Minufiya J. Agric. Res. Vol.36 No. 1: 93 - 108 (2011) "http://www.mujar.net"

EFFECT OF PRE HARVEST CALCIUM SPRAYS ON FRUIT QUALITY AND STORABILITY OF FUERTE AVOCADO

S.M.A. Mehaisen[(1)], A.A. Al Kfrawey[(2)] and A.A. Zaghloul[(1)]
[(1)] Fruit Handling Res. Dept. [(2)] Tropical and subtropical Fruit Res. Dept.
Hort. Res. Institute, Agric. Rec. Cent. (A.R.C.) Giza, Egypt
(Received: Dec. 27 , 2010)

ABSTRACT: ***Avocado (Persea americana, Mill.) Fuerte cv. mature trees growing in a loamy clay soil were sprayed after fruit set and a month pre harvest in 2009 & 2010 seasons with three levels (0.25, 0.50 and 0.75 %ml L^{-1}) of Bio calcium (50gCa L^{-1} .) Mature fruits were harvested and stored at 7℃ for nine weeks and ambient temperature (23 ± 2 ℃) for 9 days. Results at harvest showed that pre harvest Calcium sprays increased fruit firmness especially, at 0.5%(592 & 612 gm/mm^2) as compared with control(490 & 537 gm/mm^2) in both seasons. On other hand, Calcium sprays maintained the changes in peel color and reduced respiration rate as compared with control. Finally Ca sprays increased the content of ascorbic acid, while total acidity and total phenols were reduced.***

Pre harvest treatments were effective in improving fruit quality and storability of Avocado fruits. Calcium sprays especially, at 0.5 % reduced decayed fruits %, these values were (9.63 & 9.65) for fruits stored at 7℃ for nine weeks against (4.93 &3.65)for those stored at ambient temperature (23 ± 2 ℃) for 9 days as compared with the control (18.1 & 19.01 %), (7.4 & 5.68) in the first and second seasons, respectively.

Also, fruit weight loss was reduced as affected by Ca sprays, especially, at (0.5 %) these values were (4.93, 4.98 %)) for fruits stored at 7℃ for nine weeks against (5.43&4.25) for those stored at ambient temperature (23 ± 2 ℃) for 9 days as compared with control (5.7 , 6.05 %),(8.98&7.78) in both seasons, respectively. Moreover, it maintained fruit firmness, the change in peel colour, reduced total acidity and respiration rate, while ascorbic acid and total phenols of treated fruit were decreased as compared with control in both seasons during storage.

Key words: ***Avocado, Calcium, Foliar spray, Cold storage, Fruit quality and storability.***

INTRODUCTION

The avocado (*P. Americana*, Mill.) is an important subtropical fruit with a high market value in local markets or to export, but with a relatively short storage life (Hershkovitz *et al* (2005). Avocado is a climacteric fruit and its shelf life at ambient temperature is few day, but cold storage extend its life. El khoreiby and Abd El fadeel (1988) observed that Fuerte avocado fruits can be held at 7°C for 44-45 days without any chilling injury symptoms. El oraby *et al*

(2004) reported that Fuerte avocado fruits had storage life of 9 days at 25°C, 15 days at 10°C and 35 days at 0°C & 5°C. without any appearance of chilling symptoms. Calcium has widely bean reported to play an important structural role in providing firmness and mechanical strength to cell walls, (Povaiah *et al.,* 1988 .)

Rensburg and Engelbrecht (1986). Found that calcium treatments preserved firmness and reduced respiration rate.

Mishra *et al.* (2003) cleared that pre harvest application of calcium nitrate increased the shelf life and reduced the physiological loss in weight of guava fruits. Aly and Ismail (2000) reported that guava fruits from trees treated with 0.5% $CaCl_2$ were firmer and better quality than control fruits.

Baneh *et al.* (2003) stated that the foliar application of 1 % $CaCl_2$ increased fruit firmness and had a significant effect on weight loss of apple fruit. Hisaw(1991) observed that apple fruit having adequate tissue calcium concentrations were firmer and could stored for longer periods than those of low calcium.

Moon *et al.* (2002) made electron microscopic study of the cell walls and revealed that the integrity of middle lamella of liquid calcium-treated fruits was high as compared with control. Youn *et al.* (2000) reported that earlier foliar sprays 3% $CaCl_2$ tented to decrease the incidence of the physiological disorders during storage of pear fruits.

The present investigation aims to study the effect of pre harvest foliar sprays of Calcium at three levels (0.25, 0.50 and 0.75%) on quality and storability of avocado fruits cv. Fuerte at harvest time and during storage.

MATERIALS AND METHODS

Pre harvest treatments:-

The present investigation was carried out during two successive seasons of (2009 and 2010) on mature healthy avocado trees (*P. americana*, Mill) Fuerte cv. grown at the Experimental orchard of the Horticulture Research Station at El kanater El khayreia, Kalubia Governorate, Egypt, to study the influence of foliar sprays of Bio calcium♣ at (0.25, 0.50 and 0.75%) on fruit quality and storability of avocado cv. Fuerte. The experimental trees grown in loamy clay soil, nearly uniform in vigor and subjected to the same cultural practices, were selected and divided into four groups, each group subjected to one of the following treatments after fruit set and a month pre harvest in both experimental seasons:-

♣ 50g Ca L^{-1} chelated on poly amino carboxylic acid, 2NA and special type of amino acids at PH 6.

1- Foliar spray with tap water (control).
2- Foliar spray with 0.25 % of Bio calcium.
3- Foliar spray with 0.50 % of Bio calcium
4- Foliar spray with 0.75 % of Bio calcium
The obtained data were handled as follows:

Fruit quality

At the 3rd week of September, of both season, mature Fuerte fruits were harvested at maturity stage according to Kader (1985) and directly transported to the laboratory of Fruit Handling Research Department. Uniform fruits of each treatment were washed, air dried and divided into two main groups to study the effect of storage temperature 7°C and R.H. 85-90%. and ambient temperature 23 ± 2 °C and R.H. 50-60% Fruits of all treatments fruits were packed in carton boxes in one layer.

Fruit quality assessment

For physical and chemical determination, a sample consists of 3 fruits was taken randomly from each replicate within each treatment at 3 days intervals for fruits were stored at ambient temperature and 7 day intervals for those subjected to cold storage.

Fruits decay % (physiological disorders%)

Decayed fruits were characterized by abnormal ripening, development of undesirable flavors, odors, and pitting or darkening of skin. These disorders of fruits were counted as decayed fruits and calculated as decay fruit %.

Fruit weight loss

fruit weight as % was recorded and calculated.

Peel color measurements

Peel color fruit was measured by averaging two measurements taken on two opposite points of each fruit equator with a Minolta colorimeter (Minolta Co. Ltd., Osaka, Japan) on the basis of the CIELAB color system. In this system values of (a & b) specify the green-red and blue-yellow axis, respectively. Values were determined and a/b ratio was calculated according to (Mc Guire, 1992.)

Fruit firmness

Fruit firmness were determined by Lfra texture analyzer using a penetrating needle of 1mm of diameter, 10 mm in distance, speed of 2 mm per second and the peak of resistance was recorded as g mm^{-2}.

Fruit chemical characteristics

Freshly prepared juice of avocado fruits samples were used for total acidity and ascorbic acid determinations as described by A. O. A.C (1985).

Total phenols(mg 100mg^{-1}): extraction of phenolic compounds was conducted according to Danil and George(1972) and total phenols were determinate according to A. O. A.C (1985).

Respiration rate

Respiration rate was calculated as ml CO_2 kg^{-1} hr^{-1}. According to Cross method (1966) as follows:

$$\text{Respiration rate} = \frac{\text{Concentration of } CO_2 \text{ for sample x 10) (free space of Container in liters)}}{\text{(Product fruit weight in kg) (Time container enclosed in hours)}}$$

Statistical analysis

All obtained data in both season were subjected to analysis of variance according to Snedecor and Cocran (1989). Differences among means for the specific effect of storage period and the tested pre harvest treatments were compared using Duncan's Multiple Range test (Duncan, 1955) at $p \leq 0.5$.The interaction effect between treatments and storage periods were differentiated using L. S. D. at $p \leq 0.5$.

RESULTS AND DISCUSSION

1. Fruit physical characteristics

1.1. Decayed fruits (%)

Data presented in Tables (1 & 2) show that fruit decay % high significantly increased as the storage period advanced under cold storage (7 °C.) or ambient temperature (23 ± 2 °C). Foliar sprays of calcium at (0.25, 0.50 and 0.75%) cleared much lower values of decayed fruits percentage, especially Ca at 050 % (9.63, 9.65 %) as compared with the control (18.1 and 19.01%) for the first and second seasons, respectively. The interaction effect of storage period and pre harvest treatments showed high significant effect on fruit decay% in both seasons. These observations go in line with those obtained by Fawaz (2010) on dates and Fawaz(2006) on mangoes The role of Ca in reducing decayed fruits may be due to it's role in regulation respiration rate and other metabolic processes (Raychaudhary *et al.,* 1992.) on guava. Veldman (1983) on avocado.

1.2. Fruit weight loss %

It is obvious from Tables (1, 2) showed that weight loss % high significantly was increased by prolonging the storage periods whether under cold storage or at ambient temperature storage. Fruit weight loss % was increased at a more rapid rate in ambient temperature storage than in cold storage. Furthermore, the tested pre harvest treatments induced high reduction effect in fruit weight loss as compared with the control, especially, Ca (0.5 %) was more effective (4.93, 4.98 %), for fruits stored at 7°C for nine weeks against (5.43&4.25) for those

stored at ambient temperature (23 ± 2 °C) for 9 days as compared with control (5.7 , 6.05 %), (8.98 & 7.78) in both seasons, respectively.

Table 1

Table 2

The interaction effect of storage period and pre harvest treatments was significant either at ambient temperature or cold storage in both seasons. The reduction of weight loss may be due to the role of calcium on middle lamella, Moon *et al.* (2002) made electron microscopic study of the cell walls and revealed that the integrity of middle lamella of liquid calcium-treated fruits was high as compared with control . The obtained results were in harmony with those suggested by Mishra *et al.* (2003) they cleared that pre harvest application of calcium nitrate 1% reduced weight loss of guava fruits. Baneh *et al.* (2003), Mehaisen (2005) on guava fruits. Also, Zambrano and Manzano (1995) and Fawaz (2006) on mango fruit. Rensburg and Engelbrecht (1986). On Avocado.

1.3. Fruit firmness

Data in Tables (1 and 2) show that flesh firmness of avocado fruits at harvest were increased in Ca-treated fruits especially, Ca at 0.5 % (592 & 612 gm/ mm^{-2}) as compared with control (490& 537 gm/ mm^{-2} %), but flesh firmness high significantly were decreased by extending storage period under cold storage or at ambient temperature storage. Ca-treated fruits at 0.50 % during cold storage exerted the highest value of fruit firmness (410 & 428.1 gm/ mm^{-2}) than control (273&29 gm/ mm^{2}) in both seasons, respectively. Also, the same trend of results was noticed during storage at ambient temperature. These results are in agreement with those suggested by El oraby *et al.* (2004) on Fuertes Avocado. Similar results were obtained by Mehaisen (2005) on guava fruits. Calcium has widely bean reported to play an important structural role in providing firmness and mechanical strength to cell walls, (Povaiah *et al.,* 1988 .)

1.4. Fruit colour

Fig. (1) demonstrates that pre harvest treatments delayed the change in fruit colour as a/b ratio during cold storage. Ca sprays (0.25, 0.75) showed fewer changes in peel colour, followed by Ca at 0.50. Calcium effect on peel colour may be due to reduce total phenols and polyphenol oxidation.

The obtained data are in harmony with the results of Mehaisen (2005) on guava fruits. El oraby *et al.* (2004) on Fuertes Avocado.

1.5. Respiration rate

Fig. (2) illustrate that there was a progressive significant increase in respiration rate of Fuerte avocado fruits by expanding storage period. Storage periods induced a significant increase in respiration rate, but it was more rapidly at periods of 6&9 weeks. Ca sprays significantly reduced respiration rate as compared with the control. Low level (0.25%) of Ca was

more effective in this concern. These results are in agreement with those Mehaisen (2005) on guava fruits. Tingwa and Young (1974) on avocado Rensburg and Engelbrecht(1985).found that respiration rate was reduced in avocado fruits were dipped in 0.1M of calcium salts

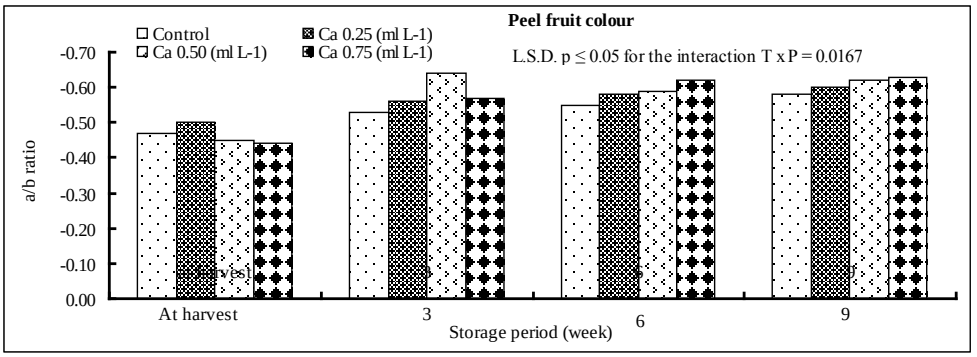

Fig. (1): Effect of pre harvest foliar sprays of calcium on peel fruit colour during storage at (7 oC) average of two seasons.

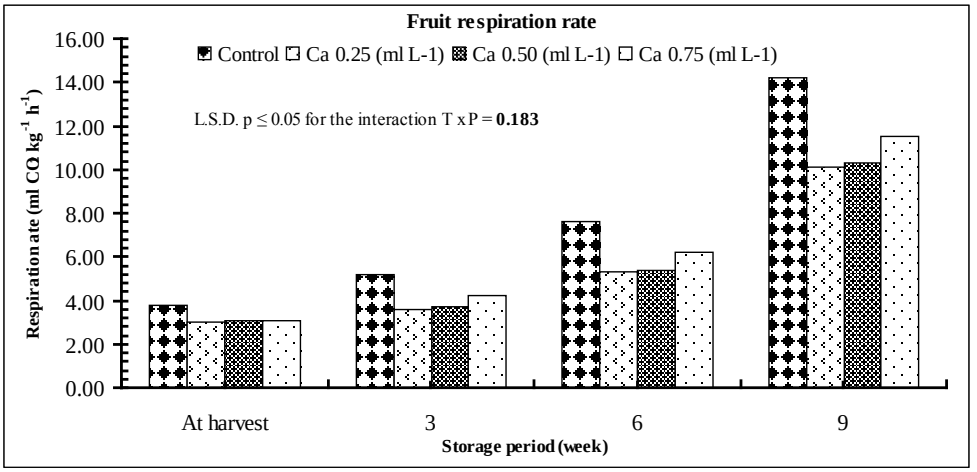

Fig. (2): Effect of pre harvest foliar sprays of Calcium on Fuerte Avocado fruit respiration rate (ml CO_2 kg^{-1} h^{-1}) during storage at (7 oC) (average of both seasons).

2. Fruit chemical characteristics

2.1. Total Acidity and ascorbic acid content.

Tables (3&4) show that changes in total acidity was significantly decreased by prolonging the storage period under all tested treatments during storage either at cold storage or ambient temperature. Pre harvest sprays of Ca at (0.25 , 0.50 & 0.75 %) were more effective in decreasing total acidity in both seasons as compared with control.

Table 3

Table 4

On the other hand, the pre harvest treatments significantly decreased the loss of ascorbic acid content by extending the storage period at cold storage or ambient temperature in both seasons. Ca spray at 0.5 % induced high values of ascorbic acid, these values were (11.38 & 10.35) for fruits stored at 7°C for nine weeks against (11.65 &11.13)for those stored at ambient temperature (23 ± 2 °C) for 9 days as compared with the control (9.68& 8.2 %), (9.7&9.15) in the first and second seasons, respectively.

The interaction effect of pre harvest treatments and storage period was significant either at cold storage or ambient temperature in both seasons. Ca-treated fruits maintained its total acidity and ascorbic acid content during storage period due to the role of Ca in regulating respiration rate and other metabolic processes (Raychaudhary *et al.,* 1992.) on guava. Mishra et al. (2003) they cleared that pre harvest application of calcium nitrate 1% reduced ascorbic acid content of guava fruits for more than 3 days at room storage temperature

These results go in line with those obtained by Mehaisen (2005) on guava fruits and El oraby *et al* (2004) on Fuerte avocado

2.2 Total phenols.

It is obvious from Fig. (3 that pre harvest sprays of calcium decreased total phenols at harvest and during cold storage. Untreated fruits contained the highest values at harvest (0.21mg.)and after cold storage for nine weeks (0.17).The least values total phenols (0.08) were obtained in fruits treated with Ca at 0.5 %,which more effective compared with control. Reduction in total phenols in Ca-treated fruits may due to the role of calcium in reducing respiration rate and polyphenol oxidation resulting reducing total phenols (Rensburg and Engelbrecht,1986). These results go in line with those obtained by El khoreiby and Abd El fadeel (1988),Bower *et al.* (1990) and El oraby *et al* (2004) on Fuerte avocado.

Conclusively, it is preferable to spray avocado trees cv. Fuerte after fruit set and a month pre harvest with calcium at 0.50 % and store the fruits at 7°C. to enhance fruit quality and storability up to nine weeks in cold storage.

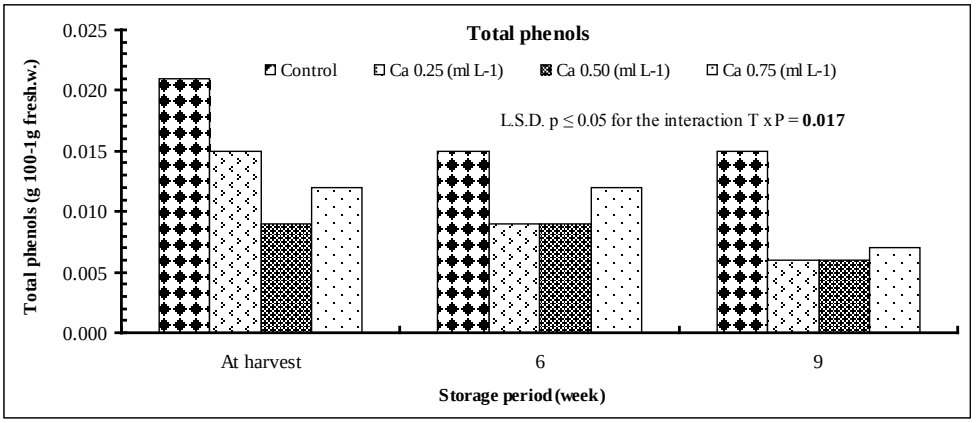

Fig. (3): Effect of pre harvest foliar sprays of Calcium on total phenols (g 100^{-1}g fresh.w.) of Fuerte Avocado fruits during storage at (7 ^{o}C) (in the 2nd season).

REFERENCES

A.O.A.C. (1985). Association of Official Agricultural Chemists. Official methods of analysis, 4th Benjamin Franklin Station, Washington, D.C., U.S.A. ed.pp.495-510.

ALY, Ek.Z. and H.A. Ismail (2000). Effect of pre harvest GA_3, $CaCl_2$ and boron treatments on fruit quality and enzymatic browning of Balady guava fruits. Annals of Agric. Sci., Moshtohor, 38 (2): 1101-1108.

Baneh, H.D., A. Hassani, A. Majidi, S. Zomorodi, G. Hassani and M.J. Malakouti (2003). Effect of $CaCl_2$ concentration and the number of foliar applications on the texture and storage quality of apple(red delicious) in Orumia region. Agric.Sci.Tabriz, 12(40)47-54.

Bower, J.P., J.G.M. Cutfing and A.B. Truter (1990). Container atmosphere as influencing some physiological browning mechanisms in stored Fuerte Avocado fruits. Acta Hort.269:315-321

Cross, R.A. (1966). Analysis of the major constituents of peel gases by a chromatography. Nature, 211: 409.

Danil, H.D. and C.M. George (1972). Peach seed dormancy in relation to indogenous inhibitors and applied growth substance. J.Amer.Soc.Hort. Sci.:51-654.

Duncan, D.B. (1955). Multiple range and multiple "F." tests. Biometrics, 11:1-42

El khoreiby, A.M. K. and M.G. Abd El-fadeel (1988). Ripening response of avocado fruit in relation to temperature and ethephon treatments. Bull. Fac. of Agric., Cairo Univ. 681-692.

EL oraby, S.M.G, A.M. Hassan and S.A. Fawaz (2004). Effect of some treatments to reduce physiological disorders during storage of Fuerte avocado fruits. Egypt J. Appl. Sci. 19(6)198-212

Fawaz, S.A. (2006). Effect of post-harvest treatments on physio-chemical characters of mango fruit (c. Bullock`s Heart)during cold storage. Annals of Agric. Sci., Moshtohor, 44:705-716.

Fawaz, S.A. (2010). Effect of using calcium chloride and cold storage on prolonging the storability of Zaghloul dates. Minfuiya J.Agric. Res. 35(3)1041-1055.

Hershkovitz, V., S.I. Saguy and E. Pesis (2005). Post harvest application of 1-MCP to improve the quality of various avocado cvs. Post. Biol. & Technol. 37: 252-264

Hisaw, L. (1991). Calcium sprays influence on apple fruit quality and storage shelf life. Compact Fruit Tree 24: 75-79.

Kader, A.A. (1985). Standardization and Inspection of fresh fruits and vegetables post harvest of Horticultural Crops USA. 122-130.

McGuire, R. G. (1992). Reporting of objective colour measurements. Hort. Sci., 27 (12): 1254-1255.

Mehaisen, S.M. A. (2005). Effect of sprays with calcium and some post harvest treatments on fruit quality and storability of guava fruits. Annals of Agric. Sci., Moshtohor, 43 (1): 323-35.

Mishra, D.S., J.P. Tiwari, K.K. Misra and S. Shant Lal (2003). Effect of calcium nitrate and method of application on nutrient content of leaves and post-harvest quality of guava fruits. Scientific Hort. 8: 11-19.

Moon-ByungWoo, Choi-JongSeung; Moon-Bw; Choi-Js (1999). Effect of pre-or/post-harvest application of calcium compound extracted from oyster shell on the calcium, pectin and ethylene evolution changes in stored apple fruit. Jour. Of the Korean Soc. For Hort. Sci. 40:2, 217-220.

Moon-Byung Woo, Lu-Wenglong, Zheng-Heling, Choi-Jongseung, Moon-Bw, Lu-Wl, Zheng-Hl, Choi-Js (2002). Effect of three-sprays of liquid calcium compounds on the calcium contents, quality and cell wall structure change of "Jingfen" pear fruits. Jour. Of the Korean Soc. For Hort. Sci. 43:1, 51-53.

Povaiah, B.W., G.M. Glenn and A.S.N. Reddy (1988). Calcium and fruit softening. Physiology and Biochemistry. Hort. Rev. 10: 107-143.

Raychaudharyi, R., J. Kaber, S.K.D.Ray and R.S. Dhua (1992). Influence of pre harvest sprayed calcium salts in the improving of fruit quality in guava fruits cv. L 49.Advances in Hort. and FORESTY,2:70-76.

Rensburg, E.V. and A.H.P. Engelbrecht (1985). Effect of calcium salts on the components causing browning of avocado fruits. South African Avocado Grower's Association Yearbook 8:14-15.

Rensburg, E.V. and A.H.P. Engelbrecht (1986). Effect of calcium salts on susceptibility to browning of avocado fruits. Jour. Of food Sci. 5 (4): 1067-1068.

Snedecor, G. W. and W. G. Cochran (1989). "Statistical Methods". 8th Ed. The Iowa State Univ. Press Iowa U.S.A. pp. 503-507.

Tingwa, P.O. and R.E. Young (1974). Effect of calcium on ripening of avocado fruits(*Persea americana*, Mill.) J. Amer. Soc. Hort. Sci.99(6)540-542.

Veldman, G. (1983). Calcium nitrate sprays on avocados at Westfalia Estate with the objective to reduce pulp spot. South African Avocado Growers' Association Yearbook, 6: 64-65.

Youn, Cheolku, Kirn Seonkyu, Lim Sangcheol, Kim Haghyun, Kim Youngho, Lee CheolHee, Choi Kwansoon, Youn-Ck, Kim Sk, Lim Sc, Kim HH, Kim YH, Lee CH, Choi KS. (2000). Effect of GA paste and calcium chloride on tree growth, fruit quality and storability of "Niitaka" pears. Journal of the Korean Society for Hort. Sci. 41:5, 517-522.

Zambrano, J and J. Manzano (1995). Effect of post-harvest calcium application on mango ripening and storage. Fruit-Paris,50:145-152.

تأثير الرش بالكالسيوم قبل الحصاد على صفات الجودة والقدرة التخزينية لثمار الزبدية (الأفوكادو)

صلاح محمود أحمد محيسن[١] ، أيمن عبد الرحمن الكفراوى[٢] ، على السيد زغلول[١]

[١] قسم بحوث تداول الفاكهة [٢] قسم بحوث الفاكهة الأسوائية وشبه الأسوائية

معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر

الملخص العربي

أجريت هذه الدراسة على أشجار زبدية بالغة نامية بمزرعة محطة بحوث البساتين بالقناطر الخيرية – القليوبية – مصر.

رشت الأشجار الزبدية بعد العقد وقبل الحصاد بشهر خلال موسمى ٢٠٠٩/٢٠١٠ بالكالسيوم بالتركيزات (٠.٢٥ و٠.٥٠ ٠.٧٥%). وعند وصول الثمار إلى مرحلة اكتمال النمو والصلاحية للقطف، قطفت الثمار فى الأسبوع الثالث من سبتمبر خلال موسمى الدراسة. نقلت الثمار إلى معمل بحوث تداول الفاكهة بمعهد بحوث البساتين حيث تم غسل وتجفيف وفرز الثمار. قسمت الثمار إلى مجموعتين للتخزين على درجة حرارة الغرفة (٢٣ ± ٢ °م) ورطوبة نسبية (٥٠ – ٦٠ %) والتخزين على درجة حرارة ٧ °م ورطوبة نسبية ٨٥–٩٠ %.

أوضحت نتائج هذه الدراسة أن رش أشجار الزبدية بالكالسيوم (٠.٢٥ و٠.٥٠ ٠.٧٥%) أدى تحسين صفات الجودة عند الحصاد والقدرة التخزينية للثمار. وأنه يمكن تخزين ثمار الزبدية لمدة ٩ أيام على درجة حرارة الغرفة ولمدة ٩ أسابيع على درجة حرارة ٧ °م.

قللت المعاملة بالكالسيوم نسبة التالف أثناء التخزين وسجلت معاملة الرش بتركيز ٠.٥ % أقل نسبة تالف فى الثمار المخزنة على٧ °م (٩.٦٣ ، ٩.٦٥ %) أو الثمار المخزنة على درجة حرارة الغرفة (٤.٩٣، ٣.٦٥%) خلال موسمى الدراسة مقارنة بمعاملة المقارنة (١٨.١، ١٩.٠١ %). (٧.٤، ٥.٦٨ %).

قللت المعاملات المستعملة الفقد فى وزن الثمار أثناء فترات التخزين سواء على٧ °م أو على درجة حرارة الغرفة وكانت معاملة الرش بالكالسيوم بتركيز ٠.٥ % هى أفضل المعاملات فى خفض نسبة الفقد للثمار المخزنةعلى٧ °م (٤.٩٣، ٤.٩٨ %) أو الثمار المخزنة على درجة حرارة الغرفة (٥.٤٣، ٤.٢ %) مقارنة بثمار المقارنة (٥.٧، ٦.٠٥ %)، (٨.٩٨، ٧.٧٨ %) خلال موسمى الدراسة.

أدت معاملات الرش بالكالسيوم إلى زيادة صلابة الثمار عند الحصاد، وخاصة الرش بالكالسيوم بتركيز ٠.٥% (٥٩٢ & ٦١٢ جم/مم^{٢}) وكانت ذات تأثير معنوى، والمحافظة عليها أثناء التخزين مقارنة بثمار المقارنة.

أدتت العاملات المختبرة إلى خفض معدل التغير فى لون الثمار، معدل التنفس، الحموضة الكلية والفينولات الكلية، بل حققت اعلى محتوى فى الثمار من حامض الأسكوربيك عند الحصاد وبعد إنتهاء فترة التخزين مقارنة بثمار المقارنة.

Table (1): Effect of pre harvest foliar sprays of Calcium on some physical characters of Fuerte Avocado fruits during storage at (7 ^{o}C) in 2009/2010 seasons.

Season	1st season(2009)														
Character	Fruit decay (%)					Fruit weight loss (%)					Fruit firmness (g mm^{-2})				
Storage period in weeks(P) / Treatment(T)	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean
Control	0.00	5.80	21.00	45.60	18.1A	0.00	3.15	8.22	11.43	5.70A	490.0	425.0	106.4	70.5	273.0C
Ca 0.25(ml L^{-1})	0.00	3.20	13.10	25.20	10.38B	0.00	2.81	8.10	10.18	5.28AB	571.0	510.0	448.4	80.0	402.3A
Ca 0.50(ml L^{-1})	0.00	2.90	11.80	23.80	9.63C	0.00	2.81	7.19	9.70	4.93B	592.0	543.0	420.2	84.8	410.0A
Ca 0.75(ml L^{-1})	0.00	3.10	12.50	24.50	10.03BC	0.00	3.04	8.13	11.36	5.63A	540.0	518.0	365.8	80.3	376.0B
Mean	0.00D	3.75C	14.60B	29.78A		0.00D	2.95C	7.91B	10.67A		548.3A	499.0B	335.2C	78.9D	
L.S.D. $p \leq 0.05$ for the interaction T x P = 0.842						T X P = 0.830					T X P = 14.95				
2nd season(2010)															
Control	0.00	5.45	19.80	50.80	19.01A	0.00	3.39	8.58	12.20	6.05A	537.0	455.0	115.0	74.0	295.3D
Ca 0.25 (ml L^{-1})	0.00	3.10	11.90	24.50	9.8B	0.00	3.10	7.46	10.70	5.32B	577.0	515.0	450.0	79.0	405.3B
Ca 0.50 (ml L^{-1})	0.00	3.00	12.00	23.60	9.65B	0.00	2.90	7.00	10.00	4.98B	612.0	545.0	459.0	96.5	428.1A
Ca 0.75 (ml L^{-1})	0.00	2.90	12.80	24.20	9.98B	0.00	3.19	7.70	11.10	5.50B	557.0	520.0	360.0	73.3	377.6C
Mean	0.00D	3061C	14.13B	30.78A		0.00D	3.15C	7.69B	11.00A		570.8A	508.8B	346.0C	80.7D	
L.S.D. $p \leq 0.05$ for the interaction T x P = 0.805						T X P = 0.891					T X P = 11.74				

Means followed with the same letter (s) within each column or row are not significantly different at $p \leq 0.05$.

Table (2): Effect of pre harvest foliar sprays of Calcium on some physical characters of Fuerte Avocado fruits during storage at ambient temperature (23 ± 2 ^{o}C) in 2009/2010 seasons.

Season	1st season(2009)														
Character	Fruit decay (%)					Fruit weight loss (%)					Fruit firmness (g mm^{-2})				
Storage period in days(P) / Treatment(T)	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean
Control	0.00	4.30	9.80	15.50	7.40A	0.00	9.50	12.10	14.30	8.98A	490.0	301.0	172.0	72.0	258.8D
Ca 0.25(ml L^{-1})	0.00	3.40	7.10	11.00	5.38BC	0.00	7.70	8.72	10.90	6.83B	571.0	344.0	255.0	92.0	315.5B
Ca 0.50(ml L^{-1})	0.00	3.00	6.90	9.80	4.93C	0.00	6.00	7.20	8.50	5.43C	592.0	356.0	320.0	122.0	347.5A
Ca 0.75(ml L^{-1})	0.00	3.60	7.80	11.40	5.70B	0.00	8.20	9.85	11.50	7.39B	540.0	225.0	227.0	80.0	268.0C
Mean	0.00D	3.58C	7.91B	11.93A		0.00D	7.85C	9.47B	11.30A		548.3A	306.5B	243.5C	91.5D	
L.S.D. $p \leq 0.05$ for the interaction T x P = 0.825						T X P = 1.257					T X P = 15.56				
2nd season(2010)															
Control	0.00	3.90	6.70	12.10	5.68A	0.00	8.22	10.80	12.10	7.78A	537.0	319.0	176.0	76.0	277.0D
Ca 0.25(ml L^{-1})	0.00	2.80	6.10	8.30	4.30B	0.00	6.59	8.60	9.70	6.22B	577.0	340.0	280.0	91.0	322.0B
Ca 0.50(ml L^{-1})	0.00	2.10	5.20	7.30	3.65B	0.00	4.58	5.80	6.60	4.25C	612.0	362.0	296.0	107.0	344.3A
Ca 0.75(ml L^{-1})	0.00	2.50	5.40	8.70	4.15C	0.00	7.65	9.70	11.10	7.11AB	557.0	333.0	235.0	85.0	302.5C
Mean	0.00D	2.83C	5.85B	9.10A		0.00D	6.76C	8.73B	9.88A		570.8A	338.5B	246.8C	89.8D	
L.S.D. $p \leq 0.05$ for the interaction T x P = 0.230						T X P = 1.247					T X P = 15.35				

Means followed with the same letter (s) within each column or row are not significantly different at $p \leq 0.05$.

Table (3): Effect of pre harvest foliar sprays of Calcium on some chemical characters of Fuerte Avocado fruits during storage at (7 oC) in 2009/2010 seasons.

Season	1st season(2009)									
Temperature	7 °C									
Character	Total acidity (%)					Ascorbic acid content (mg 100^{-1}g)				
Storage period in week (P) / Treatment(T)	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean
Control	1.15	1.10	1.06	0.92	1.06A	10.50	10.10	9.60	8.50	9.68C
Ca 0.25 (ml L^{-1})	1.09	0.94	0.85	0.81	0.92C	11.80	11.20	10.60	9.40	10.75B
Ca 0.50 (ml L^{-1})	1.09	0.95	0.80	0.68	0.88D	12.50	11.90	11.00	10.10	11.38A
Ca 0.75 (ml L^{-1})	1.20	1.03	0.88	0.75	0.97B	12.00	11.20	10.60	9.80	10.90B
Mean	1.13A	1.01B	0.90C	0.79D		11.70A	11.10B	10.45C	9.45D	
L.S.D. $p \leq 0.05$ for the interaction T x P = 0.053						T X P = 0.279				
2nd season(2010)										
Control	1.09	0.98	0.96	0.89	0.98A	9.90	8.60	7.50	6.80	8.20D
Ca 0.25 (ml L^{-1})	0.99	0.94	0.92	0.87	0.93A	10.70	9.40	8.50	7.50	9.03C
Ca 0.50 (ml L^{-1})	0.97	0.91	0.89	0.85	0.91C	12.20	11.20	9.50	8.50	10.35A
Ca 0.75 (ml L^{-1})	1.00	0.95	0.91	0.88	0.94B	11.80	10.50	9.20	8.00	9.88B
Mean	1.01A	0.95B	0.92C	0.87B		11.15A	9.93B	8.68C	7.70D	
T x P = 0.0167						T X P = 0.217				

Means followed with the same letter (s) within each column or row are not significantly different at $p \leq 0.05$.

Table (4): Effect of pre harvest foliar sprays of Calcium on some chemical characters of Fuerte Avocado fruits during storage at (23 ± 2 oC) in 2009/2010 seasons.

Season	1st season(2009)									
Temperature	23 ± 2 °C									
Character	Total acidity (%)					Ascorbic acid content (mg 100^{-1}g)				
Storage period in days(P) / Treatment(T)	At harvest	3	6	9	Mean	At harvest	3	6	9	Mean
Control	1.20	1.00	0.92	0.84	0.99A	10.50	10.00	9.90	8.40	9.70D
Ca 0.25 (ml L^{-1})	1.09	0.95	0.78	0.53	0.84D	11.80	11.20	10.80	9.30	10.78C
Ca 0.50 (ml L^{-1})	1.15	0.98	0.80	0.55	0.87C	12.50	12.00	11.70	10.40	11.65A
Ca 0.75 (ml L^{-1})	1.09	0.93	0.84	0.78	0.91B	12.00	11.40	11.30	9.50	11.05B
Mean	1.13A	0.97B	0.84C	0.68D		11.70A	11.15B	10.93C	9.40B	
L.S.D. p ≤ 0.05 for the interaction T X P = 0.0527						T X P = 0.32				
2nd season(2010)										
Control	1.09	0.94	0.78	0.56	0.84A	9.90	9.40	9.30	8.00	9.15D
Ca 0.25 (ml L^{-1})	0.97	0.84	0.75	0.70	0.82C	10.70	10.20	9.80	8.40	9.78C
Ca 0.50 (ml L^{-1})	0.99	0.87	0.72	0.50	0.77D	12.20	11.40	11.20	9.70	11.13A
Ca 0.75 (ml L^{-1})	1.00	0.84	0.77	0.71	0.83B	11.80	11.10	11.00	9.40	10.83B
Mean	1.01A	0.87B	0.76C	0.62D		11.15A	10.53B	10.33C	8.88D	
L.S.D. p ≤ 0.05 for the interaction T X P = 0.0167						T X P = 0.224				

Means followed with the same letter (s) within each column or row are not significantly different at $p \leq 0.05$.