

**RELATIONSHIP BETWEEN FRUIT CONTENT OF Ca, N AND Mg AND PHYSIOLOGICAL DISORDERS OF APPLE CVS. FUJI AND GRANNY SMITH**

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The study carried out in Jordan University, College of Agriculture to investigate the relationship between apple fruit disorders and mineral content of N, Ca and Mg of apple fruits cvs. Fuji and Granny Smith after dipping in 0, 2 and 4% CaCl<sub>2</sub> or 0, 500 and 1000 mg.l<sup>-1</sup> AVG and storage at 0° c for three months. The results indicated that CaCl<sub>2</sub> treatments were significantly increased fruit contents of Ca and significantly decreased fruit incidence with bitter pit in the Granny Smith cultivar, while no clear relationship noticed between AVG treatments and mineral fruit contents and disorder incidence. The increment of Ca content in the fruits, or the reduction of Mg/Ca and N/Ca ratios resulted in a reduction in bitter pit incidences. Granny Smith fruits was more susceptible to bitter pit disorder than Fuji fruits.

**INTRODUCTION**

Fuji and Granny Smith apples and many other apple cultivars are susceptible to physiological disorder during storage, such as to bitter pit and superficial scald, Granny Smith apple are particularly prone to bitter pit and scald, and in some areas, the incidence in this cultivar reaches 100% after several months of storage (Barlow, 1988). Bitter pit is a corking disorder in apple characterized by sunken lesion that develop just prior to harvest or during storage. The tissue below the skin in the pitted fruits becomes discolored and dehydrated (Faust and Shear, 1968). Susceptibility to bitter pit varies among cultivars and geographic regions, disorder incidence has been associated with environmental and cultural conditions, excessive tree vigor, light cropping, calcium deficiency and moisture stress are among the factors that predispose the fruit to bitter pit (Perring, 1986 and Ferguson and Watkins, 1989). Fruits that immature at harvest are also prone to develop bitter pit (Burmeister and Dilley, 1993). The development of superficial scald may be manifested as peel browning with some pitting if the damage is sever (Emmongor *et al.*, 1994). Scald symptom development is accelerated when the stored fruits are warmed to room temperature (~ 22 C°) 3-7 days following low temperature storage (Ingle and D'Souza, 1989). AVG plant growth regulator is a commercial formulation of aminoethoxyvinylglycine (AVG). This compound known to inhibit the production of ethylene via the competitively inhibit the activity of the enzyme 1- aminocyclopropanecarboxylate synthase. The material was proved to be effective as a pre- and post-harvest treatments of many fruits. It resulted in reducing ethylene productand increased storage quality (Curry, 2002; Gastier, 2003), and maintained flesh firmness (Xiao, 1993; Beaudry and Jayanty, 2003), beside the reducing of storage physiological disorders such as

superficial scald (Ingle and D'Souza, 1989;

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Zhi Guo and Curry, 2000), senescence breakdown (Brackman and Waclawovsky, 2001) and water core (Curry and Thompson, 1999). Many studies have shown relationship between mineral composition of apples and the development of storage disorders. For example, the development of senescent breakdown during long-term storage can be negatively related to fruit Ca (Bramlage, *et al.*, 1983; Bramlage, *et al.*, 1985 and Marmo, *et al.*, 1985) and Mg concentrations (Sharples, 1968) and positively related to N concentrations (Wills and Scott, 1976). The incidence of decay, bitter pit and low temperature breakdown (Sharples, 1980) also may be related to fruit mineral composition at or shortly before harvest. Among them the Ca concentration in the fruit have been shown to be important. A low fruit Ca level is associated with the occurrence of bitter pit and other physiological disorders. However since Mg supplies also promote bitter pit, directly or indirectly by lowering the fruit Ca level, the incidence of bitter pit can be predicted more reliably from the Mg /Ca or (K+Mg)/Ca ratio. Also increase nitrogen applications increase nitrogen in the fruit at a much greater rate than in the leaves further aggravating the nutrient imbalance in the fruit by rapidly increasing the N/Ca ratio in the fruit which Shear (1972) showed to be more closely, correlated with bitter pit and cork spot than calcium alone.

The aim of this work is to investigate the effect of CaCl<sub>2</sub> and AVG on Fuji and Granny Smith apple fruits and their relationship with the incidence of bitter pit and superficial scald disorders.

## MATERIALS AND METHODS

Fruits from 15 years old Fuji and Granny Smith apple trees were harvested on September 20<sup>th</sup> from Salem Alayyan orchard in Al-Shoubak area, south of Amman, Jordan, and transported in 20-25 Kg plastic boxes to the Faculty of Agriculture College and stored in cold room. In the second day fruits of the two cultivars (Fuji and Granny Smith) randomized into six lots each comprised nine kgs. of fruits. The fruit of each lots were placed in net sacks and immersed for a minute in one solutions of calcium (CaCl<sub>2</sub>) at the concentrations (0, 2 and 4%) and aminoethoxyvinylglycine AVG (Retain®, Abbot Laboratories, USA) at the concentrations (0, 500 and 1000 mg.l<sup>-1</sup>). After treatments, the fruits were allowed to dry in the air, and each lots divided into 3 replicates, the three kgs. of fruits were placed in a small plastic boxes and stored in the cold room at 0° c and 85-90% R.H. for three months and inspected after a further 3 days at ambient temperature. The experiment was considered factorial by using complete randomized design (CRD) with three replicates. After storage, these traits were estimated:

1- Incidence of bitter pit and superficial scald disorders: The disorders were visually estimated as describe by Faust and Shear, 1968 and Emmongor *et al.*, 1994, and calculated as a percentage of incidence.

2- Fruit contents of minerals: Section of fruits (peel and flesh) were taken and dried to determine fruit contents of minerals:

Calcium and Magnesium: were determined by titration method with version (E.D.T.A.).

Nitrogen: was determined by Kjeldal method (Page, 1982).

## RESULTS AND DISCUSSION

### Fruit mineral content :

**Calcium:** Dipping apple fruits of Fuji and Granny Smith in 2% and 4%  $\text{CaCl}_2$  increased significantly calcium concentrations in the fruit (Table 1). This results agreed with previous investigations of dipping fruits in calcium salts (Glenn and Poovaiah, 1990; Lurie and Klein, 1992 and Saftner and Conway, 1998), because calcium entry to the fruit either via lenticle on fruit peel (Hardenburg and Anderson, 1981) or through calyx opening of the fruit (Scott and Wills, 1977), whereas, apple fruits dipped in AVG did not increased calcium concentration significantly in the two cultivars.

**Magnesium:** Dipping Fuji and Granny Smith apples in  $\text{CaCl}_2$  or AVG solutions did not resulted in a significant differences in magnesium concentrations between treatments (Table 1).

**Nitrogen:** nitrogen concentrations of untreated Fuji fruits were somewhat more than fruits treated with  $\text{CaCl}_2$  or AVG, but differences were not significant among all treatments in the two cultivars (Table 1).

Table (1): Effect of  $\text{CaCl}_2$  and AVG treatments on Ca , Mg and N content of fruits of Fuji and Granny Smith , stored for 3 months at 0° c for three months.

Cultivars	Treatments	Ca (mg.1 <sup>-1</sup> )	Mg (mg.1 <sup>-1</sup> )	N (mg.1 <sup>-1</sup> )
Fuji	0 Control	410.0 cd	403.3 a	1166.7 a
	2% $\text{CaCl}_2$	550.0 b	343.3 a-d	1200.0 a
	4% $\text{CaCl}_2$	720.0 a	333.3 a-d	1400.0 a
	500 mg.1 <sup>-1</sup> AVG	506.6 bc	390.0 ab	1300.0 a
	1000 mg.1 <sup>-1</sup> AVG	513.3 bc	313.3 d	1033.3 a
Granny Smith	0 Control	373.3 d	386.6 a-c	1300.0 a
	2% $\text{CaCl}_2$	540.0 b	326.6 b-d	1300.0 a
	4% $\text{CaCl}_2$	670.0 a	316.6 cd	1300.0 a
	500 mg.1 <sup>-1</sup> AVG	460.0 b-d	326.6 b-d	1133.3 a
	1000 mg.1 <sup>-1</sup> AVG	470.0 b-d	380.0 a-d	1033.3 a

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

**Mg/Ca ratio:** Dipping treatments of Fuji and Granny Smith apples fruits in  $\text{CaCl}_2$  specially 4% decreased significantly Mg/Ca ratio (Table 2), may be as a resultant of Ca concentration increase caused by  $\text{CaCl}_2$  dip or light reduction of Mg concentration, whereas the effect of AVG dip did not affect Mg/Ca ratio significantly.

**N/Ca ratio:** No significant differences in N/Ca ratio appeared between treatments of Fuji apple fruits (Table 2), but Granny Smith apple fruits dipped in 4% CaCl<sub>2</sub> had less N/Ca ratio significantly as Ca increased in comparison with control fruits.

**Physiological disorders :**

**1-Bitter pit:** General speaking, CaCl<sub>2</sub> treatments showed a noticed reduction of bitter pit incidence (Table 2). No incidence appeared in Fuji apples treated with 2 and 4% CaCl<sub>2</sub> or 1000 mg/L AVG, were the incidence was slight in untreated apples. Granny Smith apples dipped in 2% or 4% CaCl<sub>2</sub> were less incidence significantly than untreated apples or that treated with AVG, which showed the highest bitter pit incidence (45.93, 44.43 and 43.2%). Some studies found that apple fruit dip in Ca salts resulted in bitter pit incidence reduction (Scott and Wills, 1977 and Webster and Forsyth, 1979).

**2-Superficial scald:** No significant differences appeared between all treatments of CaCl<sub>2</sub> and AVG, except 2% CaCl<sub>2</sub> treatment in Granny Smith apples which gave the lowest value (5.04%), and differed significantly with the highest value (20.8%) of the control treatment. Hardenburg and Anderson (1981) noticed that dipping “Stayman” apple fruits in 4% CaCl<sub>2</sub> reduced scald incidence. AVG treatments had no effect on the incidence of superficial scald (Table 2).

**Relationship between fruit minerals and disorders:** Ca level in the fruit was more clearly related with the incidence of bitter pit and superficial scald than Mg and N level, correlation coefficient of Ca and bitter pit and superficial scald incidence were -0.571 and -0.693, respectively (Table 3), that's mean increasing Ca content in fruits reduced the incidences, while correlation coefficient of Mg and bitter pit and superficial scald were 0.214 and 0.554 respectively. The role of Ca in maintaining fruit quality may be due to the soluble Ca involved in protein phosphorylation via Ca-calmodulin binding (Poovaiah *et al.*, 1988). A large portion of the Ca in plant cells is located in the cell wall and plasma membrane where it plays a major role in senescence and ripening. Cell wall-bound Ca is involved in maintaining cell wall integrity by binding carboxyl groups of polygalacturonate chains, which are mainly present in the middle lamella and primary cell wall (Tobias *et al.*, 1993).

The high correlation coefficients (0.461 and 0.574) obtained from N/Ca ratio (Table, 3) and bitter pit and superficial scald incidences, resulted in a high incidence of the disorders, especially bitter pit (Table 2). Also Curtis *et al.*, 1990 found that corkspotted fruits of Anjou pear has higher N/Ca ratio than sound fruits, and may be because high nitrogen apples respire in accelerated rate and stimulate appearance of disorder, and this negative effect can be overcome by increased level of calcium in the fruits (Faust and Shear, 1968).

The highest correlation coefficient of Mg/Ca (0.557 and 0.767), respectively (Table 3), means that high Mg level and low Ca level encourage bitter pit and superficial scald incidences. Hopfinger *et al.*, 1984 found than “Golden Delicious” apples treated with MgCl<sub>2</sub> increased fruit Mg level which resulted in increment affected fruits after storage. The importance of calcium in

maintaining cell membrane are influenced by the concentration of other elements like magnesium can displace Ca on membrane surface binding site. Magnesium may crosslink membrane component, but perhaps with small but important difference in resultant behavior of membrane, this substitution may alter physical behavior, such as leakage of solutes, that resulted in the occurrence of disorders (Bramlage *et al.*, 1985).

Table (2): Effect of CaCl<sub>2</sub> and AVG treatments on Mg/Ca , N/Ca ratios and bitter pit and superficial scald incidence of Fuji and Granny Smith apples stored at 0° c for 3 months .

Cvs.	Treatments	Mg/Ca	N/Ca	Bitter pit (%)	Superficial scald (%)
Fuji	0 Control	0.90 a	2.86 ab	6.88 b	12.36 ab
	2% CaCl <sub>2</sub>	0.63 cd	2.15 b	0.00 b	7.13 ab
	4% CaCl <sub>2</sub>	0.46 d	1.95 b	0.00 b	8.16 ab
	500 mg.1 <sup>-1</sup> AVG	0.76 bc	2.56 ab	0.00 b	9.14 ab
	1000 mg.1 <sup>-1</sup> AVG	0.61 cd	2.06 b	3.99 b	9.14 ab
Granny Smith	0 Control	1.00 a	3.45 a	45.93 a	20.80 a
	2% CaCl <sub>2</sub>	0.61 cd	2.44 ab	8.95 b	5.04 b
	4% CaCl <sub>2</sub>	0.47 d	1.95 b	9.70 b	6.22 ab
	500 mg. 1 <sup>-1</sup> AVG	0.71 bc	2.46 ab	44.43 a	15.34 ab
	1000 mg.1 <sup>-1</sup> AVG	0.80 a-d	2.19 b	43.20 a	20.23 a

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

Table (3): Correlation between Ca, Mg, N, Mg/Ca, N/Ca and incidence of bitter pit and superficial scald.

	Ca	Mg	N	Mg/Ca	N/Ca	Bitter pit
Mg	-0.625					
N	0.483	-0.021				
Mg/Ca	-0.936	0.827	-0.267			
N/Ca	-0.800	0.675	0.117	0.886		
Bitter pit	-0.571	0.214	-0.331	0.557	0.461	
Superficial Scald	-0.693	0.554	-0.391	0.767	0.574	0.877

العلاقة بين محتويات الثمار من الكالسيوم والنيتروجين والمغنيسيوم واصابتها بالاضرار الفسلجية  
للتفاح صنفى فوجي وكراني سميث  
نمير نجيب فاضل  
قسم البستنة وهندسة الحدائق/ كلية الزراعة والغابات / جامعة الموصل

الخلاصة

اجريت الدراسة في كلية الزراعة/ الجامعة الاردنية. حيث جنيتم ثمار صنف التفاح فوجي وكراني سميث من احدى المزارع الاهلية في مدينة الشوبك، ونقلتم بدون تاخير الى الغرف المبردة في قسم البستنة، واجري عليها التبريد المبدئي. وفي اليوم التالي عوملت الثمار بغمرها في محاليل كلوريد الكالسيوم بالتراكيز صفر و ٢ و ٤% واي في جي بالتراكيز صفر و ٥٠٠ و ١٠٠٠ ملغم/لتر لمدة دقيقة واحدة. استخرجت الثمار وتركت لتجف، ووضعت حسب معاملاتهما في صناديق بلاستيكية، ثم خزنت في الغرف المبردة على درجة حرارة صفر±١ م لمدة ٣ اشهر، واخذت القراءات للصفات الخزنانية في نهاية كل مدة. دلت النتائج على ان غمر ثمار الصنفين في كلوريد الكالسيوم زاد معنوية من محتويات الثمار من الكالسيوم، وقلل من اصابة الثمار بالنقر المرة للصنف كراني سميث بصورة معنوية مقارنة بالثمار غير المعاملة. معامل الارتباط اوضح علاقة سلبية بين تركيز الكالسيوم في الثمار او نسبة المغنيسيوم الى الكالسيوم واصابة الثمار بالاضرار الفسلجية. في حين لم تعط المعاملة بالاي في جي تأثيرا ايجابيا لزيادة تركيز الكالسيوم في الثمار، او التقليل من اصابة الثمار بالاضرار الفسلجية. بصورة عامة كانت ثمار الصنف كراني سميث اكثر اصابة من الصنف فوجي.

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