

Effect of harvesting time on quality and shelf-life of three 'Galia' cultivars

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ABSTRACT

Two harvesting maturities in the boarder-line of physiological maturity of three 'Galia' cultivars (41 and 44 days after anthesis, DAA) were evaluated during the winter season (2008/2009) at Silate Agricultural Scheme, with respect to quality and shelf-life of the fruits at $18 \pm 1^\circ\text{C}$ and 8590% relative humidity. The cultivars studied were 'Galia' F₁ Standard, 'Galia' F₁ MN-318 and 'Galia' F₁ Solar King. The respiration curves of the three cultivars exhibited a typical climacteric pattern of respiration at both harvesting maturities. Fruits harvested slightly immature (41 DAA), had a lower respiration rate at harvest and during the pre-climacteric phase and higher rates during the post-climacteric phase, compared to those harvested at physiological maturity (44 DAA). Although the fruits harvested at physiological maturity (44 DAA) ripened normally, those harvested slightly immature (41 DAA) failed to develop rind color, to soften, to accumulate TSS or to develop flavor during ripening. At the end of the ripening period, the fruits picked 44 DAA reached the full yellow color (color score 6), while those picked 41 DAA had only reached an average of 2.3 color score. At the full ripe stage, TSS accumulation reached an average of 12.2% in fruits harvested 44 DAA, compared to only 8.8% in those harvested 41 DAA. The drop in fruit flesh firmness during the course of ripening was about 94% in fruits picked 44 DAA and only 33% in fruits picked 41 DAA. The fruits harvested 44 DAA developed excellent flavor (score 5), but those harvested 41 DAA failed to develop flavor. 'Galia' cantaloupes should be harvested at the physiological maturity, which corresponds to a change in rind color from green to yellow at the stem-end and with complete netting and formation of the abscission layer.

INTRODUCTION

Cantaloupe (*Cucumis melo* L.) is an important vegetable crop in Sudan for local consumption and export. 'Galia' cantaloupe is the only melon cultivar grown for export (Baraka, 2004). It ranks first in exported vegetables and second to mango in Sudanese total horticultural exports (AOAD, 2008). 'Galia' melon is superior in quality, compared to other melon cultivars, due to its excellent flavor, aroma and sweetness.

The stage of maturity for picking cantaloupes depends on cultivar, temperature at harvest, method of shipment and the length of time required reaching the market. For local markets, cantaloupes are left on vine until they are fully mature, but still hard. For shipment, they are picked before they are fully mature, but not so immature that they never develop good edible quality (Salunkhe and Desai, 1984).

The correct harvest maturity of cantaloupe is rather difficult to determine. However, as the melon approaches maturity, the netting becomes fully rounded out, the color changes from darkgreen to grayish-green and then to yellowish-green at maturity. As ripening advances, a crack develops around the peduncle at the base of the fruit and when fully ripe, the fruit slips easily from the stem, leaving a large scar (Salunkhe and Desai, 1984). Kader (2002) indicated that the principal harvest indices for cantaloupe are: green-yellow surface color, well-developed netting and formation of abscission zone. Mutton *et al.* (1981) reported that a practical grade standard might be 10% minimum solids with upper and lower limits for flesh firmness of 2.0 and 1.0kg/cm², respectively. Most cantaloupes are commercially harvested when half of the stems are separated from the melon (half-slip) (Kasmire *et al.*, 1970). Abscission zone development often corresponds to a change from green to yellow in rind color. If picked at proper maturity, cantaloupes will continue to soften and become more aromatic after harvest (Ayub *et al.*, 1996).

During the last few years, farmers failed to harvest and keep their product to comply with export requirements, and about 40% to 55% of the total yield was classified as local market grade (Abbas, 2004). That was mainly attributed to smooth or incomplete netted fruits. Although the fruits in that grade meet the specification required for export in terms of weight and shape, they had low quality grade with respect to sugar content and flavor. Importers feed-back indicated that a considerable part of shipments

are discarded at destination for poor quality, due to improper harvesting maturity and handling practices (MACK, 1999; Rustenburg Co., 1999).

This study was carried out to compare two harvest maturities of 'Galia' cantaloupes in the boarder-line of physiological maturity on quality and shelf-life of three 'Galia' cultivars.

MATERIALS AND METHODS

Experimental material

A field experiment was conducted during the winter season (2008/2009) at Silate Agricultural Scheme, Khartoum North, (15° 40' N, 32° 22' E). Land preparation and cultural practices were carried out as recommended. Chicken manure and triple super phosphate (43% P₂O₅) were applied during land preparation, at rates of 14 tons and 50 kg per hectare, respectively. The soil was then disc-harrowed, leveled and made into beds of 1.75m wide. The field was divided into plots, 10 meters long with four beds. A randomized complete block design with four replicates was used. Seeds of 'Galia' F₁ Standard and 'Galia' F₁ MN-318 were provided by Pop Vriend Seed Company and seeds of 'Galia' F₁ Solar King were obtained from Nunhem Seed Company. Two seeds per hole were sown on both sides of the bed at 25 cm intra-row spacing. Fifty kg of urea (46% N₂) were applied 15 and 45 days after sowing. The crop was irrigated at seven day intervals until flowering, then the interval was extended to 10 days till the harvesting time. Insecticides and fungicides were applied when necessary to control insect pests and powdery mildews. Hundred and sixty plants were selected randomly and fruits were tagged at the time of flowering on the selected plants.

The fruits were harvested and evaluated at two harvesting maturities; (a) fruits were harvested 41 days after anthesis. The fruits were green with partial or incomplete netting formation and the abscission layer was not completely formed. (b) fruits were harvested 44 days after anthesis at physiological maturity. The fruits were green, with slight yellow color that started to appear at the stem-end. The fruits were fully grown with complete netting and the abscission layer was well formed.

One hundred and sixty fruits from each of the three 'Galia' cultivars were harvested at each of the two harvesting maturities. The fruits were packed in carton boxes (6 fruits each) and kept in a cold room of the Department of Horticulture, Faculty of Agriculture, at 18 ± 1°C and 85%-90% relative humidity.

Parameters studied

Respiration rate (mg CO₂/kg- hr) was determined daily on six fruits from each replication using the total absorption method (Mohamed-Nour and Abu-Goukh, 2010). Rind color was determined daily in 10 fruits from each replicate. The color score used was, mature-green (=0), trace yellow on rind (= 1), 20% yellow (=2), 40% yellow (= 3), 60% yellow (= 4), 80% yellow (=5), and 100% yellow (=6). Fruit flesh firmness was determined daily on three fruits picked randomly from each replication, other than those used for respiration rate and rind color determination. It was measured by the Magness and Taylor firmness tester (D. Ballauf Meg. Co.), equipped with an 8 mm-diameter plunger tip. Two readings were taken from opposite sides of each fruit after the rind was removed and firmness was expressed in kg /cm². Total soluble solids (TSS) was determined daily on the same fruits used for flesh firmness determination. TSS was determined directly from the fruit juice extracted by pressing the fruit flesh in a garlic press, using a Kruss hand refractometer (Model HRN-32). Two readings were taken from each fruit and mean values were calculated and corrected according to the refractometer chart.

An organoleptic test was carried out according to Larmond (1967) to investigate the effects of the two harvest maturities of the three 'Galia' cultivars on fruit flavor. Twenty five panelists participated daily in the test and they were asked to evaluate the fruit samples for flavor according

to a 5-point structured hedonic scale given to them. The scale ranged in descriptive terms from poor or flat (score 1) to excellent flavor (score 5).

Statistical analysis

Analysis of variance and Fishers protected LSD Test with a significance level of $P \leq 0.05$ were performed on the data (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Changes in respiration rate

The respiration curves of the three 'Galia' cultivars exhibited a typical climacteric pattern of respiration of both harvesting maturities (Fig.1). This agrees with earlier reports that cantaloupes have moderate rate of respiration and with a climacteric observed with fruit ripening (Kader, 2002; Abu-Goukh *et al.*, 2011). In the fruits harvested 44 days after anthesis (DAA) (i.e. at physiological maturity), 'Solar King' had the highest respiration rate with a peak of 124.7 mg CO₂/kg-hr, followed by 'MN-318' with a peak of 92 mg CO₂/kg-hr and 'Standard' with the lowest peak of 84 mg CO₂/kg-hr. That peak of respiration was reached in the three cultivars after three days after harvest (Fig.1).

The fruits of the three cultivars picked 41 DAA, which were slightly immature, had significantly lower respiration rate at harvest and during the pre-climacteric phase and higher rate at the post-climacteric phase during ripening. The peak of respiration was delayed by one day in fruits of the three cultivars, compared to those harvested at physiological maturity. Respiration rate per unit weight is highest for the immature fruits and then steadily declines with age reaching a minimum value at physiological maturity (Wills *et al.*, 1998).

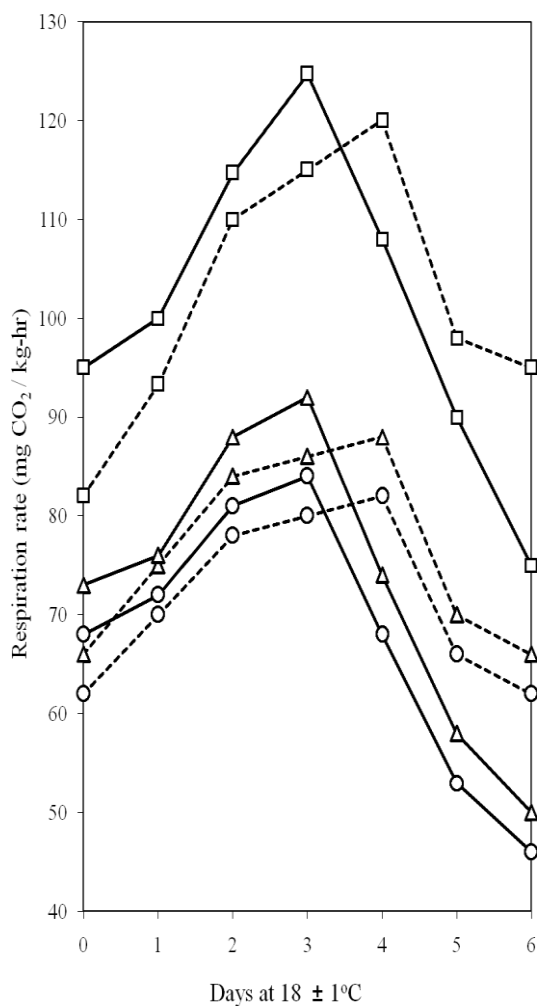


Fig. 1. Changes in respiration rate during ripening of 'Galia F₁ Standard' (○), 'Galia F₁ MN-318' (Δ) and 'Galia F₁ Solar King' (□) cantaloupe cultivars harvested 41 DAA (immature) (-----) or 44 DAA (mature) (—).

Changes in rind color

Rind color score progressively increased during ripening of 'Galia' fruits in the three cultivars at both harvesting maturities (Fig. 2). Fruits harvested 44 DAA (at physiological maturity) developed rind color significantly faster than fruits harvested 41 DAA (slightly immature). Fruits harvested 44 DAA, at physiological maturity, reached the full yellow color

(color score 6) after three, five, and six days in 'Solar King', 'MN-318' and 'Standard' Galia cultivars, respectively, while fruits harvested 41 DAA (slightly immature), failed to develop color during ripening. After six days, the maximum color score reached by the immature fruits was only 4.0, 1.7 and 1.4 in 'Solar King', 'MN-318' and 'Standard' Galia cultivars, respectively (Fig. 2). The color of cantaloupes changes from dark-green to grayish-green and then to yellowish-green as the fruit approaches maturity (Salunkhe and Desai, 1984). Kasmire *et al.* (1970) reported that cantaloupes should be harvested at least when half of the stems separated from the melons (half-slip), which corresponds to a change from green to yellow in rind color. Kader (2002) indicated that the principal harvest indices for cantaloupes are: green-yellow surface color, well-developed netting and formation of abscission zone.

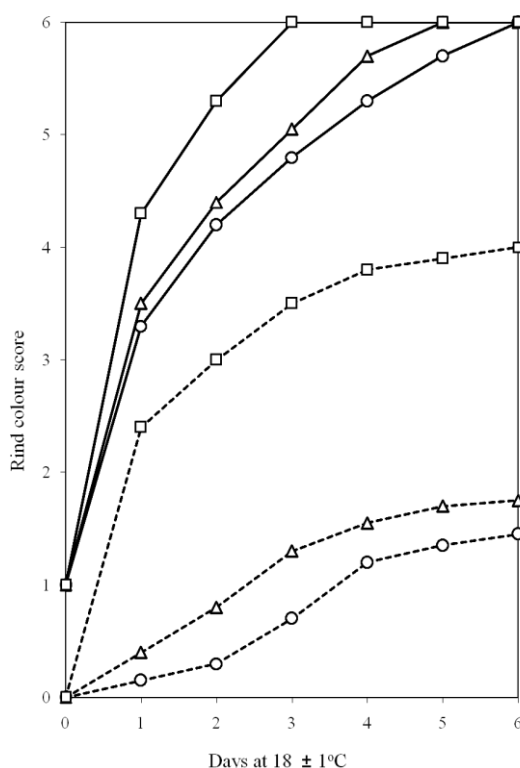


Fig. 2. Changes in rind color during ripening of 'Galia F₁ Standard' (○), 'Galia F₁ MN-318' (Δ) and 'Galia F₁ Solar King' (□) cantaloupe cultivars harvested 41 DAA (immature) (-----) or 44 DAA (mature) (—).

Changes in fruit flesh firmness

Fruit flesh firmness progressively declined during ripening of the three cultivars of Galia cantaloupes (Fig. 3). Fruits harvested slightly immature (41 DAA) were significantly more firm at harvest and during the course of fruit ripening, compared to those harvested at the physiological mature stage (44 DAA). The fruits flesh firmness at harvest was 2.15, 1.85 and 1.75 kg/cm² in the fruit harvested 41 DAA and 1.85, 1.58 and 1.40 kg/cm² in fruits harvested 44 DAA, in 'Solar King', 'MN-318' and 'Standard' cultivars, respectively. The drop in fruit flesh firmness during the ripening period was 35.5 %, 31.7 % and 32.6 % in fruit harvested 41 DAA and 90.2%, 94.9 % and 97.2% in fruits harvested 44 DAA of 'Solar King', 'MN-318' and 'Standard', respectively (Fig. 3). Similar drop in flesh firmness was reported during ripening of physiologically mature fruits in banana (Osman and Abu-Goukh, 2008), mango (Mohamed and Abu Goukh, 2003) and guava (Bashir and Abu-Goukh, 2003). 'Solar King' cultivar was more firm at harvest and during ripening, compared to the others two cultivars. Since fruit flesh firmness is an important attribute of quality and shelf-life of the produce (Dostal, 1970), this finding may indicate a longer shelf-life of 'Solar King' over the other two cultivars.

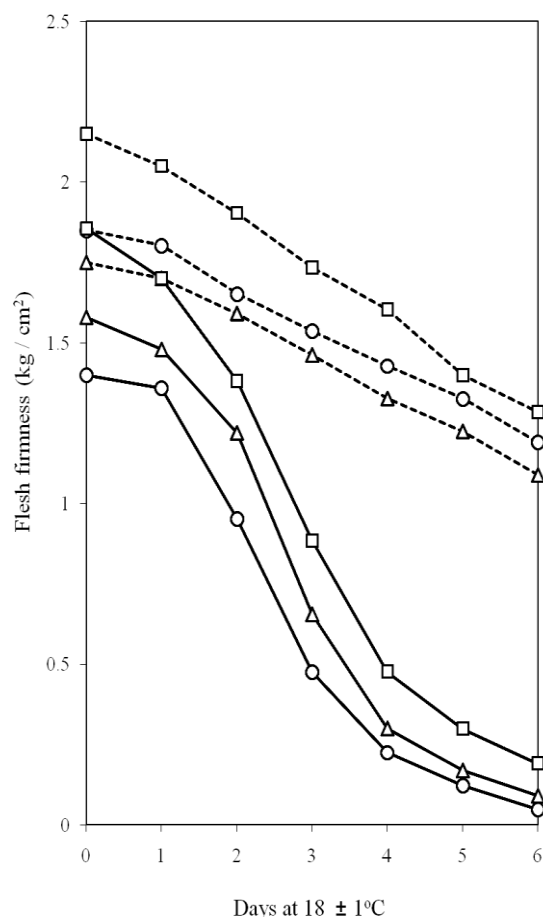


Fig. 3. Changes in fruit flesh firmness during ripening of ‘Galia F₁ Standard’ (○), ‘Galia F₁ MN318’ (Δ) and ‘Galia F₁ Solar King’ (□) cantaloupe cultivars harvested 41 DAA (immature) (-----) or 44 DAA (mature) (—).

Changes in total soluble solids

Total soluble solids (TSS) progressively increased during ripening of the three Galia cultivars with different levels with regard to the harvesting maturities (Fig. 4). TSS were significantly higher and were accumulated faster during ripening in fruits harvested 44 DAA (physiologically mature) than those harvested 41 DAA (slightly immature). In fruits harvested at physiological maturity (44 DAA), TSS had increased during ripening from 10.1%, 9.4% and 8.9 % to 12.9%, 12.1% and 11.6% in ‘Solar King’, ‘MN318’ and ‘Standard’ cultivars, respectively.

That increase in TSS represents 27.7%, 30.1% and 30.3% in the three cultivars, respectively. On the other hand, TSS at harvest in fruits picked slightly immature (41 DAA) were only 8.9%, 8.1% and 7.9% in ‘Solar King’, ‘MN-318’ and ‘Standard’, respectively. During ripening, the slightly immature fruits failed to accumulate more than 9.2%,

8.7% and 8.5 %; and the increase in TSS during the ripening period was only 8.2%, 7.4% and 7.6% in the three cultivars, respectively. Total soluble solids, refractive index and sucrose content of fruit juice increase as the melon ripens (Salunkhe and Desai, 1984). Sugar content was reported as the most important quality factor of cantaloupes, which can be estimated by determining the TSS in the juice of the edible portion (Salunkhe and Desai, 1984). Of twelve factors thought to be associated with eating quality of cantaloupes, Mutton *et al.* (1981) found that only percent of soluble solids and flesh firmness were used to judge the eating quality of melons. They further reported that a practical grade standard might be 10% minimum TSS, with upper and lower limits for flesh firmness of 2.0 and 1.0 kg /cm², respectively. Lyons *et al.* (1962) reported that cantaloupes harvested pre-maturely, had low soluble solids concentration, produced little aroma and were not properly ripe.

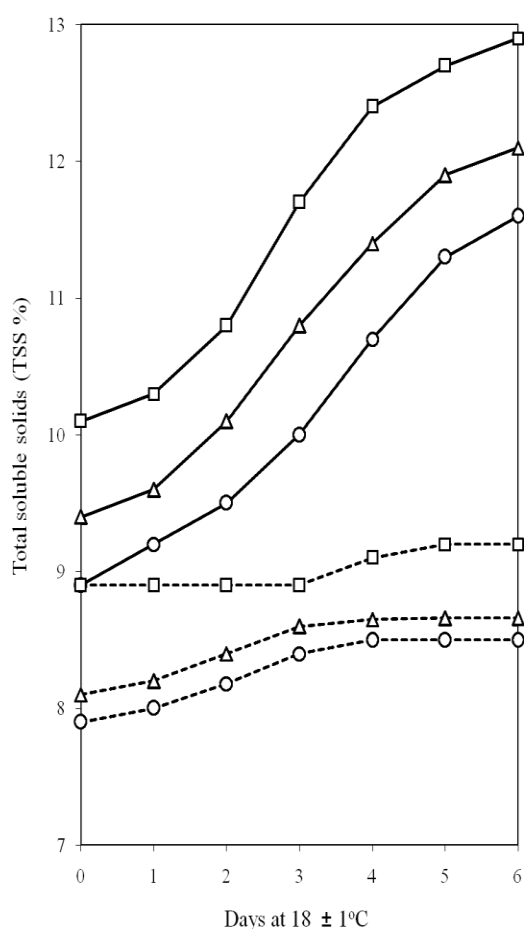


Fig. 4. Changes in total soluble solids (TSS) during ripening of ‘Galia F₁ Standard’ (○), ‘Galia F₁ MN-318’ (Δ) and ‘Galia F₁ Solar King’ (□) cantaloupe cultivars harvested 41 DAA (immature) (---) or 44 DAA (mature) (—).

Changes in fruit flavor score

Fruit flavor score advanced with ripening in the three cultivars harvested at both maturities (Fig.5). Fruit flavor was significantly higher and advanced faster during ripening in the fruits harvested 44 DAA, compared to those harvested 41 DAA. The flavor scores were increased in fruits harvested at physiological maturity (44 DAA) from 3.6, 2.6 and 2.9 at harvest in 'Solar King', 'MN318' and 'Standard', respectively, to excellent flavor (score 5) after 4,5 and 6 days during ripening. While fruits harvested slightly immature (41 DAA) failed to score more than 2.75 in 'Solar King' and 'MN-318' and 2.65 in 'Standard' Galia, even at the end of the ripening period.

Most cantaloupes are commercially harvested when half of the stems separated from the melon (half-slip) (Kasmire, *et al.*, 1970). Cantaloupes harvested pre-maturely by cutting the stems prior to the abscission zone development had little aroma, low soluble solids concentration and were not properly ripe (Lyons *et al.*, 1962). Mutton *et al.* (1981) reported 10% TSS as a minimum standard grade for harvesting cantaloupes. If picked at the proper stage of maturity, cantaloupes will continue to soften and become more aromatic after harvest (Ayub *et al.*, 1996).

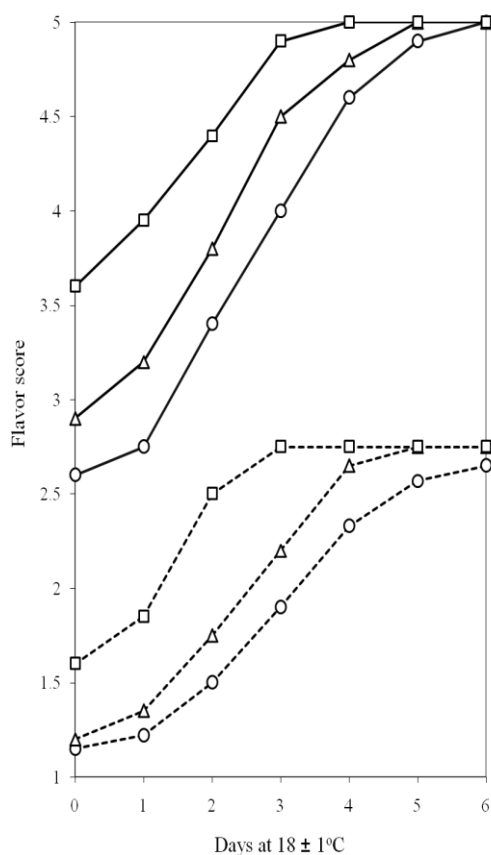


Fig. 5. Changes in flavor during ripening of 'Galia F₁ Standard' (○), 'Galia F₁ MN-318' (Δ) and 'Galia F₁ Solar King' (□) cantaloupe cultivars harvested 41 DAA (immature) (-----) or 44 DAA (mature) (—).

CONCLUSION

'Galia' cantaloupes should be harvested at the physiological maturity, which corresponds to a change in rind color from green to yellow at the stem-end and with complete netting and formation of the abscission layer.

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تأثير موعد الحصاد علي جودة ثمار شمام 'القاليا' وطول عمرها التسويقي

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الخلاصة

تم تقويم وقت الحصاد في درجتين على حافة اكتمال النمو الفسيولوجي (13 و 11 يوماً من تفتح الأزهار في مشروع السلبيت أثناء الموسم الشتوي) 8002/8002، فيما يختص بالجودة والعمر التسويقي لثمار ثلاثة أصناف من شمام 'القاليا' عند Galia F₁ درجة حرارة $32 \pm 3^\circ$ ورطوبة نسبية 25-20%. كانت الأصناف الثلاثة التي أجريت الدراسة عليها هي) ، (اتبعت الثمار على مستوى درجتي اكتمال النمو في Galia F₁ Solar King (و) Galia F₁ MN-318 (و) Standard تتنفسها نمط التنفس الكلابماكتيري في الأصناف الثلاثة. وكان تنفس الثمار التي حصدت قبيل اكتمال النمو الفسيولوجي (13 يوماً من تفتح الأزهار) منخفضاً نسبياً عند الحصاد وأثناء مرحلة ما قبل ذروة التنفس وأعلى نسبياً أثناء مرحلة ما بعد ذروة التنفس، مقارنة بالثمار التي حصدت في مرحلة اكتمال النمو الفسيولوجي (11 يوماً من تفتح الأزهار). بالرغم من أن الثمار التي حصدت مكتملة النمو فسيولوجياً (11 يوماً من الإزهار) قد نضجت بصورة طبيعية، إلا أن الثمار التي حصدت قبيل اكتمال النمو الفسيولوجي (13 يوماً من الإزهار) قد فشلت في أن تتلون قشرتها ويلين لبها وتتجمع المواد الصلبة الذائبة الكلية فيها وتتطور النكهة فيها أثناء النضج. عند نهاية فترة النضج وصل لون قشرة الثمار التي قطفت بعد 11 يوماً من الإزهار إلى اللون الأصفر الكامل) معدل 6 نقاط) بينما لم يزد معدل تلون قشرة الثمار التي قطفت بعد 13 يوماً من الإزهار عن معدل اللون 3.8 نقطة. في مرحلة النضج الكامل وصل متوسط مقدار المواد الصلبة الذائبة الكلية المتراكمة 8.38% في الثمار التي حصدت بعد 11 يوماً من الإزهار، مقارنة ب 2.2% فقط في تلك التي حصدت بعد 13 يوماً من الإزهار. بلغ الانخفاض في صلابة الثمار أثناء نضجها 21% في الثمار التي قطفت بعد 11 يوماً من الإزهار و لم يتجاوز نسبة 33% في الثمار التي قطفت بعد 13 يوماً من الإزهار. وصلت النكهة في الثمار المكتملة النمو فسيولوجياً (11 يوماً من الإزهار) درجة الامتياز (5 درجات) ، ولم تتكون النكهة في الثمار التي حصدت بعد 13 يوماً من الإزهار. يجب حصاد ثمار شمام القاليا عند مرحلة اكتمال النمو الفسيولوجي، والتي تتوافق مع تغيير لون قشرة الثمار بالطرف الساقلي من الأخضر إلى الأصفر، و اكتمال التكوين الشبكي عليها، وتكوين طبقة الانفصال بين الثمرة والفرع الحامل لها .