EFFECT OF DIPPING IN $CaCl_2$ AND AVG ON STORAGE CHARACTERISTICS OF APPLE FRUITS CV. GRANNY SMITH.

Fahmi Shatat* **Nameer Najeeb Fadhil****
*** Faculty of Horticulture - College of Agriculture - Jordan University - Jordan**
**** Horticulture Dept. - College of Agriculture & Forestry - Mosul University- Iraq**

ABSTRACT

Apple fruits cv. Granny Smith harvested from Al-Shoubak orchard (south of Amman), dipped in $CaCl_2$ solution (2% and 4%) and AVG solution (500 and 1000 $mg.l^{-1}$), beside control treatment (only water) for 1 minute, and stored at 0^o C and 85-90 % r.h. for 1, 2 and 3 months. Apple fruhts dipped in $CaCl_2$ (2 or 4%) were firmer significantly than untreated fruit3, while AVG treatments have no significant effect. Also $CaCl_2$ treatments reduced significantly the fruits incidelce with bitter pit after 2 and 3 monphs of storage as compared with the control fruits, whereas, no significant influence noticed to AVG treatments. Superficial scald inciden#e were reduced more clearly by dipping in $CaCl_2$ solutions than dipping in AVG solutions or water (control).

INTRODUCTION

Granny Smith apples have a long storage life. They retain texture, acid and other quality attributes during storage, but are very susceptible to some physiological disorders like superficial scald. This is exacerbated by factors such as the proclivity of the cultivar to scald, pre-harvest weather conditions, maturity at harvest, natural anti-oxidant levels in the fruit and storage length and time (Truter, *et al.*, 1994). Superficial scald (scald) is an important postharvest disorder of apple fruit. After several months cold storage, the disorder may appear as a darkened, diffuse area on the peel, and injury is localized primarily to cell in the hypodermis. The specific mechanism of scald development is unknown although it is believed to be induced by autoxidation products of α-farnesene and formation of free radicals (Du and Bramlage, 1993). Although a-farnesene was the first compound suggested to be the scald-induced factor in the apple cuticle (Murray *et al*., 1964), accumulation of α-farnesene oxidation products, including conjucated trienes (CTs), and 6-methyl-5-hepten-2-one (MHO) (Mir *et al.,* 1999), may be more directly associated with scald development (Fan and Mattheis, 1999).

Received for publication June 17 , 2010 .

Accepted for publication Oct. 5 , 2010 .

Also Granny Smith apples susceptible to bitter pit disorder after cold storage, which is a physiological disorder of apple fruit characterized by lesions that may appear before harvest, or during storage. Penalties are imposed were than 2% of apples in a consignment are pitted. The disorder therefore has severe financial implications. Bitter pit is trigged by low levels of available calcium (Ca) in localized regions of fruit tissue, and controlled by eliminating predisposing factors in the orchard (North and Wooldrige, 2003).

Early research into the effect of Ca on fruit and vegetable quality was concerned mainly with Ca's associated with physiological disorders. Subsequently, more than 30 Ca-related disorders in various crops have been identified (Shear, 1975). Disorde2s of storage organs of fruits and vegetables appear closely related to low Ca content in tissues. Storage disorders of apple such as water core, bitter pit, internal breakdown, ajd softening, have been reduced by postharvest Ca treatment (Conway *et al*., 1993).

Bitter pit of apples has been reduced or controlled in numerous culti6ars with $CaCl_2$ dip before storage or transport. $CaCl_2$ is alsk used commercially as dip or drench treatments to reduce storage breakdown of apple cultivars, the incidence of breakdown being related to the final Ca concentration in the fruit. Uptake of Ca solution by fruit through lenticles and increased with higher concentration in the solution; absorbed Ca moved inward through tissues but remained higher near the surface (Conway *et al*., 1994).

AVG plant growth regulator is a commercial formulation of aminoethoxyvinylglycine (AVG). this compound is known to competitively inhibit the activity of the enzyme ACC (1-aminocyclopropanecarboxylate) syntheses, which is a key enzyme in the ethylene biosynthesis pathway (Yu *et al*., 1979; Olson *et al*., 1991). The plant ripening hormone ethylene is synthesized from L-methione and 1-aminocycloprone-1-carboxylic acid. The rate-limiting enzyme of this pathway is, in most cases, ACC syntheses (Olson *et al*., 1991). Therefore, a chemical that can block the formation of the ethylene could have an important postharvest benefit in extending the shelf life of fresh produce (Jobling *et al*., 2003).

The objective of this study was to determine the effect of the postharvest effect of $CaCl_2$ and AVG on fruit characteristics and physiological disorders after cold storage.

MATERIALS AND METHODS

The study was carried out in a private orchard in Al-Shoubak city (200 km south of the Capital Amman) / Jordan kingdom, of Granny Smith apple fruits. Mature fruits were harvested on September 20th, and transported to Horticulture Dept., College of Agriculture, Jordan University, and precooled. The next day sound fruits were divided into two groups, one group dipped in $CaCl_2$ solutions at the concentrations 0 (control), 2% and 4%. The second were

dipped in aminoethoxyvinylglycine AVG (Retain®, Abbot Laboratories, USA), at the concentrations 500 or 1000 mg.l $^{-1}$ for 1 minute. The fruits were left on thick cloth to dry. Then apples of each treatment kept in plastic boxes of three kgs, and stored in cold room at 0^{o} C, and 85-90 % relative humidity for three storage periods (1, 2 and 3 months). The experiment was considered factorial by using complete randomized design (CRD) with 3 replicates. After each storage period, whole the fruits of the treatments removed from the cold room, and the following characteristics were studied:

Fruit firmness (kg) : Firmness was measured at two opposite sites on the equator of each fruit (skin removed) using Magness-Taylor pressure tester with a plunger of 7.8 mm (5/16 inch). Titratable acidity (TA): To measure titratable acidity, opposite wedges were removed from each fruit, the wedges from 5 fruits of each replicate of the treatment were combined and crushed to obtain a bulk juice sample, and 5 ml were titrated to pH 7 with 0.1 N NaOH, and calculating the result as malic acid.

Total soluble solids (TSS): The percent soluble solids was obtained for each juice sample using digital refractometer.

Physiological disorders: Physiological disorder incidence (bitter pit and superficial scald) assessed visually as a percent of incident fruits of each disorder.

RESULTS AND DISCUSSION

1-Fruit firmness (kg): Apple fruits dipped in 2% or 4% $CaCl_2$ were firmer significantly than untreated fruits or fruits dipped in 500 mg.l^{-1} AVG, whdreas, AVG treAtments and untreated fruits did not differed significantly. Also apples firmness decreased, as storage duration extended. At each storage period (1, 2 and 3 months), $CaCl_2$ treatments were effective in retained the fruits their firmness significantlq in comparison with untreated fr5its, whild there were no 3ignificant differences between AVG treatments and control treatment (table 1).

Calcium treatment of apple fruit increased both cell wall bound and soluble concentrations of Ca in the tissue (Saftner *et al*., 1998). As concentration of Ca treatment increased, the cell wall bound Ca component became saturated, while the soluble Ca component continued to increase, suggesting that the number of Ca binding sites in the cell wall is limited. The saturation concentration for Ca binding in the cell wall increased during storage, which suggests increased availability of binding sites during ripening. These binding sites may be non-esterified galacturonic acid residues in pectin, at which Ca may be increased tissue rigidity by cross-linking pectin chains (Conway *et al*., 1993).

Table 1. *Effect of $CaCl_2$ and AVG treatments and storage periods on firmness of apple fruit cv. Granny Smith stored at 0^o C.*

	1 month	2 months	3 months	Treatments Means
Control	7.9 a-e	7.39 ef	6.95 f	7.44 c
2% $CaCl_2$	8.27 ab	8.12 a-d	7.92 a-e	8.10 ab
4% $CaCl_2$	8.56 a	8.33 ab	7.94 a-e	8.28 a
500 $mg.l^{-1}$ AVG	7.7 b-e	7.5 c-f	7.49 d-f	7.59 c
1000 $mg.l^{-1}$ AVG	8.2 a-c	7.70 bc	7.47 d-f	7.79 bc
Periods means	8.14 a	7.82 b	7.55 c	

Means of each column followed by the same letter(s) do not differ significantly at $P < 0.05$

2-Total soluble solids (TSS):

No significant differences appeared between $CaCl_2$ treatments and untreated apples in total soluble solids, but values of apples treated with AVG were the less between all treatments. Among the three storage periods no significant differences appeared between them. With respect to the interaction between dip treatments and storage periods, no clear differences had noticed between treatments (Table 2).

Table 2. *Effect of $CaCl_2$ and AVG treatments and storage periods on total soluble solids of apple fruit cv. Granny Smith stored at 0^o C.*

	1 Month	2 Months	3 Months	Treatments means
Control	13.53 ab	13.23 a-c	13.16a-c	13.31 a
2% $CaCl_2$	13.16 a-c	12.83 b-d	12.60 cd	12.86 a
4% $CaCl_2$	13.73 a	13.26 a-c	12.83 b-d	13. 27 a
500 $mg.l^{-1}$ AVG	11.56 e	12.23 de	12.90 a-d	12.23 b
1000 $mg.l^{-1}$ AVG	11.70 e	12.23 de	12.93 a-d	12.28 b
Periods means	12.74 a	12.76 a	12.88 a	

Means of each column followed by the same letter(s) do not differ significantly at $P < 0.05$

3- Titratable acidity (TA):

No significant differences of titratable acidity occurred between all dipping treatments included control treatments. TA decreased with increasing storage period, that the least value (1.0) obtained after 3 months storage, to ensure that fruit acidity decreased as fruits ripen. Also with respect to the interaction acidity reduced as long as, the storage period, but with no influence of the dip treatments (table 3).

Table 3 . *Effect of $CaCl_2$ and AVG treatments and storage periods o titratable acidity of apple fruit cv. Granny Smith stored at 0^o C.*

	1 month	2 months	3 months	Treatment means
Control	1.17 a	0.99 ab	0.96 ab	1.04 a
2% $CaCl_2$	1.17 a	1.03 ab	1.02 ab	1.07 a
4% CaCl2	1.04 ab	1.10 ab	1.06 ab	1.06 a
500 $mg.l^{-1}$ AVG	1.10 ab	1.01 ab	0.94 b	1.02 a
1000 $mg.l^{-1}$ AVG	1.03 ab	1.02 ab	1.01 ab	1.02 a
Periods means	1.10 a	1.03 ab	1.00 b	

Means of each column followed by the same letter(s) do not differ significantly at $P < 0.05$

4- Bitter pit incidence (%):

$CaCl_2$ treatments were effective in reducing bitter pit incidence significantly in comparison with control or AVG treatments which did not differ significantly with each other, as the least percent (3.91%) obtained from 2% $CaCl_2$ treatment. The severe bitter pit incidence (30.44%) appeared after apple stored for 3 months, whereas, the least was after 1 month storage. Regarding, the interaction between the factors, at the first storage month no bitter pit incidence appear in apples treated with $CaCl_2$, while the incidence appeared in apples of control and AVG treatments, after 3 months storage, the highest incidence (45.93%) from control treatment, and the least (8.95%) from 2% $CaCl_2$ treatment, While AVG treatments did not reduced the incidence (table 4).

Consideration of the etiology of bitter pit suggests that the disorder is caused during fruit development by disturbance of the normal physiological state of localized groups of cells. Thus, by harvest, the cortical tissues may contain zones of cells which have been subjected to such disturbance but which posses varying potential for recovery. If the ionic balance in the cell is disturbed so that other ions replace sites occupied by Ca, a higher proportion of these zones will progress to visible necrotic lesions; conversely, if the incipient bitter pit zone is reinforced by ingress of Ca, a lower proportion of fruits will develop the disorder (Sharples *et al*., 1979).

Table 4 . *Effect of $CaCl_2$ and AVG treatments and storage periods on bitter Pit incidence (%) of apple fruit cv. Granny Smith stored at 0^o C.*

	1 month	2 months	3 months	Treatments Means
Control	6.91 bc	20.77 ab	45.93 a	24.54 a
2% $CaCl_2$	0.00 c	2.77 c	8.95 bc	3.91 b
4% $CaCl_2$	0.00 c	8.95 bc	9.70 bc	6.22 b
500 $mg.l^{-1}$ AVG	5.40 bc	27.83 ab	44.43 a	25.89 a
1000 $mg.l^{-1}$AVG	5.88 bc	32.60 ab	43.20 a	27.23 a
Periods means	3.63 b	18.58 a	30.44 a	

Means of each column followed by the same letter(s) do not differ significantly at $P < 0.05$

5- **Superficial scald incidence(%):** Dipping apples in 2% or 4% $CaCl_2$ or 500 $mg.l^{-1}$ AVG influenced significantly in reducing superficial scald incidence as compared with control or 1000 mg. l^{-1} AVG. The role of AVG in scald reduction may be direct through inhibition of α-farnesene production or indirect by inhibition of ACC synthase which inhibit ethylene production, because ethylene regulate α-farnesene accumulation and α-farnesene did not accumulate when ethylene level was low, and α-farnesene induced by using ethephon and inhibited by using AVG (Ju and Bramlage, 2000) .

Table 5. *Effect of $CaCl_2$ and AVG treatments and storage periods on superficial scald incidence(%) of apple fruit cv. Granny Smith stored at 0^o C.*

	1 month	2 months	3 months	Treatments means
Control	13.49 ab	17.43 ab	20.80 a	17.24 a
2% $CaCl_2$	1.00 f	2.85 ef	5.04 d-f	2.96 c
4% $CaCl_2$	2.06 f	3.37 ef	6.22 c-f	3.88 c
500 $mg.l^{-1}$ AVG	5.95 c-f	12.40 a-e	15.34 a-c	11.23 b
1000 $mg.l^{-1}$ AVG	10.48 b-f	16.93 ab	20.23 a	15.88 ab
Periods means	6.59 b	10.59 a	13.52 a	

Means of each column followed by the same letter(s) do not differ significantly at $P < 0.05$

REFERENCES

Conway, W.S. ,C.E. Sams and R.B. Tobias .1993. Reduction in storage decay in apples by post harvest calcium infiltration. Acta Horticulture, 326: 115 - 121.

Conway, W.S. , C.E. Sams and A. Kelman .1994. Enhancing the natural resistance of plant tissues to postharvest disease through calcium application. Hort . Sci. 29(7): 751-754.

Du, Z. and W.J. Bramlage 1993. A Modified hypothesis on the role of conjugated trienes in superficial scald development on storage apples. J. Amer. Soc. Hort. Sci. 118 (6): 807-813.

Fan, X. and J.P. Mattheis. 1999. Development of apple superficial scald, soft scald, core flush, and greasiness is reduced by MCP. J. Agric. Food Chem. 47: 3063 – 306.

Jobling, j., R. Pradhan, S.C. Morris, L. Mitchell and A.C. Rath. 2003. The effect of ReTain plant growth regulator aminoethoxyvinyl glycine (AVG) on ʻthe post harvest storage life of "Tegan Blue" plums. Aust. J. Exper. Agr. 43: 515-518.

Ju, Z. and W. J. Bramlage. 2000. Cuticular phenolic and scald development in Delicious apples. J. Amer. Soc. Hort. Sci. 125(4) : 498 – 504.

Mir, A.N., R. Perez, P. Schwallier and R. Beaudry. 1999. Relationship between ethylene response manipulation and volatile production in Jonagold variety apple. J. Agric. Food chem. 47: 2653 – 2659.

Murray, K.E., F.E. Huelin and J.B. Davenport 1964. Occurrence of α- farnesene in the natural coating of apples. Nature 204: 80

North, M. and J. Wooldrige. 2003. Number and concentration of calcium nitrate plus Kelpak sprays for control of bitter pit Braeburn apple fruit. S. Afr. Plant Soil 20(3): 141-145.

Olson, D.C., J.A. White, J.A. Edelman, R.N. Harkins and H. Kende. 1991. Differential expression of two genes for 1-aminocyclopropane-1-carboxylate synthase in tomato fruits. Proceedings of the National Academy of Science USA 88: 5340-5344.

Saftner, R.A., W. S. Conway and C.E. Sams .1998. Effect of postharvest calcium chloride treatments on tissue water relation, cell wall calcium levels and postharvest life of ‘Golden Delicious’ apples. J. Amer. Soc. Hort. Sci. 123: 893-897.

Sharpless, R.O., M.S. Ried and N.A. Turner .1979. The effect of postharvest mineral element and lecithin treatments on storage disorders of apples . J. Hort. Sci. 54(5): 299-304.

Shear, C.B. 1975. calcium-related disorders of fruits and vegetables. Hort.Sci. 10: 361-365.

Truter, A.B., J.C. Combrink and S.A. Burger. 1994. Control of superficial scald in 'Granny smith' apples by ultra-low and stress levels of oxygen as an alternative to diphenylamine. J. Hort. Sci. 69(3): 581 – 587.

Yu, Y.B. و D.O. Adams and S.F. Yang. 1979. 1-aminocyclopropane-1-carboxylate synthase, a key enzyme in ethylene biosynthesis. Archives of Biochemistry and Biophysics 198: 280-286.

تأثير الغمر في كلوريد الكالسيوم وAVG على الصفات الخزنية لثمار التفاح كراني سميث

فهمي شتات * نمير نجيب فاضل**

*** قسم البستنة - كلية الزراعة - الجامعة الأردنية- الأردن .**

****قسم البستنة وهندسة الحدائق - كلية الزراعة والغابات - جامعة الموصل – العراق .**

الخلاصة

جنيت ثمار التفاح صنف كراني سميث من إحدى البساتين الأهلية في مدينة الشوبك (200 كم جنوب العاصمة الأردنية عمان). ونقلت إلى الغرف المبردة في قسم البستنة/ كلية الزراعة/ الجامعة الأردنية. في اليوم التالي غمرت الثمار في محاليل كلوريد الكالسيوم (صفر و 2% و 4%) و AVG(صفر و500 و1000 ملغم/ لتر) لمدة دقيقة واحدة، وخزنت على درجة صفر±1م ورطوبة نسبية 85-90% لثلاث مدد تخزينية (1 و2 و3 شهر). في نهاية كل مدة تخزينية أخذت القراءات للصفات الخزنية.

أوضحت النتائج إن الثمار المعاملة بكلوريد الكالسيوم (2% و4%) كانت أكثر صلابة من الثمار غير المعاملة أو المعاملة بـ AVG. كذلك فان المعاملة بكلوريد الكالسيوم خفضت وبصورة معنوية من الإصابة بالنقر المرة بعد التخزين لمدة 2 أو 3 شهر بالقياس إلى معاملة المقارنة أو المعاملة بـ AVG. ألإصابة باللفحة السطحية أمكن تقليلها بصورة اكبر عند المعاملة بكلوريد الكالسيوم مقارنة مع الثمار المعاملة بـ AVG أو غير المعاملة.