International Journal of Botany

ISSN: 1811-9700

International Journal of Botany 6 (1): 21-27, 2010
ISSN 1811-9700

Total Aroma and other Quality Factors of Hugo Charentias Melons as Affected by Harvest Date and Refrigeration

N. El-Assi and N. Alsmeirat
Department of Horticulture and Crop Science, College of Agriculture,
University of Jordan, Amman 11942, Jordan

Abstract: The aim of this study was to monitor the changes in the common quality parameters including aroma volatiles of Charentais melon (*Cucumis melo* L.) cv. Hugo fruit occurring after harvest and refrigeration in order to establish a proper harvest date. Fruit were harvested at three stages of development: early ripening, moderately ripe and ripe corresponding to 70, 75 and 80 Days after Sowing (DAS) the seeds, respectively. Testing was performed immediately after harvest and after 5, 10 or 15 days holding under refrigeration at 7°C. External and internal color, firmness, Soluble Solids Content (SSC), Titratable Acidity (TA), weight and aroma were investigated. Date of harvest markedly impacted most of the quality parameters, while holding under refrigeration affected firmness and aroma. Seventy DAS fruit were firmer than 80 DAS, but the later acquired higher SSC and aroma concentration and a larger size. Seventy five DAS fruit were intermediate between both. Holding under refrigeration increased or decreased total aroma volatiles concentration, increased weight loss, decreased firmness, slightly affected color change and had no effect on SSC and TA. It can be concluded, therefore, that harvesting Charentais melons cv. Hugo at 80 DAS might best meet consumer preferences for fruit quality with some doubt that the fruit will withstand the handling and shipping stresses. While harvesting at 70 DAS might very well withstand the shipping stress, the fruit quality may not be acceptable to the consumers. Harvesting at 75 DAS might, therefore, meet both requirements.

Key words: *Cucumis melo*, aroma volatiles, firmness, color, quality

INTRODUCTION

Charentais cantaloupe melons (*Cucumis melo* L. var. *cantalupensis* Naud.) are orange-fleshed fruit with light green striped skin that becomes creamy when the fruit are ripe. The climacteric fruit, distinguished for its fragrance, is characterized by its aroma volatiles as a major quality attribute (Flores *et al*., 2002) and by a rapid ripening rate (i.e., short shelf life), limiting long-distance market commercialization (Flores *et al*., 2007). Determining their optimal harvest time for production of high quality fruit necessitates an understanding of the proper physicochemical parameters associated with consumer preference and acceptance.

Melon fruits, in general, differ in their behavior during ripening, in their patterns of sugar and acid accumulation and in the content and composition of secondary metabolites associated with color, taste and aroma (Perin *et al*., 2002; Burger *et al*., 2006). The most easily observed changes during fruit ripening are those related to color, texture and taste, whereas, the internal changes and taste modification of melons are due to changes in aromatic compounds, organic acids and soluble sugars (Seymour *et al*., 1993). Soluble Solids Content (SSC), although, an important quality parameter, does not guarantee a high quality fruit and thus, should be used in conjunction with flavor (Lester and Shellie, 1992), which is a combination of the basic taste and aroma (Meilgaard *et al*., 1991; Shewfelt, 1993). Aroma is a complex mixture of a large number of volatile compounds with composition specific to species and variety (Sanz *et al*., 1997). The SSC and Titratable Acidity (TA) are often evaluated because of their critical impact on sensory quality. Additionally, some melon (*Cucumis melo* L.) cultivars show an extremely rapid decrease in flesh firmness during ripening, limiting their transport, storage and shelf life (Nishiyama *et al*., 2007). Hence, melon fruit from the US and Central America are harvested at different stages of development to adapt to different transit times (Lester and Saftner, 2008). Harvest of melons at the proper stage of maturity (when SSC is above 8%) is crucial to good eating quality (Lester and Shellie, 1992; Artes *et al*., 1993) and is of fundamental importance, because sugar content does not increase after

Corresponding Author: Najib El Assi, Department of Horticulture and Crop Science, College of Agriculture, University of Jordan, Amman 11942, Jordan

this moment. Therefore, if the fruit is not sufficiently mature when harvested, it will not reach an optimum level of quality when ripened and if it is harvested too ripe, its storage potential will decrease.

Seed sowing date, although governed by many factors including the climatic conditions prevailing in a given region, has been implicated in influencing many crop aspects (Asbagh *et al*., 2009; Naab *et al*., 2005). Harvest date, based on Days after Sowing (DAS) during the estimated ideal time for commercial harvest that coincides with different ripening stages of development, might be utilized as an additional tool, for its simplicity and applicability, to determine the proper date for harvesting high quality produce.

The objective of this research was to study the effect of harvest date and storage on some quality criteria of Charentais cv. Hugo melons including aroma volatiles (esters, alcohols and acetaldehyde). Comparison of the results of the aroma volatile analysis with common quality parameters such as firmness, color, SSC, TA, SSC/TA and weight might shed some light on the most suitable combination of parameters leading to high quality fruit that is acceptable by the consumer and withstands handling and shipping stresses as well.

MATERIALS AND METHODS

Plant materials: Seeds of a commercial hybrid Hugo, French type Charentais melon (*Cucumis melo* L.), were sown in September of 2008 in open fields at two locations, 60 km apart, in the Jordan Valley. Identical standard cultural practices were followed in both locations. Fruits were harvested at three dates (70, 75 and 80 days after sowing the seeds (DAS)) during the estimated ideal time for commercial harvest, corresponding to early ripening, moderately ripe and ripe stages of development, respectively. Forty eight fruit were harvested from each location in each harvest, selected for uniformity in size and freedom from defects to obtain homogeneous samples. The samples were transported immediately to the laboratory, pooled and divided randomly into four treatments with three replicates. Twelve fruit, from each harvest in each location, were assigned for immediate analysis and the remained fruit were packed in standard cardboard melon shipping cartons and placed under refrigeration at 7°C and 85% relative humidity for either 5, 10 or 15 days for simulation of the transportation period.

Quality measurements: Fruit quality was evaluated immediately after each harvest and after 5, 10 and 15 days holding under refrigeration (i.e., twelve testing points were carried out).

External and internal colors of each fruit were determined using a CR-400 Chroma Meter (Minolta, Osaka, Japan) and expressed in the Axiphos GmbH 2002 L* a* b* color space (illuminant D55, 10° view angle, illumination area diameter 8mm). Results were expressed as Lightness (L*), Chroma ($C^* = [(a^*)^2 + (b^*)^2]^{0.5}$) and hue angle ($h_{ab} = \tan^{-1}[(b^*)\ (a^*)^{-1}]$. Four readings were taken for each fruit from four sides, avoiding the ground spot, before cutting the fruit for another four readings for the internal color measurement.

Fruit weight was evaluated after harvest and after each storage period using a Sartorius CP 16001 balance (Frankfurt, Germany).

Weight loss was calculated as the difference between the initial (prior to storage) and final weight (after storage).

Flesh firmness was measured at three equidistant positions on the equator of each fruit using a Penetrometer (Effegi, Milan, Italy) equipped with a 6.5 mm diameter plunger tip after peeling 3×3 cm of the fruit surface and the results were expressed in Newton "N".

Soluble Solids Content (SSC) was measured at 20°C (the samples removed from cold storage were kept at room temperature until adjustment) using a digital refractometer (Atago) expressed as percentage. Two longitudinal slices (from stem end to calyx-end) were taken, core and peel were removed, the remaining tissue was blended and filtered and three readings were recorded and expressed as °Brix.

Titratable acidity was measured according to AOAC (1990), in which 10 mL of juice was titrated with 0.1 N NaOH to pH 8.2 with 1% (v/v) Phenolphthalein and the results were recorded as meq/100 mL.The results were expressed as percent of citric acid.

Sugar/Acid ratio was calculated as °Brix value/acid percentage.

Aroma volatile compounds: Two slices from each fruit sample were taken, peeled, chopped into small cubes and blended for 2 min. The procedure of Scalzo *et al.* (2001) was followed, in which a 10 g sample of the homogenized melon flesh was placed into a 20 mL vial, closed tightly and frozen at -30°C until used. A gas chromatograph-mass spectrometer (GC-MS; Model QP2010-Shimadzu, Japan) with automatic head space sampler (HT 250-LabHut, Italy) and software (GCMSolution V2.4- Shimadzu, Japan) was used. The GC was equipped with a TRB-WAX column (length = 30 m; diameter = 0.25 mm and film thickness = 0.25 μm), with a purge flow rate of 3.0 mL min^{-1}, a column flow rate of 1.0 mL min^{-1} and a total flow rate of 13.7 mL min^{-1}. The column temperature was programmed as follows: 45°C for

8 min, then 6°C min^{-1} up to 100°C. The split injection ratio was 1: 9.7 and injector port temperature was at 200°C. The MS detector interface temperature was at 250°C and the ion source temperature was at 200°C. At the time of analysis, the vials with samples were kept at 80°C for 60 min and then 300 µL of the head-space were injected into the GC. Known concentrations of commercial standards (SIGMA; FL UKA; ALDRICH; SUPELCO; TEDIA; and Riedel-deHaen, USA and Europe) were used to identify and quantify the chromatographic peaks of 12 esters, 5 alcohols and acetaldehyde. However, only total aroma is reported herein for a more relevant and useful correlated with other quality parameters tested.

Statistical analysis: A Randomized Complete Block Design with three replicates of four units each (from each location) was followed in this experiment. Analyses of Variance (ANOVA) were performed using the Statistical Analysis Systems computer package (SAS Institute, 2004, Cary, NC, USA). Treatment means were compared by the Duncan's multiple range test at p = 0.05. Similar results with no consistent statistically significant differences were detected between the two locations, so means presented in this paper are combined averages of the two locations.

RESULTS AND DISCUSSION

Charentais type melon, a climacteric fruit with rapid ripening processes (Hadfield *et al*., 1995), is newly grown at the commercial level in the region. The challenge facing the international agro-food industry and local producers for a successful commercialization of this type of melon is the proper harvest date. Introducing an additional simple and practical factor, namely Days after Sowing (DAS) the seeds, which is used for the first time in melons, coinciding with three ripening stages in a short period of time (19 to 29 days after anthesis) might be an additional tool to guide for the proper harvest date. The results presented herein discuss some common factors of quality along with the aroma volatiles to give a more complete and reliable indication for the quality that is most acceptable by the consumer.

Color: Table 1 shows that no significant differences in L* values of external color were noticed between harvests or subsequent holding under refrigeration except between the initial L* value of fruit of the first harvest picked 70 Days after Sowing (70 DAS) at the early ripening stage and that kept under refrigeration for 10 days (70 DAS-10). No significant changes in external chroma were recorded except a decrease in the second harvest fruit (75 DAS-15) kept under refrigeration and an increase in the 75 DAS-5 and 75 DAS-10 fruit of the second harvest (Table 1). The hue angle of external color significantly decreased with harvest and refrigeration in all fruit of the three harvests (Table 1). Normally, the hue angle can best reflect the changes in the external color (Martinez-Madrid *et al*., 1999). Although, no major significant changes were noticed during refrigeration, but as DAS increased the skin color of the fruit changed from dark green to yellow-green to creamy, hence the decrease in hue angle. Similar changes in external color of muskmelons were reported previously (Shellie, 1999).

Table 1: External and internal color of Charentias Hugo melons harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10, or 15 days

	External			Internal		
Treatments	L*	c	h	L*	c	h
70 DAS	66.2b[1]	2.5bc	221.0a	63.6b-e	26.1ab	67.5a
70 DAS-5	68.2ab	3.7abc	213.5ab	63.1bce	26.2ab	66.8ab
70 DAS-10	69.1a	2.4bc	214.2ab	65.5abc	27.7ab	63.8bc
70 DAS-15	68.4ab	2.0bc	203.3abc	67.5a	21.1b	63.7bc
75 DAS	66.6ab	4.2ab	201.1abc	63.9b-e	31.8a	65.0abc
75 DAS-5	66.8ab	2.6bc	141.6d	64.7a-d	27.7ab	64.8abc
75 DAS-10	66.8ab	1.9bc	171.3bcd	66.3ab	28.3a	63.4bc
75 DAS-15	66.6ab	1.0c	163.8cd	62.4de	31.4a	64.1abc
80 DAS	67.8ab	3.3abc	132.9de	62.9cde	32.0a	65.4abc
80 DAS-5	67.8ab	5.8a	93.6ef	61.1e	31.0a	62.3c
80 DAS-10	67.7ab	6.1a	88.3f	63.8b-e	29.3a	62.3c
80 DAS-15	67.4ab	4.6ab	90.7f	62.4de	25.9ab	63.0c

[1]Means within the same column followed by the same letter are not significantly different at p = 0.05 according to Duncan's multiple range test

The L* values of the internal color showed a significant decrease in the 75 DAS-15 fruit as compared with the 70 DAS fruit (Table 1). Chroma showed no significant changes as a function of harvest time or refrigeration period (Table 1). The hue angle showed a significant decrease only in the 70 DAS -10 and 70 DAS-15 fruit with respect to 70 DAS fruit (Table 1). A decrease in hue angle of 80 DAS fruit and its corresponding storage periods compared with the initial hue angle of 70 DAS fruit (Table 1), indicating that the changes in color might be as a result of ripening advancement, rather than an effect of refrigeration. This has been emphasized by Flores *et al.* (2007) postulating that the development of the orange-colored pulp required that the fruit remain on the plant for an additional few days before harvest. It is possible that these changes are due mainly to the increasing β-carotene concentration, as was reported in ripening orange-fleshed muskmelons (Lester and Eischen, 1996).

Firmness: Flesh firmness showed a steady decline with delaying harvest date and extending refrigeration holding (Table 2). Significant differences in firmness existed among all three harvests as a result of harvest date and

Table 2: Firmness, average weight and weight loss of Charentias Hugo melon harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10, or 15 days

Treatments	Firmness (N)	Average weight (g)	Weight loss (%)
70 DAS	71.3a[1]	765.7de	0.0
70 DAS-5	68.6a	709.0f	2.5
70 DAS-10	66.7a	734.2ef	3.4
70 DAS-15	59.2bc	741.6ef	3.9
75 DAS	63.9ab	841.8c	0.0
75 DAS-5	57.9bc	850.8c	2.3
75 DAS-10	57.2bc	807.2cd	2.9
75 DAS-15	55.0c	786.3de	3.4
80 DAS	51.7c	862.6bc	0.0
80 DAS-5	42.6d	950.0a	1.9
80 DAS-10	31.6e	909.5ab	2.2
80 DAS-15	30.4e	860.8bc	2.8

[1]Means within the same column followed by the same letter are not significantly different at p = 0.05 according to Duncan's multiple range test

refrigeration (Table 2). The highest rate of firmness loss occurred in the 80 DAS-5, 80 DAS-10 and 80 DAS-15 with respect to all other treatments. A 12% decline in the average firmness values was observed between the 70 and the 75 DAS fruit, a 34% decrease between the 75 and 80 DAS and a 42% decrease between the 70 and 80 DAS fruit, collectively. While, firmness loss reached up to 42% under refrigeration. These firmness losses are comparable with Portela and Cantwell (1998), reporting a 28% decrease in cantaloupe pieces stored at 5°C for 12 days and Saftner *et al.* (2006), reporting a decrease between 20-50% in all muskmelon genotypes tested.

Size: The size of the fruit, measured by its weight, increased with delaying harvest time. The average weight of the 75 and 80 DAS, collectively, increased 11 and 21%, respectively, as compared to that of the 70 DAS fruit (Table 2). These results are in agreement with previous work reporting a considerable increase in weight noticed during ripening (Villanueva *et al.*, 2004).

Weight loss: The first 5 days in storage resulted in higher rate of weight loss in all stored fruit of the three harvests (Table 2). Beyond that, the weight loss rate declined as lower values were obtained for the 80 DAS fruit, collectively (Table 2). In a previous report by Miccolis and Saltviet (1995) the fruit weight loss was under 3% after three weeks of storage at 7 or 12°C but it was around 4% for melons stored at 15°C. In this experiment, it is believed that the size and the well developed rind in the third harvest fruit (80 DAS) might have been the protective factors in resisting the water loss (2.8%) as compared to (3.9%) of the first harvest (70 DAS). These results are in conformity with Flores *et al.* (2007), reporting that water loss was the highest in the youngest fruits of the first harvest. Additionally, weight loss values obtained in this experiment were still below the 5% that is considered as unacceptable for commercial quality (Wills *et al.*, 1982; Lester and Burton, 1986).

Table 3: Total aroma, Soluble Solids Content (SSC), Titratable acidity (TA) and SSC/TA of Charentais Hugo melons harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10, or 15 days

Treatments	SSC (%)	TA (%)	TSS/TA (ratio)	Total aroma (mg/100 g f.w)
70 DAS	8.8c	0.124bc	71.0c	46.3g[1]
70 DAS-5	8.3c	0.117c	70.9c	220.3d
70 DAS-10	8.6c	0.123bc	70.1c	285.1c
70 DAS-15	8.3c	0.121bc	69.1c	167.2e
75 DAS	10.6b	0.129abc	81.9b	172.6e
75 DAS-5	10.8b	0.131abc	82.3b	300.2c
75 DAS-10	10.7b	0.135abc	80.0b	289.4c
75 DAS-15	10.7b	0.133abc	80.9b	100.9f
80 DAS	12.8a	0.141ab	90.5a	264.9cd
80 DAS-5	13.6a	0.149a	91.5a	642.7a
80 DAS-10	12.9a	0.135abc	95.9a	351.9b
80 DAS-15	13.0a	0.136abc	95.0a	375.5b

[1]Means within the same column followed by the same letter are not significantly different at p = 0.05 according to Duncan's multiple range test

SSC: An increase in the Soluble Solids Content (SSC) in the 75 and 80 DAS fruit, with significant differences, was recorded as compared to the 70 DAS fruit of the first harvest (Table 3). The increase was a function of delaying harvest time, while refrigeration for 5, 10, or 15 days resulted in no significant difference among the values obtained (Table 3). Similarly, Miccolis and Saltveit (1995), found that SSC did not change significantly during three weeks of storage at 7, 12 and 15°C plus three days at 20°C for six indoors melon cultivars. It has been reported also that melons harvested immature (prior to full slip) are generally not as high in SSC as those harvested at full slip (Beaulieu *et al.*, 2004). In our experiment, the average SSC increased by 25.9 and 21.5% between the 70 DAS and the 75 DAS fruit and the 75 and 80 DAS, respectively. Moreover, the increase in the average SSC was as high as 52% between the 70 DAS and 80 DAS fruit in matter of 25 days (the difference between the first and the last sampling). These values are higher than a previous work reporting an increase in SSC of 0.3-3.0% between the first (3/4 slip-commercial maturity) and second harvest (full slip-mature ripe) in cantaloupe (Saftner *et al.*, 2006).

TA: The titratable acidity showed some increase but was limited between the 70 and 80 DAS fruit, collectively, as a function of harvest date only, otherwise no significant differences were recorded among all treatments (Table 3). Generally, total acidity was reported to increase, stabilize and decrease during ripening in muskmelon fruit (Villanueva *et al.*, 2004).

SSC/TA: The ratio of the SSC/TA followed the pattern of the SSC increased (Table 3). With increasing the SSC the ratio increase with significant differences among harvests (Table 3).

Total aroma volatiles: The compounds tested were 12 esters, 5 alcohols and acetaldehyde. In general, an increase in total aroma was noticed with delaying harvest date and with extending storage time (Table 3). However, refrigeration for 5 and 10 days resulted in an increase in total aroma in the 75 DAS-5 and 75 DAS-10, but a decrease in 70 and 75 DAS-15 fruit (Table 3). Interestingly, a decrease in total aroma was observed in 80 DAS-10 and 80 DAS-15 but the values remain higher than any of those obtained for the other two harvests. This might indicate that those fruit have a better retention of their aroma volatiles than the other two harvests fruit. The increase in the average total aroma was 1.2 folds in the 75 DAS as compared to the 70 DAS fruit, 1.9 folds in the 80 DAS as compared to the 75 DAS and 2.3 folds in the 80 DAS as compared to that of 70 DAS fruit. It has been reported that aromatic volatile concentrations generally increased during melon maturation and ripening (Beaulieu *et al*., 2004). Present results showed an increase in the total volatile concentration for the first 10 days in storage and then decrease thereafter. In a contrast report, production of aroma volatiles was suppressed at 10 days after storage and then increased toward 15 days of storage in melon cv. Prince Melon (Khanom *et al*., 2003).

CONCLUSIONS

Determining the optimal harvest time for this type of melons should be based on several quality criteria associated with consumer acceptance, since it is crucial to good eating quality (Artes *et al*., 1993; Lester and Shellie, 1992). Hence, several quality parameters such as color, firmness, SSC, TA, SSC:TA, water loss were studied in details for a twelve point-testing experiment. However, it has been reported that SSC above 8% is not always directly associated with melon sweetness, flavor or overall acceptability and it does not necessarily reflect a high quality fruit and should be used in conjunction with flavor (Lester and Shellie, 1992). Thus, total aroma was incorporated with the above parameters, since specific aroma volatiles, mostly esters, were linked to the sweet taste and fruity attribute of fruit flavor (Saftner *et al*., 2006).

The ripening stage of the fruit, a function of harvest date, resulted in noticeable differences in most parameters investigated. Fruit of 70 DAS picked at early ripening stage were with less developed external and internal pigmentation (Fig. 1), low aroma compounds concentration with low SSC (Fig. 2) and high flesh

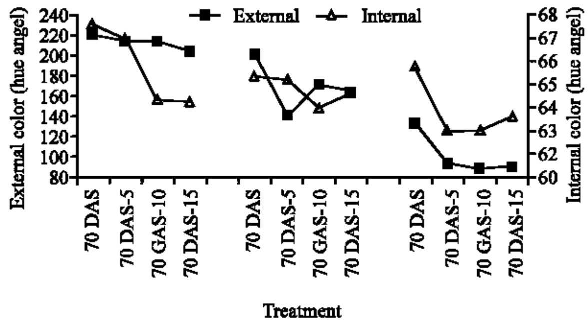

Fig. 1: Changes in external color relative to the internal color in Charentais Hugo melons harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10 or 15 days

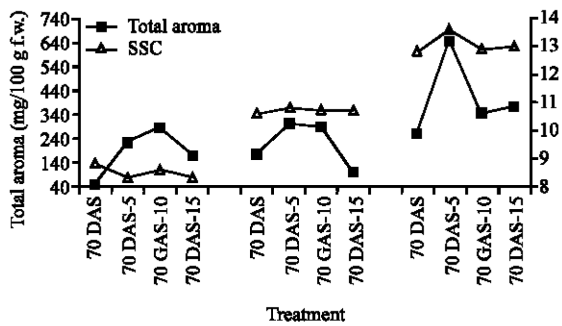

Fig. 2: Changes in total aroma relative to SSC in Charentais Hugo melons harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10 or 15 days

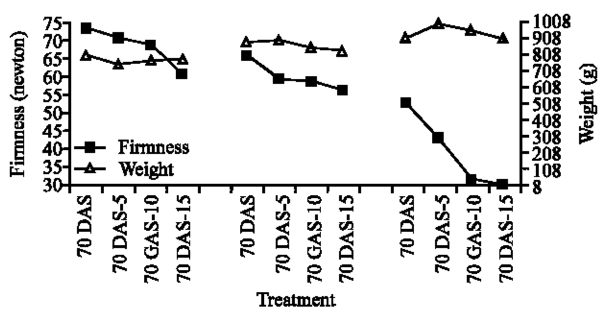

Fig. 3: Changes in firmness relative to the weight in Charentais Hugo melons harvested at 70, 75 and 80 Days after Sowing (DAS), corresponding to early ripening, moderately ripe and ripe stages of development and stored at 7°C for either 0, 5, 10 or 15 days

firmness with a small size (Fig. 3). Whereas, fruit of 80 DAS picked at the ripe stage were with fully developed external and internal pigmentation (Fig. 1), high aroma compounds concentration with high SSC (Fig. 2) and low flesh firmness with a large size (Fig. 3). An intermediate between the two were the 75 DAS fruit picked at moderately ripe (Fig. 1-3). On the other hand, refrigeration resulted in increasing the aroma volatiles, slight increase in color, decreasing firmness and weight, but exerted no effect on SSC and TA. Therefore, Charentias Hugo melons at the ripe stage (80 DAS) can be suitable for the closer destinations markets, whereas at moderately ripe stage (75 DAS) are more appropriate for the furthest destination markets.

ACKNOWLEDGMENTS

This study was funded by the Deanship of Academic Research at the University of Jordan. We would like to thank Professor Jeffrey Brecht for his helpful review of this study.

REFERENCES

AOAC, 1990. Official Methods of Analysis Association of Analytical Chemist. 14th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

Artes, F., A.J. Escriche, J.A. Martineze and J.G. Marin, 1993. Quality factors in four varieties of melon (*Cucumis melo* L.). J. Food Qual., 16: 91-100.

Asbagh, F.T., A.F. Moghddam and A.H. Gottapeh, 2009. Influence of water stress and sowing date on sunflower yield and oil percentage. Res. J. Biol. Sci., 4: 487-489.

Beaulieu, J.C., D.A. Ingram, J.M. Lea and K.L. Bett-Garber, 2004. Effect of harvest maturity on the sensory characteristics of fresh-cut cantaloupe. J. Food Sci., 69: 250-258.

Burger, Y., U. Saar, H.S. Paris, E. Lewinsohn, N. Katzir, Y. Tadmor and A.A. Schaffer, 2006. Genetic variability for valuable fruit quality traits in *Cucumis melo*. Isr. J. Plant Sci., 54: 233-242.

Flores, F., F. El-Yahuaoui, G. de Billerbeck, F. Romojaro and A. Latche *et al*., 2002. Role of ethylene in the biosynthetic pathway of aliphatic ester aroma volatiles in Charentais Cantaloupe melons. J. Exp. Bot., 53: 201-206.

Flores, B.F., F. Romjaro, A. Latche, J.C. Pech and M.C. Martinez-Madrid, 2007. Assay of potential post-harvest handling procedure for Cantaloupe Charentais melon fruit with inhibited ethylene production. J. Sci. Food Agric., 87: 2034-2039.

Hadfield, K.A., J.K.C. Rose and A.B. Bennett, 1995. The respiratory climacteric is present in Charentais (*Cucumis melo* cv. Reticulatus F1 Alpha) melons ripened on or off the plant. J. Exp. Bot., 46: 1923-1925.

Khanom, M.M., Y. Ueda and M. Ishimaru, 2003. Relationship between volatiles and other factors indicating quality of melon (*Cucumis melo* L. Prince Melon) during fruit development and storage. Sci. Rep. Grag. Sch. Agric. Biol. Sci., 55: 7-14.

Lester, G.E. and B.D. Burton, 1986. Relationship of netted muskmelons fruit water loss to postharvest storage life. J. Am. Soc. Hort. Sci., 111: 727-731.

Lester, G. and K.C. Shellie, 1992. Postharvest sensory and physicochemical attributes of honey dew melon fruits. HortSci., 27: 1012-1014.

Lester, G.E. and F. Eischen, 1996. Beta-carotene content of postharvest orange-fleshed muskmelon fruit: Effect of cultivar, growing location and fruit size. Plant Foods Hum. Nutr., 49: 191-197.

Lester, G.E. and R.A. Saftner, 2008. Marketable quality and phytonutrient concentrations of a novel hybrid muskmelon intended for the fresh-cut industry and its parental lines: Whole–fruit comparisons at harvest and following long-term storage at 1 or 5°C. Postharvest Biol. Technol., 48: 248-253.

Martinez-Madrid, M.C., G. Martinez, M.T. Pretel, M. Serrano and F. Romojaro, 1999. Role of ethylene and abscisic acid in physicochemical modification during melon ripening. J. Agric. Food Chem., 47: 5285-5290.

Meilgaard, M., G.V. Civille and B.T. Carr, 1991. Sensory Evaluation Techniques. 2nd Edn., CRC Press, Boca Raton.

Miccolis, V. and M.E. Saltveit, 1995. Influence of storage period and temperature on the postharvest characteristics of six melon (*Cucumis melo* L., Indorus group) cultivar. Postharvest Biol. Technol., 5: 211-219.

Naab, J.B., F.K. Tsigbey, P.V.V. Prasad, K.J. Boote, J.E. Bailey and R.L. Brandenburg, 2005. Effects of sowing date and fungicide application on yield of early and late maturing peanut cultivars grown under rainfed conditions in Ghana. Crop Prot., 24: 325-332.

Nishiyama, K., M. Guis, J.C. Rose, Y. Kubo and K.A. Bennett *et al*., 2007. Ethylene regulation of fruit softening and cell wall disassembly in Charentais melon. J. Exp. Bot., 48: 1281-1290.

Perin, C., M. Gomez-Jimenez, L. Hagen, C. Dogimont and J.C. Pech *et al*., 2002. Molecular and Genetic characterization of non-climacteric phenotype in melon reveals two loci conferring altered ethylene response in fruit. Plant Physiol., 129: 300-309.

Portela, S.I. and M.I. Cantwell, 1998. Quality changes of minimally processed honeydew melons stored in air or controlled atmosphere. Postharvest Biol. Technol., 14: 351-357.

Saftner, R., J.A. Abbott, G. Lester and B. Vinyard, 2006. Sensory and analytical composition of orange-fleshed honeydew to cantaloupe and green-fleshed honeydew for fresh cut chunks. Postharvest Biol.Technol., 42: 150-160.

Sanz, C., J.M. Olias and A.G. Perez, 1997. Aroma Biochemistry of Fruits and Vegetables. In: Phytochemistry of Fruit and Vegetables, Tomas-Barberan, F.A. and R.J. Robins (Eds.). Oxford Science Publications, UK., pp: 313- 329.

Scalzo, R.L., C. Papadimitriu, G. Bertolo, A. Maestrelli and D. Torreggiani, 2001. Influence of cultivar and osmotic dehydration time on aroma profiles of muskmelon (*Cucumis melo*, cv. reticulates Naud) spheres. J. Food Eng., 49: 261-264.

Seymour, G.B., J.E. Taylor and G.A. Tucher, 1993. Biochemistry of Fruit Ripening. 1st Edn., Chapman and Hall, London.

Shellie, K.C., 1999. Muskmelon (*Cucumis melo* L.) fruit ripening and postharvest quality after a preharvest spray of aminoethoxyvinylglycine. Postharvest Biol. Technol., 17: 55-62.

Shewfelt, R.L., 1993. Measuring Quality and Maturity. In: Postharvest Handling: A System Approach, Shewfelt, L. and S.E. Prussia (Eds.). Academic Press, Sn Diego, CA, pp: 99-124.

Villanueva, M.J., M.D. Tenorio, M.A. Esteban and M.C. Mendoza, 2004. Compositional changes during ripening of two cultivars of muskmelon fruits. Food Chem., 87: 179-185.

Wills, R.B., T.H. Lee, D. Graham, W.B. Glasson and E.G. Hall, 1982. Postharvest: An Introduction to the Physiology and Handling of Fruits and Vegetables. AVI Publishing Co., Westport, pp: 34-35.