. Kerje and Grum (2003) stated that watermelon (*Cucumis melo*), a family of cucumber (*Cucurbitacea*) is large, oval, round or oblong in shape.

According to the Federal Agricultural Marketing Authority of Malaysia (FAMA), the average weight of other varieties of watermelon fruit like Yellow Super was 1.8 kg and Black Boy was 6 kg. From the observations, it was found that the size of the watermelons was quite similar, which ranges from 20.20 to 24.30cm. However, the weight of the watermelons was ranging from 3.97 to 7.64 kg. This may be due to the fact that the fruits harvested have different maturity stage. According to FAMA, the watermelon which was unripe has higher moisture content, thus the weight of the fruits was heavier. At a complete maturity stage, the moisture content of the fruit is reduced, thus the weight of fruit is lighter.

Weight loss

Figure 2 shows that the weight loss of red seedless watermelon increased significantly ($p<0.01$) to 2.0% during storage at room temperature (± 28 ºC; 70-80% RH) for a period of 16 days. The increasing trend was obvious due to the loss of moisture content during storage. This was due to the losses of water vapor through stomata, stem scars and epidermis of fruit. The weight loss of this watermelon is lower than

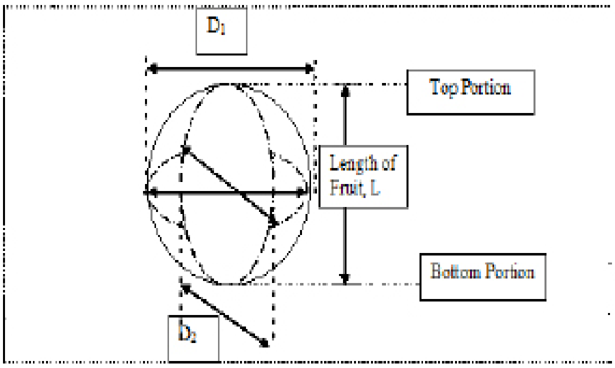

Figure 1. Longitudinal section of watermelon fruit with peel

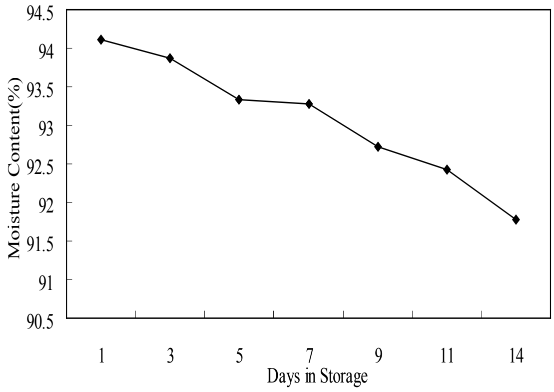

Figure 3. Moisture content of red seedless watermelon during storage

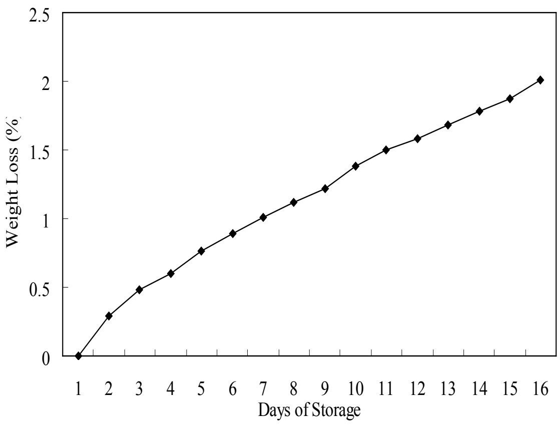

Figure 2. Weight loss of red seedless watermelon fruit during storage

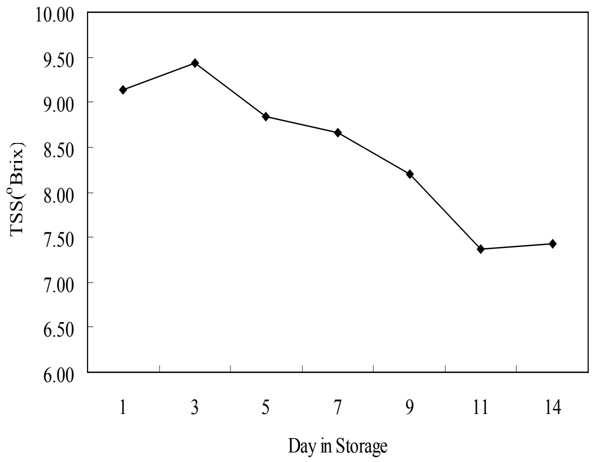

Figure 4. Total soluble solid of red seedless watermelon flesh during storage

other fruit which has been reported such as banana (Nootrudee and Propapan, 2009), mango (Aina, 1990) and orange (Singh and Reddy, 2006). This is due to a wax layer at the outer surface of the watermelon fruit. The wax layer, apart from enhancing fruit appearance, behaves as both moisture and a gas barrier, limiting water loss and thus minimizing weight loss and extending the storage life (Kays, 1991; Pantastico, 1975).

Moisture content

The average moisture content of red seedless watermelon was between 91.8 to 94.1% (Figure 3). These values were in agreement to the value of watermelon reported on the literature which is on average 92% water (Hayes, 1987; USDA, 2003). Flesh crispness is associated with high moisture content (Sargent, 2000). The result shows that, the moisture content was decreased during storage. This was due to the transpiration rate and broken of total soluble solid of watermelon. Broken of total soluble solid is the decreasing of the total soluble solid in fruit during ripening due to the respiration process. According to FAO (1989), respiration is a reaction of all plant, both in the field and after harvest. Fresh produce continues to lose water after harvest, so water content remaining at harvest must be used up.

Total soluble solid

Maturity standards for melons, grape and citrus are often based on the level of soluble solids (Wills *et al*., 1981). According to Maynard (2001), *"sweetness",* one of the prime quality factors in watermelon fruit is related to total soluble solids (TSS). During storage period, the total soluble solid content of red seedless watermelon was decreased significantly ($p<0.01$) from 9.13 to 7.43°Brix (Figure 4). The decreasing in total soluble solid was due to the respiration process of the fruit. Respiration is the oxidative breakdown of the more complex materials such as starch, sugars and organic acids into simpler molecules such as carbon dioxide and water. Picha (1988) stated that the soluble solids contents of watermelon declined after storage for 19 days at 23°C.

The values of TSS was also very low compared to other varieties of watermelon such as Crimson Sweet at about 10.2°Brix and Florida Giant at about 9.6°Brix. It may be due to these watermelons were growing during a rainy season. According to Maynard (2001), the highest TSS in watermelon fruit occurs in seasons of low rainfall. The U.S. Standards for Grades of Watermelons (USDA, 1978) indicates watermelons with 8% TSS as having good internal quality.

Colour

Colour is the most obvious change that occurs in many fruits. Customer always used colour to determine whether the fruit is ripe or unripe. Figure 5 shows the changes value of L*, a*, b* of red seedless watermelon flesh during storage at room temperature. The value of L^* in ranged from 30.0 to 40.1. The result shows that there was no significant difference in L^* values or lightness during storage period. The redness or a^* value ranges from +25.8 to +29.4, while the yellowness b^* value range from +16.8 to +21.2. The values of a^* was increased significantly ($p<0.1$) from +27.2 to +32.2 during the storage period. While the values of 'b^*' was increased significantly ($p<0.1$) from +16.8 to +21.2 during storage period. The value of a^* and b^* were increased due to the colour of the flesh of watermelon intensified within storage period. During storage at 21.1°C, the flesh of watermelon can change their intensive to red colour (Lutz and Hardenburg, 1968). Increase in red colour intensity during storage of watermelons at high temperatures was attributed to the increased synthesis of lycopene (Collins *et al*., 2006; Perkins-Veazie and Collins 2003, 2006). According to Thompson (2003), the flesh of watermelon is juicy and contains many black or brown seeds. The flesh usually can be in dark red, yellow, pink or white in colour.

pH

The pH value of red seedless watermelon juice ranges from 5.10 to 5.34 as shown in Figure 6. The value shows that there is no significant difference during storage period. According to FAO (1989), watermelon is a non-climateric fruit and ripens only while still attached to the parent plant. Generally, the pH value of fruit juice remains fairly constant during ripening and rises during senescence. Its also relates to the spoilage of fruit (Gortner *et al.*, 1967)

Total acidity

The total acidity of watermelon juice ranges from 0.09 to 0.13 % as shown in Figure 7. The result shows that there was no significant difference during storage period. This is due to the watermelon is considered as non-climateric fruit as reported by (Salman-Minkov *et al*., 2008) and acid content does not increase further after harvesting (FAO, 1989). The low titratable acidity was consistent with fruits which show that the watermelons did not acquire a sour taste during storage (Azudin *et al*., 1989).

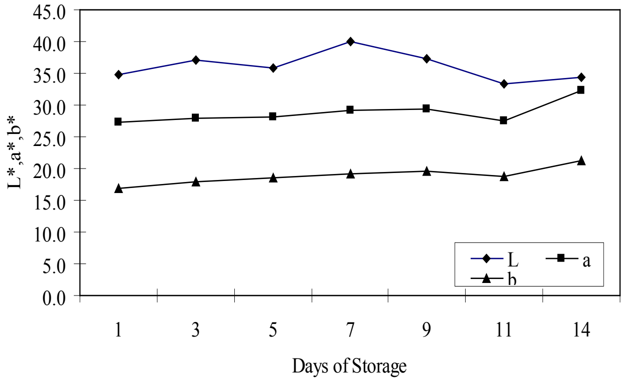

Figure 5. Values of L, a, b of red seedless watermelon flesh during storage

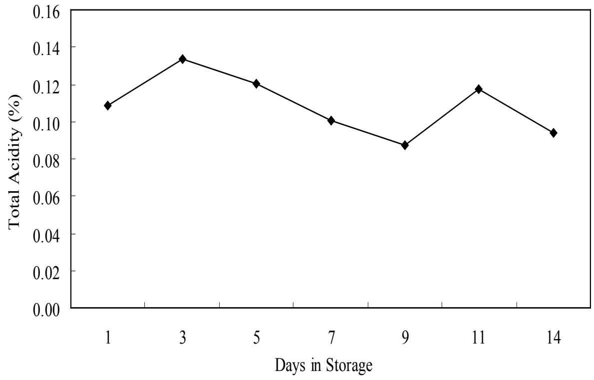

Figure 7. Total acidity of red seedless watermelon flesh during storage at room temperature

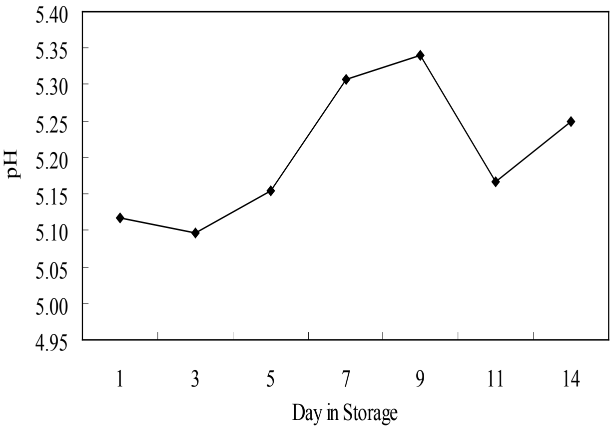

Figure 6. pH of red seedless watermelon flesh during storage

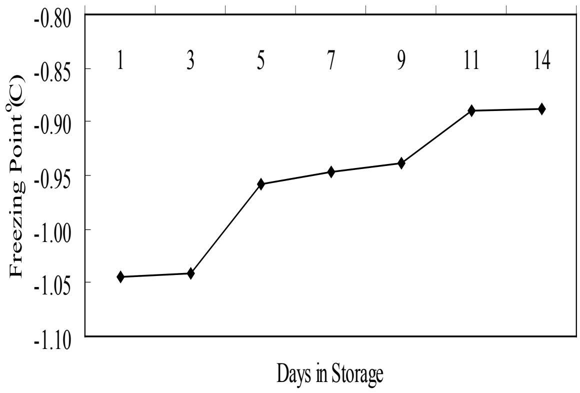

Figure 8. Freezing point of red seedless watermelon flesh during storage

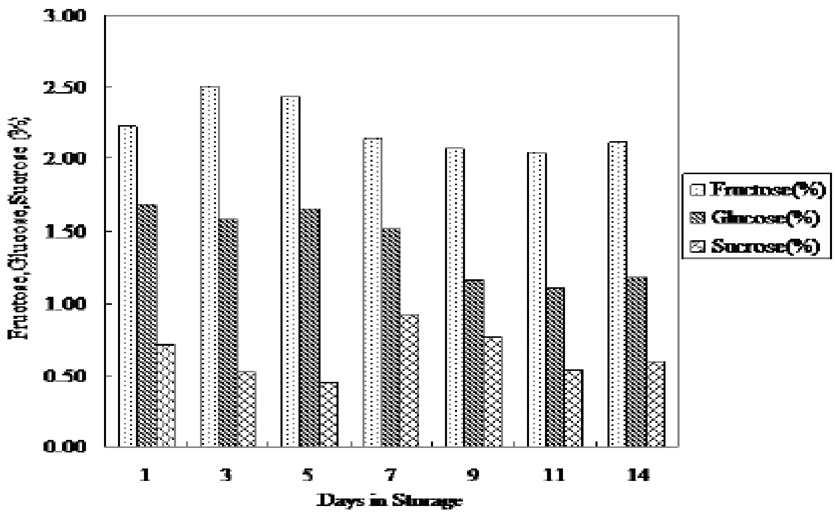

Figure 9. Fructose, glucose and sucrose of red seedless watermelon flesh during storage

Freezing point

Knowledge of freezing point is important for calculating refrigeration requirement or to design of freezing system, frozen food storage facilities and frozen food stability (Heldman, & Lund 1992). Figure 8 shows that the freezing point of red seedless watermelon juice ranges from 0.89 to -1.04°C. The freezing point of watermelon juice increases significantly ($p<0.01$) with storage period from -1.04 to -0.89°C. It is due to the total soluble solid content in the watermelon fruit. When the level of dissolved solids higher, the freezing point depression will be greater and thus lowered the freezing point (Hartel (1992). The flesh will freeze at about -1.7 to -1.4°C (Wright 1942). According to Hayes (1987), the freezing point of watermelon fruit is between –1.6 and –2.0°C at a moisture content of 92%. The value of freezing points of fruit juice and fresh fruits are different (Wang Jie *et al*., 2003).

Sugar analysis

Figure 9 shows that the percentage of fructose, glucose and sucrose of red seedless watermelon during storage at room temperature ranges from 2.04 to 2.51%, 1.10 to 1.68% and 0.44 to 0.92%, respectively. The amount of sugars present were in the order fructose>glucose>sucrose. According to Elmstrom and Davis (1981), cultivars or maturity that results in high fructose concentrations is a desirable feature since the relative sweetness of fructose is greater than that of sucrose. The relative concentration of these sugars is important since they vary in perceived sweetness.

In the process of fruit being mature, the percentage of sugar content is increased (Will *et al.,* 2004). From Figure 9, we can observed that the percentage of fructose and glucose content were higher than that of sucrose. Fructose and glucose are the predominant sugars in immature watermelon; the content increases during fruit development until about 20-36 days after anthesis and then decreases in fully mature fruit (36-48 days after anthesis, depending on the cultivar). Sucrose, however, was not evident before 20-24 days after anthesis, but thereafter sucrose content increases rapidly, becoming the main sugar in fully mature fruit (Nunes *et al*.,2008). The total sugar content increases until 32 days after anthesis and decreases slightly in fully mature fruit (Elmstrom and Davis 1981a, 1981b).

Conclusions

The experimental results indicate that there are significant changes in physico-chemical compositions of red seedless watermelon fruit except for pH and total acidity during the storage period of 16 days at room temperature (± 28ºC; 70-80% RH). TSS, moisture content and sugar analysis data are important in the designing of equipment for harvesting and post-harvest technology such as maturity detector. These three properties is an indication of the maturity of a fruit. Besides that, information about properties changes can also be used in improving the quality and processing characteristic for fresh watermelon mechanization and processing industries.

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