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Physico-Chemical Changes in Muskmelons (*Cucumis melo,* L.) during Storage

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ABSTRAK

*Buah muskmelon (*Cucumis melo, *L., cv. Asuka) yang ditanam dalam sistem hidroponik dituai pada hari yang ke-37 selepas antesis dan disimpan pada suhu bilik (25 – 28^{O}C) pada 6 – 8^{O}C. Ciri-ciri fisiko-kimia buah semasa penstoran ditentukan. Perubahan utama kerosakan yang menghadkan penstoran pada suhu bilik ialah kelembutan buah. Buah yang disimpan pada suhu bilik mempunyai jangka masa penstoran lebih kurang 5 hari tetapi buah yang disimpan pada suhu 6 – 8^{O}C tahan selama 3 minggu. Nilai pH dan keasidan buah tidak banyak berubah semasa penstoran. Terdapat sedikit kekurangan dalam kandungan jumlah pepejal terlarut dan jumlah gula terlarut semasa penstoran.*

ABSTRACT

*Fruits of muskmelon (*Cucumis melo, *L. cv. Asuka) grown under hydrophonic condition were harvested 37 days after anthesis and stored at room temperature (25 – 28^{O}C) and at 6 – 8^{O}C. The physico-chemical characteristics of the fruits during storage were evaluated. The major limiting deteriorative change during storage at room temperature was softening of the fruits. Fruits stored at room temperature had a shelf-life of about 5 days while those stored at 6 – 8^{O}C were acceptable for 3 weeks. The pH and titratable acidity did not change much during storage. There was a slight decrease in total soluble solids and total soluble sugars during storage.*

INTRODUCTION

There are a large number of muskmelon (*Cucumis melo*, L.) cultivars. Work done on different cultivars have shown that there are marked differences in growth patterns and ripening physiology of muskmelon. There are obvious differences in colour, flavour and shape. In addition, the quality of one cultivar can vary with locality (Pratt, 1971; Yamaguchi *et al.*, 1977).

Work on various aspects of ripening and post-harvest technology of different muskmelon cultivars have been carried out. Studies on fruit development in muskmelon (cv. Hara Madhu) showed that optimum fruit quality occurred 28 – 30 days after flowering (Srinivas *et al.*, 1983). However, Bianco and Pratt (1977) found that fruits of muskmelon (cv. Honey Dew and Powdery Mildew Resistant No. 45) rapidly accumulated sugars between 28 and 42 days after anthesis and suggested that early harvest of muskmelon would lead to loss of quality. Evenson (1983) found that muskmelons picked at the green full-slip stage of maturity had higher total soluble solids and ascorbic acid content than those harvested at the half-slip or yellow full-slip stages of maturity. Fruits harvested at the green full-slip were superior to fruits harvested at the half-slip or yellow full-slip stages of maturity for short term storage of 2 weeks. Niculescu and Kasmire (1980) stored muskmelon (cv. Casaba) harvested at 4 maturity stages (green, green/yellow, yellow and very yellow) at 5^{O}C, 10^{O}C and 12.5^{O}C and concluded that melons harvested at the green/yellow stage were best for storage. Andre *et al.*, (1982) recommended that cantaloupe melons should be picked at the "green-turning" stage and stored at 4°C in sealed polyethylene bags in a controlled atmosphere with < 2% O_2

During storage of 6 muskmelon cultivars (Roadside, Superstar, Classic, Harvest Pride, Star Headliner and Star Trek), Evenson (1983) found that there was no evidence of chilling injury on melons harvested at the half-slip, green full-slip or yellow full-slip stages of maturity stored for 2 weeks at 0°C and 1 day at 13°C. However, Lipton (1978) found that muskmelon (Honey Dew) developed chilling injury, which was characterized as a reddish-tan surface discolouration, when stored at 2.5°C for about 2½ weeks. Chilling injury was absent in fruits stored at 5°C (Lipton, 1978). Ethylene treatment was found to reduce the incidence of chilling injury (Lipton and Aharoni, 1979). Bhatnagar and Singh (1982) found that muskmelons could be stored at their room temperature (32 ± 8°C) for up to 8 days or at 4°C for up to 25 days.

There appears to be much variability between muskmelon cultivars. The growing conditions of the fruit affects the muskmelon characteristics. The total soluble solids content of the muskmelon is affected by light intensity and rainfall (Bouwkamp *et al.*, 1978). The % soluble solids in the fruit increases with increasing salinity levels (Shannon and Francois, 1978). It is also affected by physical soil properties (Davis and Schweers, 1971). Soil moisture was found to be negatively correlated with soluble solids content of the muskmelon (Wells and Nugent, 1980).

Muskmelon has been grown in Malaysia under hydrophonic conditions. There has been no published work on the post-harvest storage of these fruits. In this study, the physico-chemical characteristics of muskmelon (cv. Asuka) grown under hydrophonic conditions were evaluated.

MATERIALS AND METHODS

Fruit Samples and Storage

Muskmelon fruit (*Cucumis melo* L., cv. Asuka) were obtained from the Hydrophonics Unit of Universiti Pertanian Malaysia. All fruits used for the storage study were grown under hydrophonic conditions. They were harvested 37 days after anthesis. This harvest date was considered the usual time for harvesting muskmelons of this variety grown under hydrophonic conditions. The fruit had not reached the 'full-slip' stage by this time although the net was already well formed. Fruits were put into their respective storage temperatures (i) room temperatures (25° – 28°) and (ii) cold room (6° – 8°C) within 3 hours after harvest. The humidity was not controlled.

Analyses

At intervals during the storage period, a random sample comprising of 6 muskmelons were taken for analyses. Each fruit was quartered. Two opposite quarters were handpeeled. The seeds were removed and the pulp homogenized in a Waring Blender. The two remaining quarters were used for texture measurements.

pH value and Titratable Acidity

25 g of homogenized pulp was transferred into a 100 ml volumetric flask and made to volume with distilled water. The filtered solution was used for measurement of pH with an Orion PT1 – 15 Digital pH meter and for determination of titratable acidity (A.O.A.C. 1975).

Total Soluble Solids

The soluble solid was measured using an Erma Hand Refractometer. The results are reported as % total soluble solids.

Sugar Determination

The method for sugar determination by HPLC was based on that of Wills *et al.* (1980). 5 g of homogenized pulp was extracted with 100 ml hot 85% methanol for 20 min. The mixture was filtered and the residue re-extracted twice with 25 ml volumes of hot 85% methanol. The extracts were combined. Methanol was stripped off using a rotary evaporator. The remaining solution was made up to 10 ml in a volumetric flask. Portions of the extract were filtered through a C-18 Sep Pak Cartridge that had been pretreated with water and methanol. The first 2 ml of the filtrate was discarded and the remaining filtrate was filtered through a 0.45μm Millipore filter prior to HPLC analysis. For recovery studies, 2 ml of a standard solution containing known amounts of fructose, glucose and sucrose was added to the homogenized pulp and the extraction carried out as above. The recoveries were calculated using the difference between the amount determined in spike samples and that obtained for samples without added sugar.

A HP 1084B liquid chromatograph with an RI detector was used. The column was an NH_2 polar bonded phase, 10μm column (250 mm x 4.6 mm I.D.). The mobile phase was acetonitrile : water (85 : 15). The flow rate was 2.5 cm min $^{-1}$ while the injection volume was 10μl. Quantification of each of the sugars was obtained by comparing peak areas of samples to peak areas of the standards as peak area was directly proportional to the concentration of the standard throughout the concentration range used. The percent recovery of added fructose, glucose and sucrose was in the range of 99 – 107%. The higher than 100% recovery may have been caused by an impurity which elutes at the same time as the sugar.

Texture

Only the middle cross-sectional portions of muskmelon fruit were used because of the possibility of gradients in texture within the fruit (Mutton, 1977). Portions of about 3 cm near both ends of the fruits were discarded. The mesocarp was sliced to 2 cm thickness with a food slicer and then cut into cylinders using an apple corer with a cross-sectional area of 4.0 cm^2.

A value approximating the rigidity modulus (G) of the mesocarp was obtained according to the method of Smidsrod and Haug (1972). The force deformation curves were obtained by using parallel plate uniaxial compression of an Instron Universal Testing Machine (Model 1140). The flat surfaces of the cylindrical sample was placed between 2 flat plates and one of the plates was made to move at a preselected constant speed of 5 cm per min. The force developed was recorded as a function of deformation (crosshead displacement).

The samples were assumed to be homogenous, isotropic and to undergo upright cylinder deformation, where the area of contact expands. Friction between the plates and the surfaces of the very moist fruit can be considered negligible as the water/juice acts as a lubricant. The G value reported is the average value of 5 cylinderical samples taken from the fruit. The yield force (Y) is taken as the force required to rupture the fruit.

RESULTS AND DISCUSSION

All fruits were green and of firm texture with little aroma on the day of harvest. During room temperature storage, most fruits showed signs of yellowing and softening with the development of a pleasant aroma on day 3 of storage. The degree of yellowing and the development of the pleasant aroma was more pronounced on day 5 but there was evidence of softening. However, most fruits were still acceptable. By day 7 at room temperature storage, the fruits become unacceptable as they had very soft pulps and a dehydrated appearance. Fruits kept in the cold room maintained an acceptable appearance for 3 weeks. Initial signs of dehydration of fruits stored in the cold room appeared on the 22nd day of storage. In addition, signs of chilling injury as evidenced by the presence of water-soaked regions of the pulp became evident on the 22nd day.

The results of the physical chemical characteristics of fruits during storage are given in Table 1.

pH and Titratable Acidity

The pH and titratable acidity of the fruits did not change appreciably during storage. The range in pH (pH 5.7 – 6.2) and the low titratable acidity were consistant with the qualitative organoleptic assessment of fruit which showed that the melons did not acquire a sour taste during storage. Previous workers have indicated that it is rare to have truly sour melon (Mutton *et al.* 1981).

Total Soluble Solids and Sugar Content

There was a slight decrease in total soluble solids and total sugars when muskmelons were stored. The decrease in total sugars may be attributed to the utilization of sugars, mainly as glucose, for respiration. Muskmelons do not have the facility for synthesizing sugars during storage because they do not have starch reserves (Bianco and Pratt, 1977).

It is noted that the % total soluble solids and sugar content is very low in these muskmelons eventhough they were picked 37 days after anthesis. Hydrophonic muskmelons have only been introduced in this region in the last 3 – 4 years. As the legal limit of 9% soluble solids content for U.S. No. 1 grade muskmelons, does not apply

TABLE 1

Physico-chemical characteristics[a] of muskmelon (cv. Asuka) during storage

Temperature	Days after Harvest	pH	Titratable acidity ml 0.1N NaOH/100g	Total soluble solids %	Fructose	Glucose	Sucrose	Total	Rigidity Modulus(G) $Nm^{-2}x10^5$	Yield (Y) $Nm^{-2}x10$
					g/100g					
Room Temperature ($25^o - 28^0C$)	0	5.80 ±0.09	25.6 ±2.8	5.4 ±1.2	1.23 ±0.19	1.28 ±0.22	1.23 ±0.59	3.73 ±0.86	5.2 ±1.5	3.9 ± 1.1
	3	6.23 ±0.16	19.6 ±4.4	4.4 ±0.8	1.07 ±0.11	0.92 ±0.10	1.45 ±0.53	3.44 ±0.53	1.5 ±0.7	0.3 ± 0.1
	5	5.85 ±0.33	24.4 ±6.4	4.6 ±0.7	1.10 ±0.16	0.79 ±0.25	1.32 ±0.59	3.22 ±0.55	2.3 ±1.0	0.7 ±0.6
Cold Room ($6^o - 8^oC$)	0	5.80 ±0.09	25.6 ±2.8	5.4 ±1.2	1.23 ±0.19	1.28 ±0.22	1.23 ±0.59	3.73 ±0.86	5.2 ±1.5	3.9 ± 1.1
	3	5.88 ±0.26	27.2 ±3.2	5.1 ±1.1	1.17 ±0.22	1.18 ±0.19	1.21 ±0.64	3.54 ±0.90	2.8 ±0.8	2.2 ± 0.8
	5	5.74 ±0.07	29.2 ±4.8	4.8 ±0.7	1.07 ±0.04	1.06 ±0.10	1.20 ±0.51	3.33 ±0.52	2.4 ±0.9	2.0 ± 1.0
	8	5.81 ±0.11	25.2 ±4.0	5.0 ±1.5	1.08 ±0.20	1.06 ±0.23	1.32 ±1.02	3.37 ±1.22	3.0 ±0.7	1.9 ± 0.6
	12	5.85 ±0.04	23.6 ±4.0	4.7 ±0.6	1.01 ±0.16	0.94 ±0.14	1.05 ±0.43	3.00 ±0.65	2.6 ±0.7	2.0 ± 0.5
	18	5.79 ±0.07	24.4 ±2.8	4.7 ±0.3	1.18 ±0.06	1.07 ±0.04	1.13 ±0.25	3.38 ±0.32	2.1 ±0.7	1.7 ± 0.7
	22	5.80 ±0.10	29.6 ±5.2	5.0 ±0.5	1.11 ±0.06	0.97 ±0.12	1.08 ±0.36	3.16 ±0.04	1.9 ±1.0	0.9 ± 0.7

[a]Each entry is the mean of 6 fruits ± S.D.

here, these muskmelons have been marketed successfully at local retail outlets. In addition, the sucrose/(fructose + glucose) ratio on the day of harvest was about 0.49 which is also much lower than the values of 1.5 and 5.0 for melons of the cultivar 'Honeydew' and PMR 45 obtained from interpolation of graphical data (Pratt 1971).

There is a marked correlation between sugar content (glucose + fructose + sucrose) and % total soluble solids. The correlation coefficient was found to be 0.88 for 62 pairs of readings. The observation that the values for % total soluble solids were higher than % sugar suggested that components other than glucose, fructose and sucrose contribute to the % total soluble solids. Although Pratt (1977) found that 97% of the total solids in maturing melons were in the form of sugar, he mentioned that while his total soluble solids agreed with that of another researcher (Rosa 1928), the latter sugar values were lower. It may also be possible that the contribution of components other than sugars to the % total soluble solids is affected by the turgidity and water retention in muskmelons.

Variation in Individual Sugars

There are variations in individual sugars and the relative concentrations of glucose, fructose and sucrose during storage (Tables 1 and 2). The rate of decrease in glucose concentration is markedly faster at room temperature than in the cold. Although there are variations in fructose content during storage, these were not as pronounced as those in glucose content. It was difficult to ascertain any trend in sucrose content during storage as there are large differences in sucrose content of individual fruit on the same day of storage and under the same storage conditions.

Trends in sugar changes became more evident when the relative changes in individual sugars for individual fruit were considered. There was an obvious trend of increasing fructose/glucose ratio during storage which may be rationalized in terms of glucose rather than fructose, being the conventional substrate for respiration. There were insignificant variations in sucrose/(fructose + glucose) ratio during storage in the cold whereas this ratio seemed to increase at room temperature.

Although the interconversions between individual sugars and factors affecting the utilization of sugars in stored fruit are complex, the variations in sugar concentrations may in part be related to an interplay of the relative importance of the action of invertase and the rate of respiration. Invertase, an enzyme which effects interconversion of sucrose to glucose and fructose, has been found to be present in muskmelon (Arasimovich; 1939).

TABLE 2
Relative changes in sugars[a] during storage

Temperature	Days after Harvest	Fructose / Glucose	Sucrose / (Fructose + Glucose)
Room Temperature (25^{o} – 28^{o}C)	0[b]	0.97 ± 0.04	0.49 ± 0.19
	3	1.17 ± 0.11	0.74 ± 0.30
	5	1.47 ± 0.30	0.75 ± 0.38
Cold Room (6^{o} – 8^{o}C)	0	0.97 ± 0.04	0.49 ± 0.19
	3	0.98 ± 0.06	0.56 ± 0.23
	5	1.02 ± 0.06	0.57 ± 0.23
	8	1.03 ± 0.08	0.55 ± 0.43
	12	1.08 ± 0.05	0.54 ± 0.17
	18	1.10 ± 0.05	0.45 ± 0.10
	22	1.21 ± 0.15	0.53 ± 0.17

[a]Each value represents the average of the ratios for 6 different fruits ± S.D.

[b]The value for 0 days of storage is the average for 12 fruits ± S.D.

Texture of Fruit

Muskmelon showed a general decrease in firmness with days of storage (Table 1). This can be numerically quantified by the rigidity or shear modulus (G), and by the yield stress (Y) required to rupture the sample. For both these parameters, the decrease in values are faster in the fruits held at room temperature than those stored in cold room.

Since G is the force required to cause small deformations in the fruit, it measures the cohesive forces between points in the frruit. Protopectin is crosslinked to other polymer chains with calcium bridges and is bound to other sugars and phosphate derivatives. During storage, the breakdown of polymeric carbohydrates, especially pectic substances and hemicelluloses, weakens the middle lamella and the cohesive forces binding the cells together. In addition to polymer size, loss of moisture during storage causes the cells to be more flacid, hence the fruit gives way to deformations more easily than turgid cells.

Y indicates the force required to break the polymer network and this value decreases as the protopectin is gradually broken down to lower molecular weight fractions which are more soluble in water during storage.

The similar trends in G and Y values suggest that there is a correlationship between these two parameters. Both these values have been used for texture measurements. However, each value may related to firmness or rigidity while Y is related to brittleness and crunchiness. However, it should be borne in mind that the Instron can not measure G accurately for ripe melons because the fruits break easily under pressure. Although it is possible that a reduction in the rate of deformation could increase the accuracy, this was not possiblee as the rate used was the lowest for this Instron Model. In view of this, the yield force, Y, would be a more reliable parameter to use for the soft and ripe melons. Work on compressive failure patterns of juicy fruit (Peleg *et al.*, 1976) have shown that in addition to different patterns of compressive failure in different fruit, failure patterns themselves also changed with degree of ripeness.

When a linear regression was plotted for 100 pairs of readings of G against Y, the correlation coefficient was found to be 0.85. The best fitted line is expressed as Y=0.9 (G–46229), the standard error of the slope being 0.5.

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