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Fruit Quality and Aroma Characteristics of a Specialty Red-fleshed Melon (*Cucumis melo* L.), 'Red Moon'

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'Red Moon' is a red-fleshed melon (*Cucumis melo* L.) that is sold as a high quality fruit trademarked "Perfect Melon." The purpose of this research was to determine whether 'Red Moon' fruit quality factors, including aroma volatiles would be altered by harvesting at different stages of fruit development (no-slip (NS), abscission layer development at stem (AL), full-slip (FS)) or by fruit storage (0, 5, or 10 days). The melons were grown in a passively-ventilated high-roof greenhouse in Florida. Data were recorded for days to harvest, fruit size, quality variables (soluble solids content, titratable acidity, pH, firmness), ethylene and respiration rates, and aroma volatiles. On S-0 (S-0), stage NS was firmest (46 N). All other fruit quality variables, ethylene and respiration rates were similar for all stages. After 5 days storage (S-5), overall firmness was decreased from S-0, however stage NS was firmest (17 N). Soluble solids content (SSC) was higher at S-5 than S-0 for stages AL and FS. There were no differences among fruit maturity stages in other quality variables, ethylene or respiration rates at S-5. Following 10 days storage (S-10), all fruit quality variables were reduced compared to S-0 and S-5 treatments, regardless of fruit maturity. There were 15 volatile compounds found to be significant contributors to the aroma of 'Red Moon' at all stages. Volatiles were greatest at S-0 for fruit maturity stages AL and FS. Following S-5 and S-10, total identified volatiles were similar regardless of maturity stage. Overall, volatiles decreased over storage time from 0 to 10 days. 'Red Moon' melons had SSC of 11 °Brix regardless of stage of maturity harvested or duration of storage. The high SSC most likely attributes to their high quality status. To ensure highest fruit quality, it is recommended that 'Red Moon' melons be harvested at stages NS or AL for best firmness and quality.

From 1990 to 2002, the United States had a 27% increase in melon consumption due to the desire of citizens to have healthier eating habits, year-round availability, strong economic growth and improved fruit quality of new cultivars (ERS/USDA, 2003). Since 2002, melon consumption remains high (Lucier and Dettman, 2008). Strong consumer demand has encouraged breeders to introduce new and improved cultivars (Mitchell et al., 2006; Schultheis and Jester, 2004), as they continue their quest for the "perfect" melon.

Among the new cultivars is the 'Red Moon' melon, which is part of a new type of melons, called European netted cantaloupes (J. Ortiz, Nunhems, personal communication, 2008). These melons are characterized by their deep orange/magenta pigmented flesh and their sutured, netted exterior. The 'Red Moon' is related to Nunhems' Magenta type melons ('Magritte', 'Magisto', 'Magenta' and 'Magnat'). The main difference between the 'Red Moon' and other Magenta types is the suture wherein the 'Red Moon' melons do not have a prominent suture (J. Ortiz, Nunhems, personal communication, 2008).

'Red Moon' parental lines orignated from many types of cantaloupes and muskmelons, resulting in confusion of its true horticultural grouping (*cantalupensis* vs. *reticulatus*). However, there are at least four parental lines that are of particular importance: true cantaloupes (*cantalupensis*), Charentais (*cantalupensis*), long shelf-life types (LSL) (*reticulatus*) and U.S. shipping types (*reticulatus*). True cantaloupes or European cantaloupes are smooth-skinned, with prominent sutures and have an aromatic, sweet, (usually) orange flesh (Guis et al., 1998; Kirkbride, 1993). Charentais, which is also a type of true cantaloupe, is the favored melon in France as it is prized for its "divine scent" and "ambrosial flavor" (Goldman, 2002). LSL types are melons known for their extended (20 to 25 d) postharvest shelf-life (Lamikanra et al., 2003). The common U.S. "shipper" melons, such as the 'Harper' hybrid also helped with shelf-life extension (J. Ortiz, Nunhems, personal communication, 2008).

The 'Red Moon' hybrid was bred in France and took about 10 years to develop. New Magenta lines have been released over the past 6 years. 'Red Moon' was bred for taste, with a high soluble solids content (SSC) as a primary objective. Color, appearance, and firmness were secondary features. The breeding goal was similar to that of the super-sweet pineapple (*Ananas comosus*) ('Gold' or 'MD-2')—to create a consistent, excellent, sweet fruit that maintains strong demand (J. Ortiz, Nunhems, personal communication, 2008). 'Red Moon' melons can average SSC as high as 14 °Brix (R. Romero, Chestnut Hill Farms, personal communication, 2007).

'Red Moon' is marketed and trade marked as the Perfect Melon™ to denote a high quality product. It is licensed exclu-

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sively to Chestnut Hill Farms (www.bountyfresh.com), a fruit and vegetable grower/packer/importer/distributor operation based in Miami, FL. Chestnut Hill Farms has produced the 'Red Moon' melons in Central America and Washington State. Other Magenta types are grown in Europe, W. Africa, Latin America, and the United States. The key to achieving the greatest fruit quality depends on production conditions and harvest stage. Good production practices require recognizing the proper time to reduce irrigation and increase specific nutrients. This facilitates fruit to develop maximum sweetness, firmness and flavor. It is recommended that Magenta type melons be harvested when they begin to crack at the abscission layer (J. Ortiz, Nunhems, personal communication, 2008) (Fig. 1).

The present research was conducted to determine whether 'Red Moon' fruit quality factors (soluble solids content, titratable acidity, firmness, aroma volatiles) would be altered by harvesting at several stages of fruit development (NS, AL, FS) or by fruit storage (0, 5, 10 d) when grown in a passively ventilated high-roof greenhouse in Florida.

Materials and Methods

Plant materials and production. Seeds of 'Red Moon' were obtained from Chestnut Hill Farms (Miami, FL) and planted on 31 July 2007. Seedlings were produced according to the methods of Mitchell et al. (2007) at the University of Florida, Gainesville, campus in polystyrene plug trays (Model 128A, Speedling, Bushnell, FL) with a commercial fine-grade plug growing medium (Premier ProMix 'PGX,' Quakertown, PA). A plant growth chamber (Controlled Env. Ltd.,Winnipeg, Manitoba, Canada) was used to grow the seedlings at temperatures of 28 °C (day) and 22 °C (night) with 10-h daily artificial lighting**.** Seedlings were fertilized after the first true leaf expanded, and fertilization continued once per week with Peters Professional All Purpose Plant Food (20N–20P–20K, Spectrum Group, St. Louis, MO) (Mitchell et al., 2007).

Once seedlings had three true leaves (15 Aug. 2007), they were transplanted into pots containing pine bark and grown according to the methods of Mitchell et al. (2007) in a passively-ventilated greenhouse (TOP greenhouses, Ltd., Barkan, Israel) located at the University of Florida Protected Agriculture Greenhouse Complex located at the Plant Science Research Education Unit located in Citra, FL. The plants were grown using commercial greenhouse muskmelon production techniques and nutrient requirements according to the guidelines of Shaw et al. (2001). Plant spacing was 60 cm between plants and 90 cm between rows. Plant density was 2.5 plants/m^2. Pollination was achieved via bumble bees (*Bombus impatiens*, Natupol, Koppert Biological Systems, Inc., Romulus, MI). Insect pests were monitored through weekly scouting of three plants per block; and beneficial insects and arthropods were released both preventatively and augmented to reduce pest populations (Mitchell-Harty et al., 2009).

Fruit selection and postharvest treatments. Fruits were harvested from 11 to 15 Oct. 2007 at three stages: a) a fully mature stage, but prior to the abscission layer development, or no-slip stage (NS); b) at the onset of the abscission layer (AL) development at the stem, ranging from ¼ to ¾ slip; and c) at full-slip (FS). Following harvest, fruits were separated into one of three postharvest storage treatments. The first treatment consisted of melons with postharvest variables measured 12 h after harvest, (S-0). The second treatment was melons stored at 20 °C and 85% RH for 5 d (S-5), and the third treatment was melons stored for 10 d at 20 °C and 85% RH (S-10). Data were recorded for days to harvest, fruit weight, fruit size, ethylene and respiration rates, flesh thickness, flesh firmness, soluble solids content (SSC), titratable acidity (TA), pH and aroma volatiles.

Fruits were harvested in the afternoon, weight and fruit size were recorded, and then fruits were transported 38 km to campus and stored at 20 °C. The next morning, 12 h after harvest, external ethylene and respiration rates were measured from all fruits according to Mitchell-Harty et al. (2009). After ethylene and respiration measurements, fruits from treatment S-0 were removed from storage. S-5 and S-10 fruits remained at 20 °C and 85% RH. Ethylene and respiration rates were measured daily for fruits in the S-5 treatment and only on days 1 and 10 for those in the S-10 treatment.

Fruit quality measurements. Directly following storage for all treatments, fruit quality variables, which included flesh thickness, internal firmness and SSC were measured on fresh fruit according to Mitchell et al. (2007). Internal color was measured on fresh pulp by reflectance with a Chromameter (Minolta-CR-200, Japan). Aroma volatiles were collected from 100 g of fresh pulp according to the methods of Mitchell-Harty et al. (2009) and remaining pulp was frozen at –20 °C for titratable acidity (TA) and pH measurements (Mitchell-Harty et al., 2009).

Statistical analysis. A randomized complete-block design (RCBD) was used with treatments replicated four times (n = 4 fruits/ treatment). Data were analyzed using the GLM procedure (SAS Institute, Version 9, Cary, NC). All data presented were subject to Fisher's least significant difference. Standard error (SE) values were calculated for each ethylene and respiration data point.

Fig. 1. 'Red Moon' melons harvested at onset of abscission layer development at the stem (**left**); and flesh and external netting of 'Red Moon' melons (**right**).

Results and Discussion

Melons from the NS, AL and FS stages averaged 36, 38 and 41 d from anthesis to harvest (DTH), respectively. Agblor and Waterer (2001) reported that melons average 42 DTH. In previous passively-ventilated greenhouse melon trials conducted at the University of Florida, 'Galia'-type muskmelons averaged 44 to 47 DTH in a fall crop and 46 to 52 DTH in a spring crop (Mitchell et al., 2007). 'Red Moon's average DTH indicates this as a fast-growing greenhouse crop. However, temperature and light may have had an effect on fruit growth as higher temperatures and light intensities are known to increase growth rates (Robinson and Decker-Walters, 1999). The average temperature during Aug. 2007 was 33 °C (max: 52 °C; min: 22 °C) with average solar radiation (*PPF*) at 42 μmol·m^{-2}·s^{-1} (max: 1937 μmol·m^{-2}·s^{-1}). In Sept. 2007, the average temperature was slightly lower at 29 °C, but there was a higher maximum (max: 54 °C; min: 20 °C). Average solar radiation (PPF) was also higher in September, at 308 μmol·m^{-2}·s^{-1} (max: 1937 μmol·m^{-2}·s^{-1}). By October, when harvesting started, the average temperature in the greenhouse was lower at 26 °C, as were the minimum (13 °C) and maximum (45 °C) temperatures. However, solar radiation remained high, averaging 127 μmol·m^{-2}·s^{-1}, but with a lower maximum value at 867 μmol·m^{-2}·s^{-1}.

Fruit quality, ethylene, and respiration

S-0. At harvest, stage of fruit maturity had a pronounced effect on fruit weights. Fruits at the AL and FS stages were 30% and 60% (respectively) larger in weight compared to NS fruits (Table 1). Since fruit size did not change during this period, weight gain appeared to correspond with an increase in flesh thickness. Soluble solids content (SSC) was similar at all harvest stages, however firmness decreased appreciably when fruit were harvested at AL and FS stages than at NS. Other quality factors (TA and pH) remained unchanged. Ethylene and respiration rates were nonsignificant (Table 1). Internal color values of chroma (C) and hue (H) were similar between stages (Table 2). Hue angle values for 'Red Moon' indicated the pulp is a dark orange, ranging in hue from 61° to 63° compared to other orange-fleshed melons, where hue ranged from 68° to 86° (Senesi et al., 2005). Lightness (L) values were lower for stage AL and FS fruits, indicating a darker pulp.

Thus, 'Red Moon' melons could be harvested at stage NS to maintain firmness for shipping without reduction of sweetness and other quality factors except fruit weight.

Table 1. Means of fruit quality characteristics at harvest (S-0 treatment) of 'Red Moon' melons harvested at no-slip (NS), onset of abscission layer (AL), and full-slip (FS) stages, Fall 2007.

	NS[z]	AL	FS	LSD[y]
Weight (kg)	1.0	1.3	1.6	0.35
Length (cm)	131	136	145	
Width (cm)	129	137	147	
Flesh thickness (mm)	24.7	35.6	35.2	8.5
Soluble solids content (°Brix)	11.6	11.3	12.3	
Titratable acidity (TA)	0.11	0.12	0.10	0.01
pH	7.01	7.02	6.91	
Firmness (N)	45.5	19.1	10.1	12.0
Ethylene (μL·kg^{-1}·h^{-1})	14.6	20.5	22.5	
Respiration (mL CO_2·kg^{-1}·h^{-1})	15.8	17.3	16.6	

[z]NS= no-slip; AL= onset of abscission layer; FS= full-slip.
[y]Means in rows separated using Fisher's least significant difference (LSD), significance at 5% level.

S-5. After 5 d of storage, no differences occurred between maturity stages in fruit weight or size both prior to and after storage (Table 3), but mean fruit weight loss decreased 1.6% for all fruit. Soluble solids content (SSC) was higher for fruits harvested at AL and FS than NS. SSC after 5 d storage was similar to SSC at harvest. S-5 TA and pH values were similar to results at harvest for fruits in all stages. The firmest melons were stage NS fruits, which were 75% and 120% firmer than stage AL and FS fruits, respectively. NS and AL fruit firmness decreased 62% compared to non stored fruits. Fruits in stage FS only had a 4% reduction in firmness when compared with S-0. Internal color values for chroma (C) and hue (H) were again similar among maturity stages. Color differences were seen in lightness (L) where stage FS fruits had the lowest L value (Table 2).

Ethylene and respiration rates were similar among stages before and after storage (Table 3). Ethylene rates increased 30% by the end of the 5 d storage for stage NS fruits, while stage AL and FS fruits had a 10 and 58% reduction in ethylene evolution, respectively. Respiration rates decreased 12% from S-0 to S-5.

S-10. At the end of the 10 d storage period, fruit weight and size were similar for all fruits (Table 4). However, fruit weight decreased (by the end of storage) 3%, 4.5% and 29% for NS, AL

Table 2. Internal color means of 'Red Moon' melons harvested at no-slip (NS), onset of abscission layer (AL) and full-slip (FS) stages at treatments S-0, S-5 and S-10, Fall 2007.

Harvest	S-0			S-5			S-10		
stage	L[z]	C	H	L	C	H	L	C	H
NS[y]	65.5	40.0	63.0	63.3	39.1	62.1	63.8	39.5	61.4
AL	60.0	38.1	61.7	61.7	38.4	61.6	63.4	38.4	61.4
FS	60.5	39.6	61.7	55.9	35.9	62.0	59.5	32.4	63.4
LSD[x] (S-0, S-5, S-10)	4.33			1.53			1.65	1.44	1.2

[z]L= Lightness expressed on a scale of 0 = black to 100 = white; C= Chroma expressed on a scale of 0 = gray to 60; H= Hue angles of the four primary colors: red, 0°; yellow, 90°; green, 180°; and blue, 270°.
[y]NS= no-slip; AL= onset of abscission layer; FS= full-slip.
[x]Means in columns separated using Fisher's least significant difference (LSD); values represent significance at 5% level within harvest/storage treatments (S-0, S-5, S-10).

Table 3. Means of fruit quality characteristics after 5 d storage at 20 °C (S-5 treatment) for 'Red Moon' melons harvested at no-slip (NS), onset of abscission layer (AL) and full-slip (FS) stages, Fall 2007.

	NS[z]	AL	FS	LSD[y]
Weight (kg)	1.4	1.7	1.6	
Length (cm)	140	144	147	
Width (cm)	142	153	150	
Flesh thickness (mm)	29.9	32.7	31.7	
Soluble solids content (°Brix)	10.3	12.5	12.4	1.5
Titratable acidity (TA)	0.11	0.10	0.09	0.01
pH	6.8	7.0	7.2	0.19
Firmness (N)	17.0	7.7	9.7	4.8
(H) Ethylene (μL·kg^{-1}·h^{-1})	11.3	17.2	23.2	
(H) Respiration (mL CO_2·kg^{-1}·h^{-1})	16.3	15.4	16.9	
Ethylene (μL·kg^{-1}·h^{-1})	14.7	15.6	9.7	
Respiration (mL CO_2·kg^{-1}·h^{-1})	14.1	15.0	13.6	

[z]NS= no-slip; AL= onset of abscission layer; FS= full-slip.
[y]Means in rows separated using Fisher's least significant difference (LSD); significance at 5% level.

Table 4. Means of fruit quality characteristics after 10 d storage at 20 °C (S-10 treatment) for 'Red Moon' melons harvested at no-slip (NS), onset of abscission layer (AL) and full-slip (FS) stages, Fall 2007.

	NS[z]	AL	FS	LSD[y]
Weight (kg)	1.2	1.4	1.0	
Length (cm)	132	139	142	
Width (cm)	139	144	145	
Flesh thickness (mm)	26.9	32.9	33.2	4.1
Soluble solids content (°Brix)	10.1	10.8	10.5	
Titratable acidity (TA)	0.10	0.11	0.11	
pH	6.82	6.81	6.93	
Firmness (N)	5.75	4.52	5.86	
(H) Ethylene ($\mu L \cdot kg^{-1} \cdot h^{-1}$)	18.48	21.8	23.1	
(H) Respiration (mL $CO_2 \cdot kg^{-1} \cdot h^{-1}$)	17.1	16.1	16.56	
Ethylene ($\mu L \cdot kg^{-1} \cdot h^{-1}$)	10.4	8.9	12.5	
Respiration (mL $CO_2 \cdot kg^{-1} \cdot h^{-1}$)	11.6	10.3	13.2	

[z]NS= no–slip; AL= onset of abscission layer; FS= full-slip.
[y]Means in rows separated using Fisher's least significant difference (LSD); significance at 5% level.

and FS fruits, respectively. Flesh thickness was greater for AL and FS than NS fruits. All other fruit quality variables were similar among maturity stages. There was a 15% reduction in SSC in FS fruits from treatments S-0 and S-5. Fruit firmness was also similar among all maturity stages by the end of 10 d storage; but was reduced from S-0 and S-5 treatments. 'Red Moon' melons harvested at any maturity stage should not be stored for extended periods of time. Internal color values were different between all stages. Both lightness (L) and chroma (C) values were greater for stage NS and AL fruits. Hue angle (H) was greatest for stage FS fruit (Table 2).

Ethylene and respiration rates were similar for fruits in all stages before and after storage. Ethylene and respiration rates were similar between treatments S-0 and S-5 for stage NS and AL fruits (Table 4).

Ethylene evolution and respiration over time

If climacteric fruits are defined by a notable increase and decrease in respiration concurrent with an autocatalytic production of ethylene during fruit ripening (Kader, 2002; Kidd and West, 1925); then stage NS fruits most likely were pre-climacteric, as no rise in CO_2 was detected during the storage period (Fig. 2).

Carbon dioxide (CO_2) and ethylene both rose simultaneously at day two from fruit harvested at stage AL, then decreased, simulating a climacteric rise and decline (Fig. 3).

Fruits harvested at stage FS were post-climacteric (Fig. 4). Ethylene and respiration rates decreased over storage.

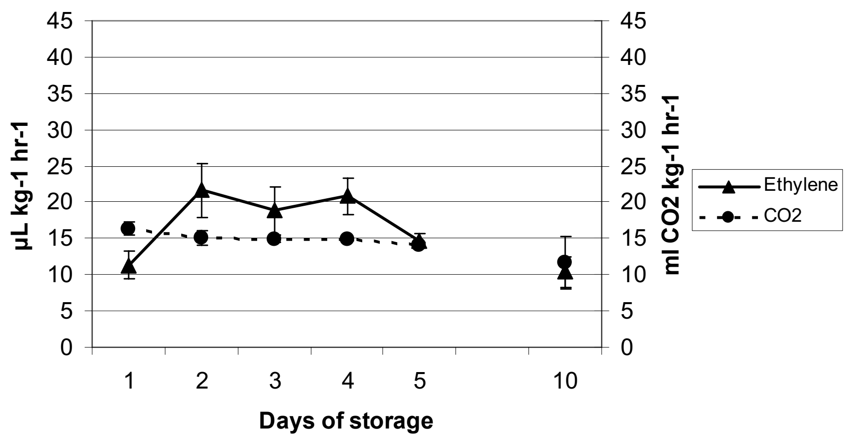

Fig. 2. Ethylene evolution and respiration rates of 'Red Moon' melons harvested at the no-slip (NS) stage and stored over 5 and 10 d at 20 °C, Fall 2007.

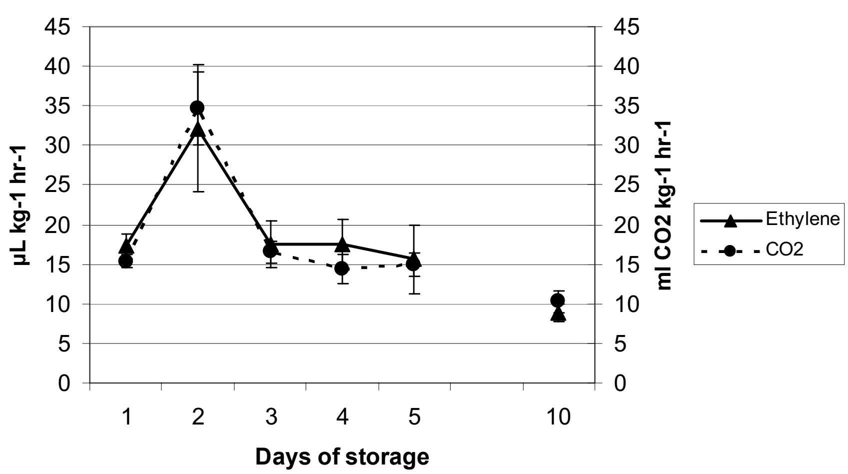

Fig. 3. Ethylene evolution and respiration rates of 'Red Moon' melons harvested at the onset of abscission layer (AL) stage and stored over 5 and 10 d at 20 °C, Fall 2007.

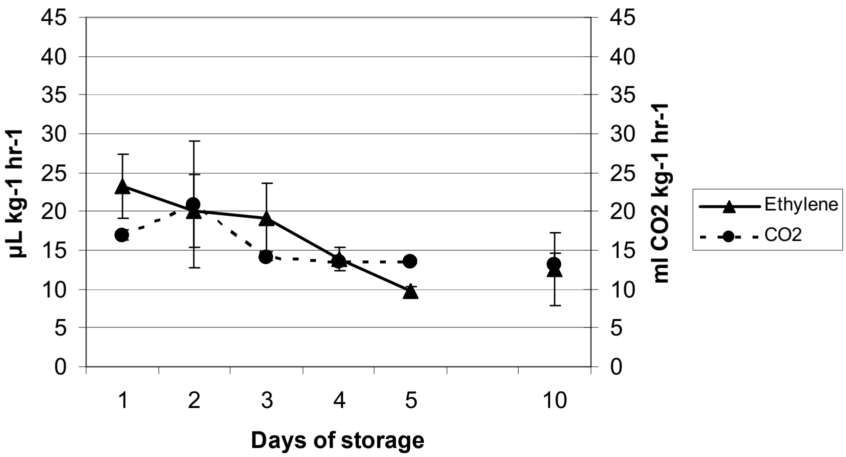

Fig. 4. Ethylene evolution and respiration rates of 'Red Moon' melons harvested at full-slip (FS) stage and stored over 5 and 10 d at 20 °C, Fall 2007.

Table 5. Odor detection threshold levels (OTV) of 15 contributing aroma compounds of 'Red Moon' melons, Fall, 2007.

Compound	Scent	Odor threshold value (OTV) (ppb)	Air/water[z]	OTV reference[y]
benzyl acetate	sweet, jasmine, apple, pear	0.04; 2–270	air; ?	1,2
ethyl isobutyrate	sweet, rubber	0.10	water	6
methyl 2-methyl butyrate	sweet, fruity	0.25	water	6
ethyl-2-methyl butyrate	sharp sweet green apple fruity	0.1–0.3	water	6
cis-6-nonen-1-ol	waxy, melon	1	water	2, 6
ethyl butyrate	fruity, pineapple, cognac	1	water	6
ethyl caproate	powerful fruity, pineapple, banana	1	water	6
hexyl acetate	fruity, green, pear (apple like)	2	water	6
benzaldehyde	bitter almond, almond	4.25; 350–3000	water	4
2-methylbutyl acetate	fruity	5	water	6
amyl acetate	bananas	7.5; 0.095	?; air	5
ethyl propionate	slightly sweetish odor	10	water	6
butyl acetate	fruity	66	water	6
isobutyl acetate	fruity	66	water	6
propyl acetate	nail-polish remover	40–700	water	3

[z]OTV as determined in air or water; ? = unknown.
[y]1.) Waldhoff and Spilker. 2005; 2.) Burdock, 2005; 3.) SIS, 2007; 4.) Fischetti, 1994.; 5.) Ladd. Res. 2006; 6.) Leffingwell.

Aroma volatiles

Thirty-seven volatile compounds were identified by GC/FID and verified by GC/MS. These compounds were comprised of mostly esters, some alcohols and aldehydes. Of the 37 compounds, 15 were found to be significant contributors to the overall aroma of 'Red Moon' melon at all stages (Table 5). The significant contributors were identified as a result of dividing the concentration of the compound by its known odor threshold value (OTV), resulting in the odor value (OV) of the compound (Bauchot et al., 1998). Compounds with OVs greater than one are significant contributors to the aroma. Odor threshold values (OTVs) were obtained through a literature search. Higher amounts of aroma volatile compounds have been reported in mature cantaloupes as compared with fruits at immature stages (Beaulieu and Grimm, 2001), which is similar to what was found in this study.

S-0. At harvest, stage of development had minimal effect on quantity of individual volatiles detected except in nine cases (Table 6). Measured in ng·g $FW^{-1}·h^{-1}$, volatile emissions were greater at stage AL as compared with NS and FS (Table 7). Methyl 2-methyl butyrate contributed to these numbers the greatest; though at stage NS, emission of this compound was low. Stage AL fruits were higher than stage NS for eight of the nine significant volatile compounds, whereas stage AL and FS fruits were similar in five of the nine significant compounds.

S-5. After 5 d storage, there were only seven compounds with significant differences between stages (data not shown). Of the seven compounds, stage NS fruits had higher amounts of propyl butyrate, butyl propionate, isobutyl butyrate and methyl butyrate than fruits at stages AL and FS. Stage NS and AL fruits were both highest in cis-6-nonen-1-ol and stage FS fruits were highest in ethyl propionate. Although stage NS fruits were significantly higher in some volatiles, total aroma volatiles were similar among all stages (Table 7). The compound most abundant in stage NS fruits was hexyl acetate (262.5 ng·g $FW^{-1}·h^{-1}$), a compound with a fruity/green aroma. Methyl 2-methyl butyrate remained low for NS fruits and decreased 88% from S-0 for stage AL fruits (339.1 ng·g $FW^{-1}·h^{-1}$). The most abundant compound at stage AL was 2-methylbutyl acetate (432.9 ng·g $FW^{-1}·h^{-1}$), another fruity aroma. Stage FS fruits were again, highest in methyl 2-methyl butyrate, which remained at similar levels to FS fruits at S-0.

Table 6. Means, presented in ng·g $FW^{-1}·h^{-1}$ of 'Red Moon' melon aroma volatiles at harvest (S-0) for no-slip (NS), onset of abscission layer (AL) and full-slip (FS) stages, Fall 2007.

Aroma compound	NS[z]	AL	FS	LSD[y]
propyl butyrate	1.16	1.98	1.43	
tiglic aldehyde	0.05	0.00	0.00	
4-methyl-1-cyclohexene	0.40	0.41	0.19	
cis-3-hexen-1-ol	1.38	1.44	1.38	
trans-cyclodecene	0.27	0.49	0.69	
cinnamyl acetate	0.34	1.18	1.51	
2-methyl-1-butanol	0.19	0.23	1.66	
furfuryl acetate	0.81	2.49	2.70	1.15
methyl isobutyrate	0.19	0.23	0.48	
allyl methyl sulfide	0.89	2.59	2.70	
butyl propionate	0.71	1.22	0.65	
cyclooctene	1.77	2.06	1.08	
isobutyl butyrate	0.85	2.03	1.12	0.91
benzaldehyde	13.0	13.7	29.0	
3-phenylpropylacetate	3.66	6.79	7.94	
methyl caprylate	2.46	6.00	9.52	
methyl caproate	7.32	6.79	3.15	1.57
isobutyl propionate	7.48	11.8	5.7	2.32
ethyl-3 -(methylthio)propionate	2.22	2.34	1.43	
heptyl acetate	1.39	5.05	4.74	2.64
phenethyl acetate	49.8	128	140	73.3
amyl acetate	10.4	35.9	25.2	
methyl butyrate	17.8	29.9	18.9	
cis-6-nonen-1-ol	70.5	263	347	
ethyl caproate	18.5	27.7	17.8	
cis-3-hexenyl acetate	1.41	3.55	2.89	
benzyl acetate	196	287	155	
ethyl propionate	148	165	192	
ethyl isobutyrate	63.1	70.6	98.5	
isobutyl acetate	72.7	61.6	94.2	
propyl acetate	47.1	178	40.7	97.1
hexyl acetate	53.5	229	254	53.8
ethyl butyrate	62.5	134	214	
butyl acetate	95.2	151	171	
ethyl-2-methyl butyrate	74.9	82.1	111	
2-methylbutyl acetate	572	433	284	
methyl 2-methyl butyrate	4.7	2811	1650	1026
Total volatiles	1605	5160	3894	1168

[z]NS= no-slip; AL= onset of abscission layer; FS= full-slip; units= ng·g $FW^{-1}·h^{-1}$.
[y]Means separated using Fisher's least significant difference (LSD), significance at 5% level.

Melons harvested at stage NS exhibited the most changes in aroma volatile emissions. Even though total aroma content was lowest at S-0 for stage NS, it had a 42% volatile increase by S-5, with 16 compounds that were significantly higher. NS was also the only stage to increase in total volatiles from S-0. Furthermore, this was the only increase in volatile production measured at any time during the study. This increase may be attributed to the rise in ethylene by day 5 of storage, even though the rise was not significant. Total aroma content for stage AL fruits decreased 52% from S-0 to S-5, and stage FS aroma decreased only slightly (Table 7).

S-10. Following 10 d storage, most volatiles were similar between each stage, except for four compounds (data not shown). Of these compounds, stage NS fruits had the highest amount of methyl caproate. Stage NS and AL fruits had higher amounts of butyl propionate and methyl buyrate, while ethyl isobutyrate was highest in fruits at AL and FS stages. Methyl 2-methyl butyrate was the compound in greatest abundance for stage NS fruits (249.4 ng·g $FW^{-1}·h^{-1}$) while 2-methylbutyl acetate was highest for stages AL (255.7 ng·g $FW^{-1}·h^{-1}$) and FS (413.8 ng·g $FW^{-1}·h^{-1}$) fruits. Total volatile content decreased for all stages from S-0 and S-5 treatments; however no differences occurred among the stages (Table 7). The reduced total aroma content may be attributed to the lower ethylene levels at S-10, even though the reduction in ethylene was not significant. Research has implied a direct relationship between reduced ethylene and low aroma volatiles in LSL melons (Lamikanra et al., 2003) and antisense Charentais melons (Bauchot et al., 2001).

Table 7. Aroma volatile totals (ng·g $FW^{-1}·h^{-1}$) for no-slip (NS), onset of abscission layer (AL) and full-slip (FS) stages of 'Red Moon' melons measured at harvest (S-0), after 5 d storage at 20 °C (S-5 treatment) and after 10 days storage at 20 °C (S-10 treatment), Fall 2007.

Harvest	Day of storage			
stage	S-0	S-5	S-10	LSD[z] (stage)
NS[y]	1605	2282	1356	*
AL	5160	2474	2147	*
FS	3894	3878	2185	*
LSD[x] (day)	*	NS	NS	

[z]Means separated within harvest stage (rows) using Fisher's least significant difference [LSD (storage × stage interaction) = 314], * = significance at 5% level.
[y]NS= no-slip; AL= onset of abscission layer; FS= full-slip.
[x]Means separated within days of storage (columns) using Fisher's least significant difference [LSD (storage × stage interaction) = 314]; * = significance at 5% level; NS = no significance.

The highest total aroma level was observed for AL fruits at harvest. And generally, the highest total aroma volatiles were measured at harvest, except for stage NS fruits (Table 7). High and maximum aroma volatile concentrations have been found in melons just prior to full-slip (Wang et al., 1996), which may explain the high aroma levels at stage AL.

Methyl 2-methyl butyrate, the compound typically found in greatest amounts as well as 2-methylbutyl acetate, propyl acetate, hexyl acetate, benzyl acetate, ethyl butyrate, butyl acetate, ethyl propionate and cis-6-nonen-1-ol all contributed the most volatile emissions at stage AL and generally throughout all stages of fruit development. All of these compounds have been identified in melon, and half were also found to be major contributors to the aroma of Charentais cantaloupes (Bauchot et al., 1998).

Methyl 2-methyl butyrate is described as a sweet, fruity scent and thus may impart some of the "marketed" high quality flavor component to 'Red Moon' melons. Benzaldehyde, though not present in large amounts, was also a significant contributor that cannot be ignored with its almond aroma. This compound may be a distinguishing feature for the 'Red Moon' melon.

Although flavor comprises taste, texture and aroma, it is a complex trait determined by many factors including genetics, environment, culture, production and postharvest handling (Baldwin, 2002). Even though the 'Red Moon' melons produced in this study did not achieve the high SSC (14 °Brix) as anticipated, its overall average SSC of 11 °Brix at all stages and after storage 5 and 10 d imparts good sweetness and probably the "perfect melon" label. Furthermore, the 11 °Brix attained would be considered the highest USDA grade (“Fancy”)—a factor important to both producers and consumers (Lester and Shellie, 2004). However, storage of ‘Red Moon’ for 10 d at 20 °C did not result in increased quality fruits, as reductions in SSC, firmness and aroma were detected. Therefore, storing these melons for 10 d or longer at this temperature is not recommended. More research with storage at lower temperatures could be beneficial for this type of melon. Harvesting ‘Red Moon’ at stage NS or AL resulted in increased firmness and high fruit quality at harvest (S-0) for both stages. Stage NS fruits were also firmest after 5 d storage.

As a result of this study, it is recommended that ‘Red Moon’ melons be harvested at stages NS or AL for best firmness, quality and, therefore, flavor.

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