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EFFECT OF POSTHARVEST DIPPING OF ANNA APPLE FRUITS IN CALCIUM CHLORIDE SOLUTION ON FRUIT QUALITY UNDER CLOD STORAGE

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ABSTRACT: The present study was carried out during the two successive seasons of 2004 and 2005 on "Anna" apple trees budded on M.M. 106 rootstock. The trees are planted 3 x 4 meters apart. Two different locations were chosen for the present study, El-Khatatba, on side of Alex.desert road (km 84 from Cairo), where the soil is loamy sand, while the other orchard in Monof (Monofea government), where the soil is loamy clay.

The present work was carried out to study the effect of dipping mature "Anna" apple fruits in different concentrations of calcium chloride solution (0, 2 and 4%) on fruit quality and storability. Fruits storage was performed under 0°c and RH 98% .

The obtained results indicated that dipping mature fruits in CaCl2 solution at concentration 4% reduced the fruit weight loss, fruit decay percentage, preserved the highest fruit firmness and increased T.S.S.% to the highest value (13.6%) .

Concerning orchard location, fruit harvested from El-Khatatba orchard possessed better fruit quality and storage ability than those obtained from Monofea orchard.

INTRODUCTION

Recently the nutrient calcium has received a considerable attention in apple orchards not only due to its relationship to some physiological disorders, but also due to its other desirable effects like extending storage life and increasing firmness (Rato *et al.*, 2008; Manganaris *et al.*, 2007; and Saftener *et al.*, 1998).

Dipping the mature apple fruits in calcium chloride solution as postharvest treatment is prefered than preharvest sprays with the same solution. Postharvest calcium application maintains cell turgor, tissue firmness, delays membrane lipid catabolism and

extends the storage life of fresh fruits (Chardonnet *et al.*, 2003 and Tsantili *et al.*, 2002).

Many workers have examined the effect of calcium on quality of apple fruits. They reported that Anna apple fruits dipped in 2% or 4% $CaCl_2$ solution reduced fruit decay, weight losses and increased fruit firmness, specially at 4% (El-Ansary *et al.*, 2001; Hussein *et al.*, 2001; Yin *et al., 2005* and Rato *et al.*, 2008).

Microclimate might affect on fruit weight losses, fruit decay, fruit firmness, TSS and total acidity of Anna fruit (Allam, 1993).

The aim of this research is to study the effect of two orchard locations and postharvest calcium chloride treatments on fruit quality and on the ability of Anna apple fruits to storage.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2004 and 2005 on Anna apple trees budded on M.M. 106 rootstock, the trees are 3 x 4 meters apart.

Apple orchards are chosen at two different orchard locations in Egypt. The first one is at El-Khatatba, on side of Alex. Desert road (km 84 from Cairo), where the soil is loamy sand. The other orchard is at Monof (Monofea government), where the soil is loamy clay.

"Anna" apple trees used, were 6 years old in both orchards and the trees were nearly similar in growth in each orchard. The trees received the same normal cultural practices such as fertilization, pruning as well as pest and disease control.

Fruits were harvested after reaching maturity stage according to (ADS, Project, 1982).

The present work was carried out to study the effect of dipping mature fruits in $CaCl_2$ solution on fruit quality during storage. The collected mature fruits were dipped in $CaCl_2$ solution at concentrations: 0 (dipped in water as control), 2% and 4% for 5 minutes before packing in carton boxes. Each treatment contained three replicates (3 boxes, 30 fruits per each replicate) for each orchard location. Boxes of fruits were stored in refrigerator at 0°c

and relative humidity 98%. The same number of boxes (3 boxes each has 30 fruits) were stored on benches at room temperature.

The loss in fruit weight during storage and also decayed fruit percentage were periodically and biweekly recorded. Fruit physical and chemical properties were also periodically and biweekly in the sound fruits determined.

Fruit decay percentage:

Fifteen fruits for each treatment were taken and the decay percentage was determined as follow:

$$Decay\% = \frac{Number\ of\ decayed\ fruits\ at\ samoling\ date \times 100}{Initial\ No\ of\ stored\ mature\ fruits}$$

Weight loss percentage:

Fruits were weighed periodically and biweekly during cold storage and every two days at room temperature. Weight loss of the fruit was calculated as follows:

$$\text{Weight loss\%} = \frac{Average\ fruit\ weight\ after\ storage - fruit\ weight\ before\ storage \times 100}{Average\ fruit\ weight\ before\ storage}$$

Physical properties of fruit:

Fruit firmness:

Fruit firmness was measured in Lb / $inch^2$ using pressure tester (digital force – Gouge Model FGV – 0.5 A to FGV- 100 A. shimpo instruments).

Chemical properties of fruit:

Total soluble solids (T.S.S.%):

A hand refractometer was used to determine the total soluble solids percentage in fruit juice (A.O.A.C., 2000) every 15 days at cold storage and every two days at room storage.

Total acidity:

Total acidity was determined in terms of anhydrous malic acid percentage after titeration against 0.1 N sodium hydroxide using phenol phythalin as an indicator (A.O.A.C., 2000).

Total soluble solids / acid ratio:

T.S.S./acid ratio was estimated by the ratio between percentage of T.S.S. and percentage of acidity.

Statistical analysis:

A split-plot design in complete randomized block design with three replications was used. The dates were assigned to the main plots, while the treatments ranked to the sub-plots. The differences between means were compared using L.S.D. values at 0.05 level of significance according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Effect of orchard location and postharvest dipping in calcium chloride solution on the physical characteristics during the storage of "Anna" apple fruits:

Weight loss percentage:

A: under cold storage:

Data presented in Fig. (1) demonstrated that the loss% in fruit weight gradually increased as storage period advanced and attained the highest loss% of fruit weight after 105 days under cold storage at $0^{o}c$ in both orchard locations and both $CaCl_2$ treatments (solution 2% and 4%) or even in control fruits.

Control fruits showed higher weight loss percentage from 75 to 105 days under cold storage than that of other $CaCl_2$ treatments. This is true in the two studied seasons, however, fruits treated with 4% $CaCl_2$ gave the lowest significant values of weight loss% during the two seasons at two orchard locations. On the other hand, Khatatba resulted in lower fruit weight loss percentage than those in Monof perhaps, that is may be due to high fruit moisture percentage in fruit collected from Monof location.

Differences among two orchard locations were significant at the 2% or 4% $CaCl_2$ concentration and in control treatment during the period from 60 or 75 days until 105 days.

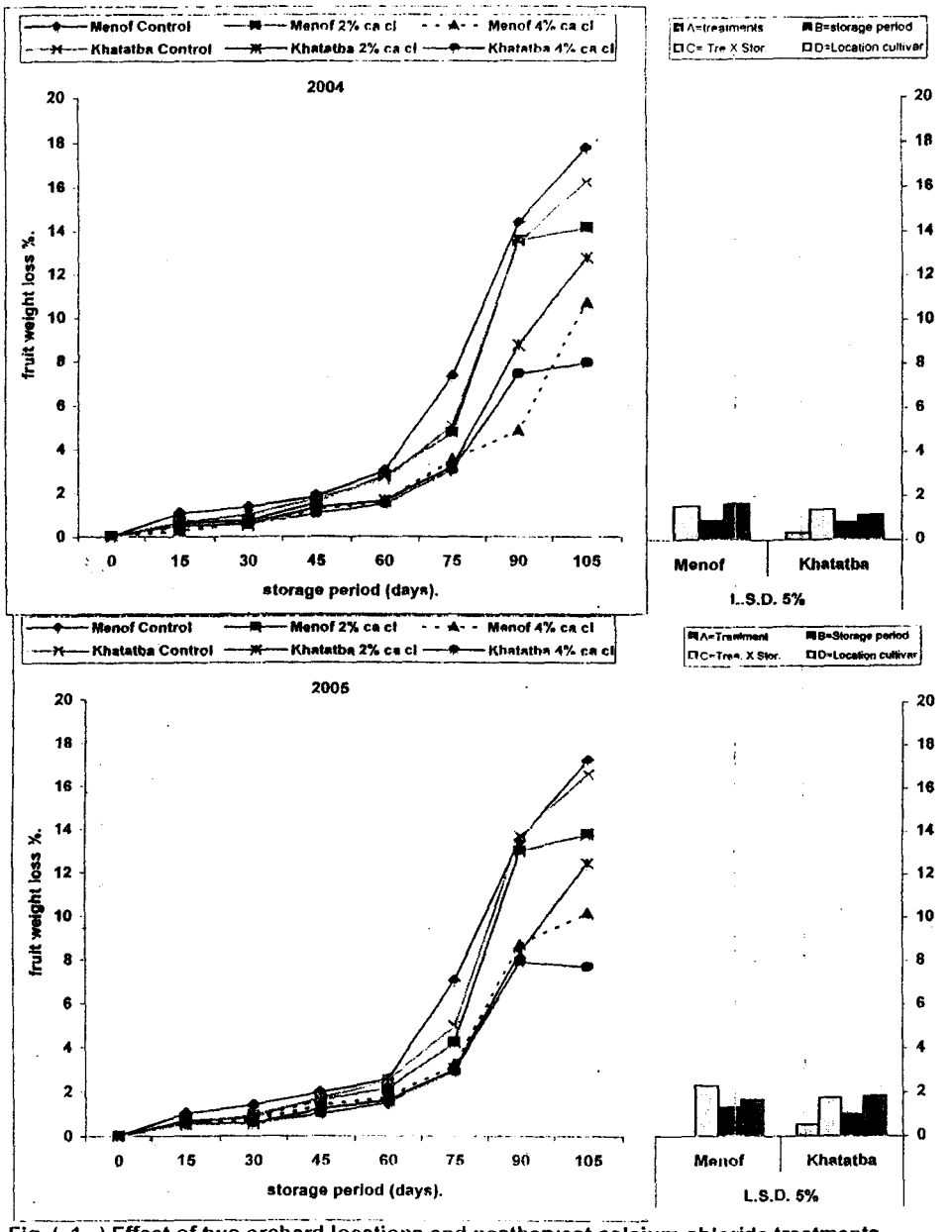

Fig. (1) Effect of two orchard locations and postharvest calcium chloride treatments on fruit weight loss percentage of Anna apple fruits under cold storage duringseasons 2004 and 2005.

B: Storage under room temperature:

It has been found that "Anna" apple fruits stored under room temperature Fig. (2) showed different values of fruit weight loss percentages by different $CaCl_2$ treatments. Control showed the highest value of weight loss percentage during 6 days, after that the fruits completely deteriorated, followed descendingly with those treated with 2% $CaCl_2$, while fruits treated with 4% $CaCl_2$ induced the lowest value of weight loss percentage in the two orchard locations.

Fruits from control and two $CaCl_2$ treatments (solution 2% and 4%) remained until 105 days at cold storage, while at room temperature it remained until 6, 10 and 10 days for control, 2% and 4% respectively in Khatatba location wherease from Monof it remained until 6, 8 and 10 days for control, 2% and 4% respectively. That is true for the two studied seasons.

These results agree with those demonstrated by Abdel-Hamid (2000) on grape who found that $CaCl_2$ treatments, greatly reduced fruit weight loss%. Reis *et al.*, (2004) working on banana found that mass loss% increased with keeping longer in storage period.

1-2. Decay percentage in:

A: Fruit under cold storage:

Results in Fig.(3) showed that the decay of the fruits under cold storage commenced in control fruits (the untreated with $CaCl_2$) after 45 days, while it commenced in those treated with 2% $CaCl_2$ after 75-90 days in the cold storage and in those treated with 4% $CaCl_2$ after 90 days. Thus the treatment of 4% $CaCl_2$ delayed the appearing of decay three months in the cold storage.

The percentage of decay attained the maximum value in the fruits of control (untreated with $CaCl_2$), followed descendingly with those previously treated with 2% $CaCl_2$, while the least decay percentage was observed in fruits previously treated with 4% $CaCl_2$.

The results showed also that orchard location played a role in determining the percentage of decay under cold storage. Orchard located in Monof exhibited higher decay percentage of stored

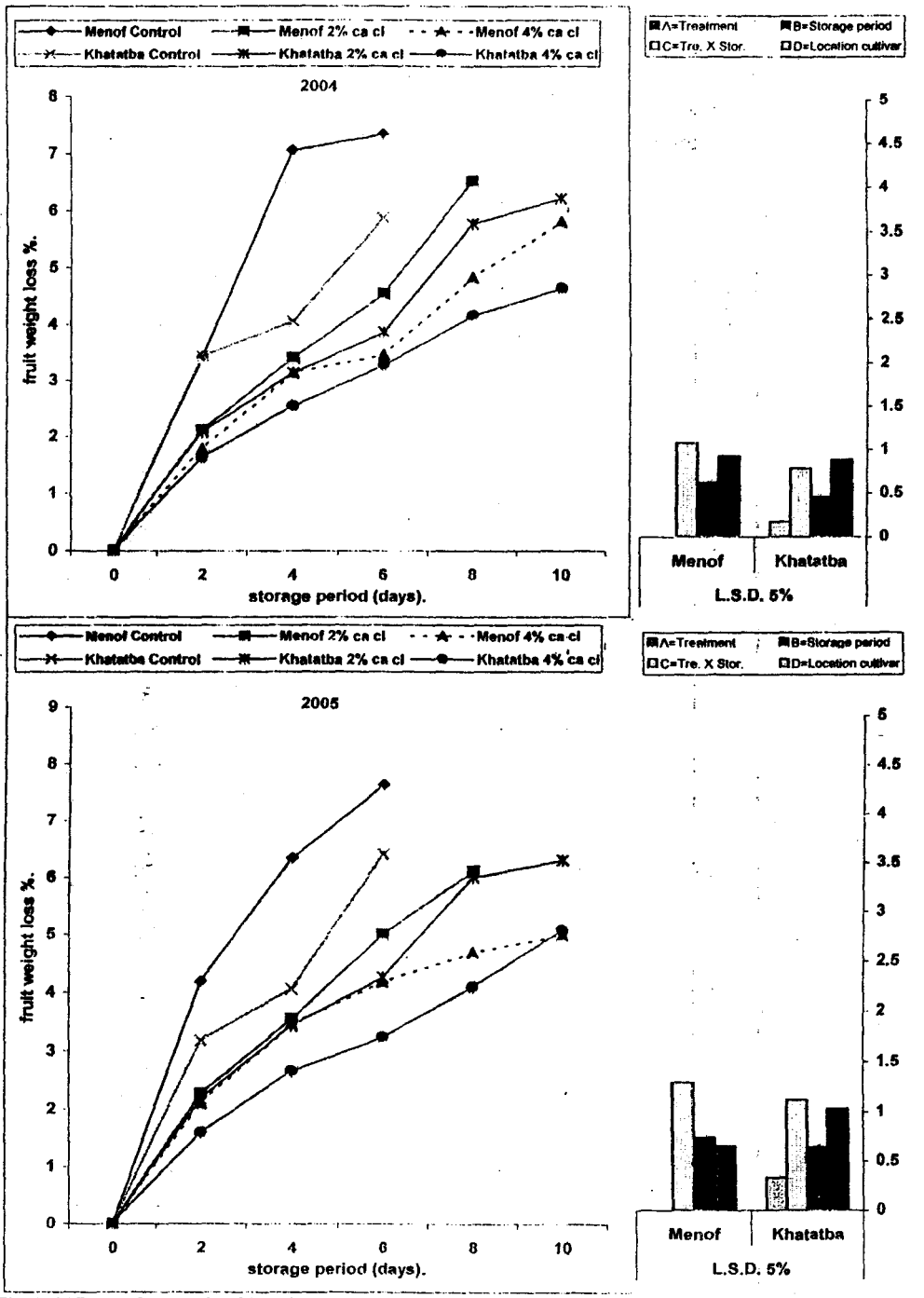

Fig. (2)Effect of two orchard locations and postharvest calcium chloride treatments on fruit weight loss % of Anna apple fruits under room condition during seasons 2004 and 2005.

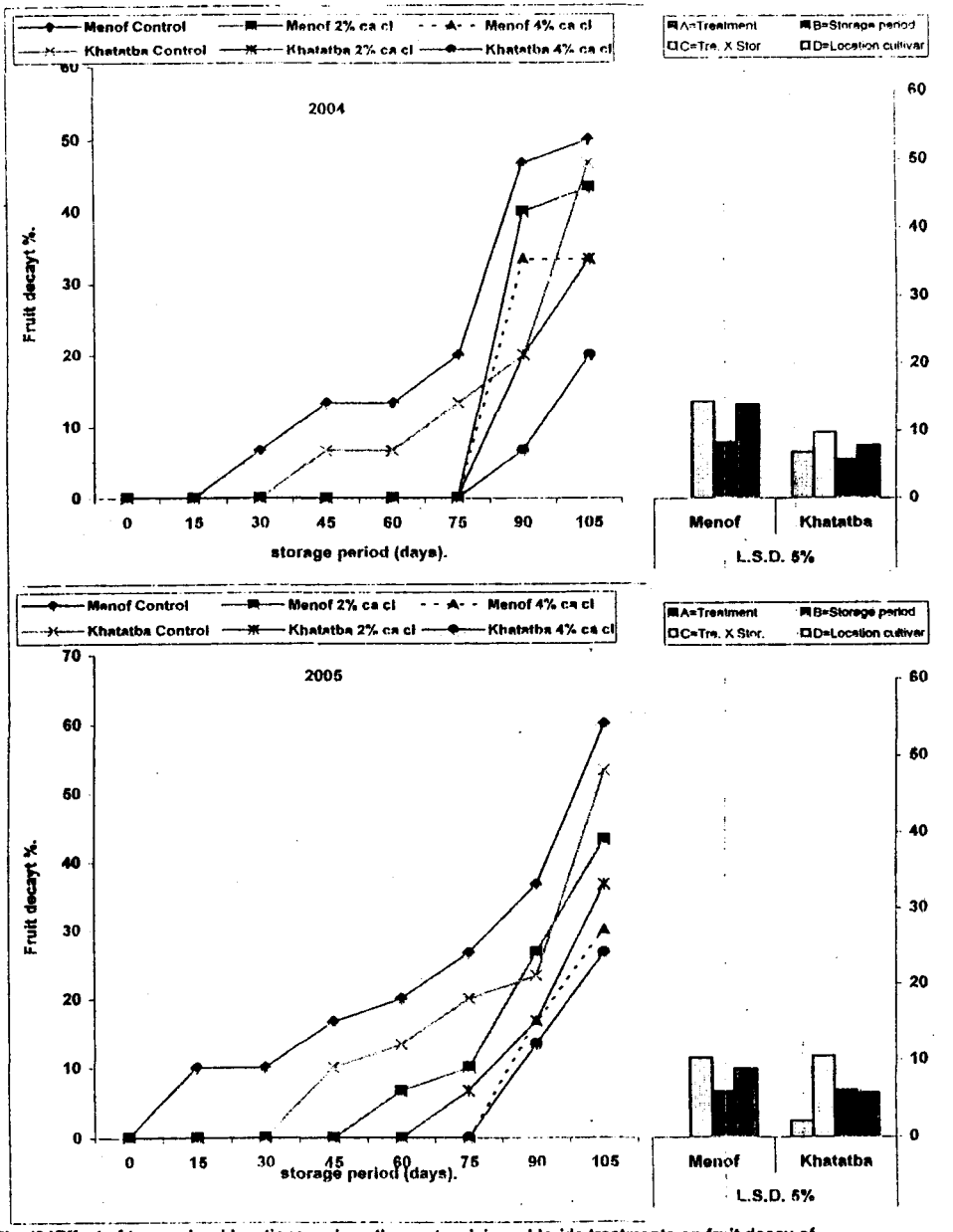

Fig. (3)Effect of two orchard locations and postharvest calcium chloride treatments on fruit decay of Anna apple fruits under cold storage during seasons 2004 and 2005.

fruits than those harvested from Khatatba location. Soil structure, water regime, climate condition and cultural survices in both locations are responsible of the difference in percentages of decayed fruits.

Differences among 4% treatment and other treatments were significant. Allam (1993) worked on "Anna" apple fruits and found that the microclimate has an effect on various character of fruits.

B: Fruit stored under room temperature:

It has been found that "Anna" apple fruits stored under room condition showed different values of decay percentage in the two studied calcium treatments Fig.(4). The fruits of control remained sound for 6 days only, while fruits treated with 2% or 4% $CaCl_2$ remained sound 10 days (Khatatba location), in comparison to those grown at Monof, which remained 8 and 10 days when previously treated with 2% and 4% $CaCl_2$, respectively. This is true for the two studied seasons. Differences among treatments and orchard locations were insignificant.

Generally, it could be concluded that, dipping fruits in calcium chloride with 4% concentration recorded lower decay values than control and 2% $CaCl_2$. When fruits were dipped in $CaCl_2$ solution, calcium accumulation occurred in the cell wall, avoiding at the same time possible surface damage (Chardonnet *et al.*, 2003).

The previous results are in the same line with those obtained by El-Ansary *et al.*, (2001) and Hussein *et al.*, (2001) who dipped fruits of "Anna" apple after harvesting in 2% or 4% $CaCl_2$ solution and reported that, 4% $CaCl_2$ reduced decay during storage in either cold storage (0-1°c) or under room temperature (34-35°c). Conway *et al.*, (1992) and Rato *et al.*, (2008) found that, dipping apple fruits in $CaCl_2$, produced the lower decay percentage.

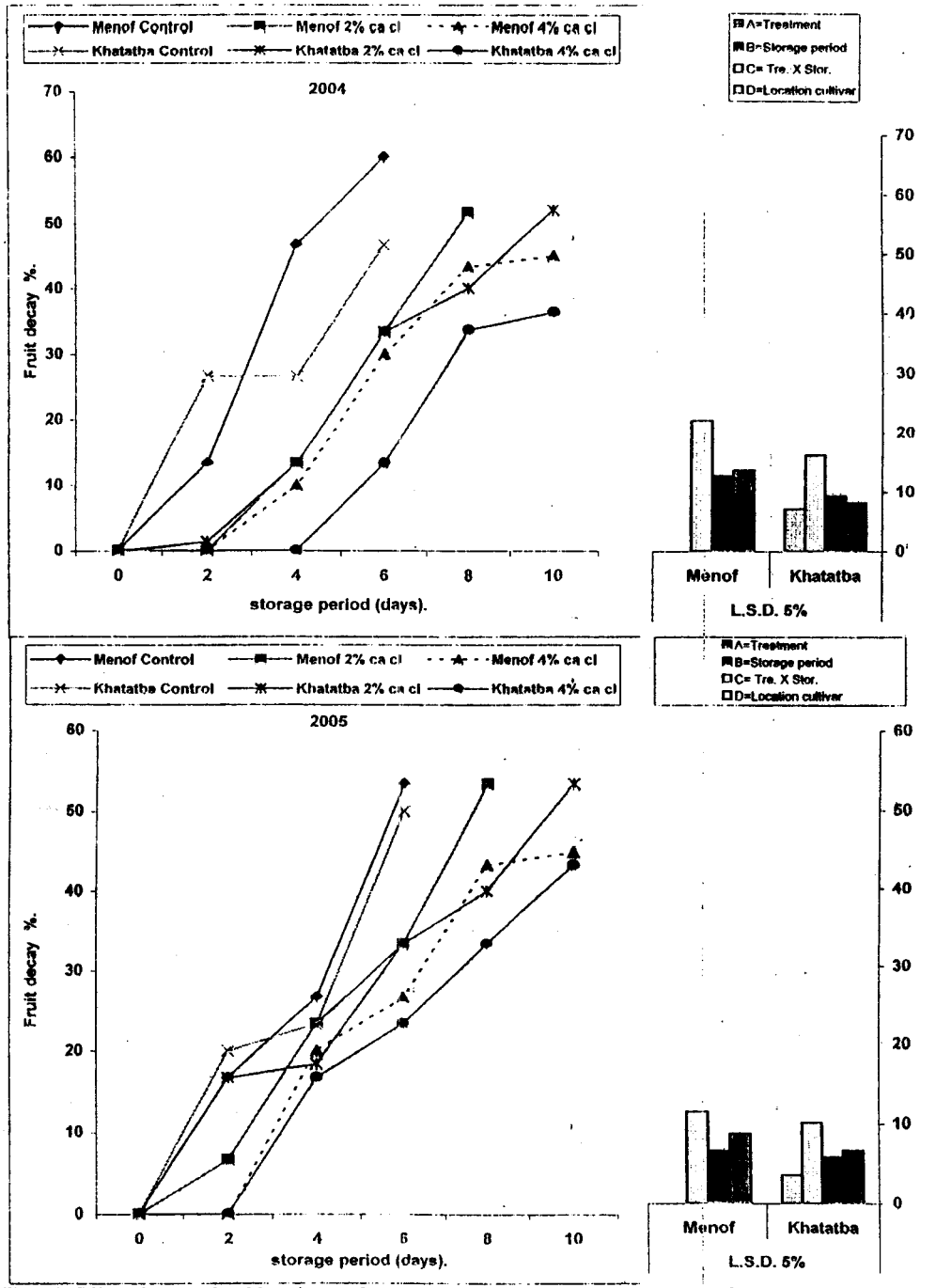

Fig. (4)Effect of two orchard locations and postharvest calcium chloride treatments on fruit decay % of Anna apple fruits under room condition during seasons 2004 and 2005.

Fruit firmness:

A: Under cold storage:

Data in Fig.(5) clearly showed that fruit firmness gradually decreased under cold storage, not only in control fruits but also in those at postharvest with $CaCl_2$ treated (2% and 4%) fruits to attain after three monthes low values. The decrease in fruit firmness occurred in control fruits as well as in those previously with $CaCl_2$ treated (2% and 4%) treated fruits up to 45-60 days under cold storage. Thereafter, fruits treated with $CaCl_2$ showed higher values of fruit firmness than those of control treatment up to 105 days in the cold storage.

Fruit firmness parameter indicates the grade of fruit ripening. Higher values of fruit firmness means that fruits are still in good state, and at better quality than those of low firmness values. At 105 days in cold storage (temperature 0°c and RH.98%) fruit firmness in control fruits attained 6.12 Lb / $inch^2$, while in fruits treated with 2% $CaCl_2$ was 7.2 – 7.39 Lb / $inch^2$ in the orchard location Khatatba. Values of fruit firmness of fruit collected from Monof attained in control (untreated) at 105 days in cold storage 5.62 Lb / $inch^2$, while at 2% $CaCl_2$ attained 6.7 and at 4% $CaCl_2$ attained 7 Lb / $inch^2$.

The quick deterioration of fruit in control treatment under cold storage indicate the higher respiration rate of control fruits in comparison to those treated with $CaCl_2$, which mainly acted to inactivate the respiration enzymes.

Abdel-Hamid (2000) working on Crimson seedless grape found that the increase in berry firmness after treating with $CaCl_2$ could be attributed to the role of ca^{2+} in building cell wall.

B: Under room temprature:

Data in Fig.(6) indicated that fruit firmness decreased quickly, when fruits were stored under room condition, not only in control fruits (untreated with $CaCl_2$) , but also in the two $CaCl_2$ treatments (2% or 4%). This was true until 6 days, after that, fruits of control were completely deteriorated, while fruits previously treated with 2% or 4% $CaCl_2$ remained until 10 days, respectively at Khatataba location and for 8 and 10 days for Monof location.

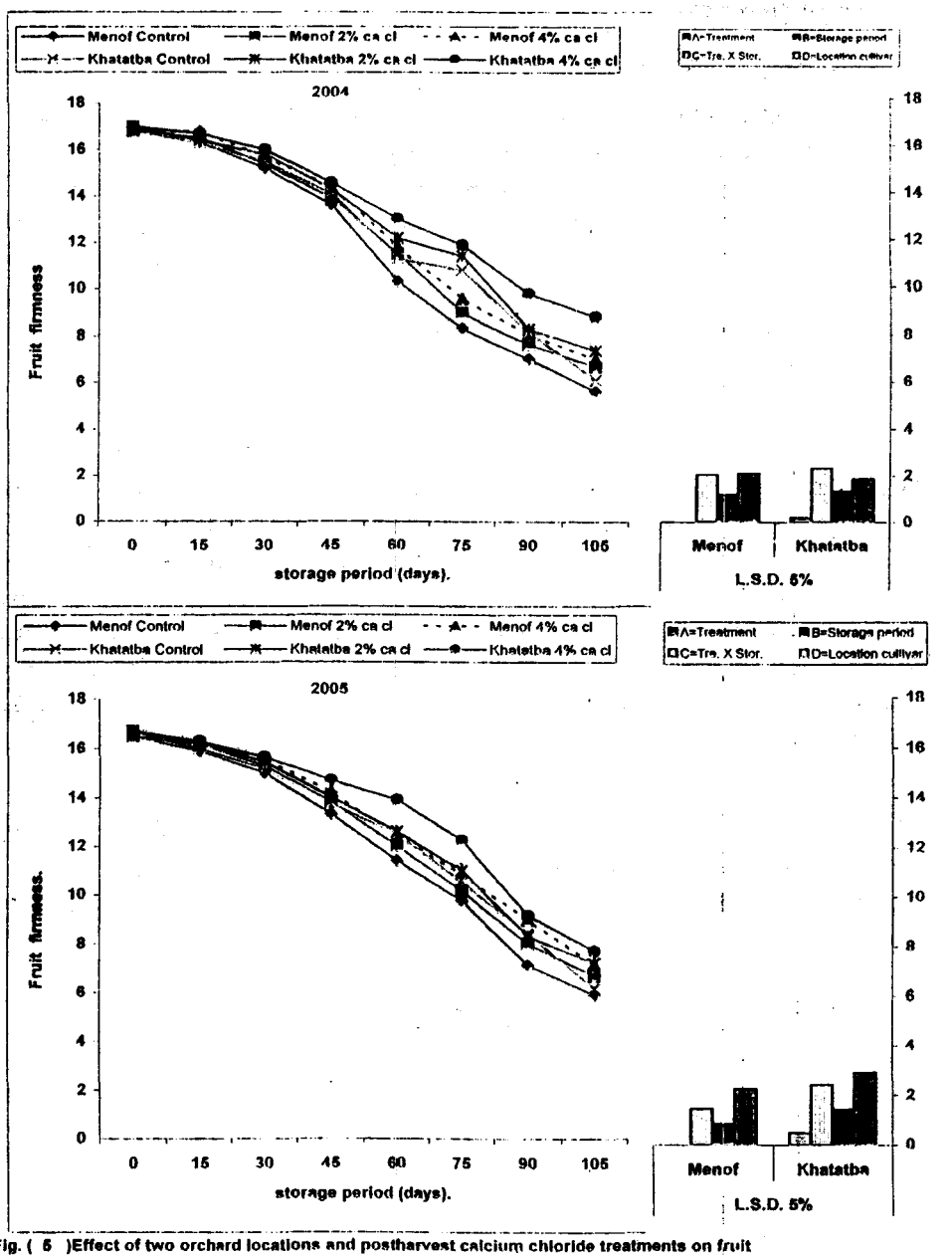

Fig. (5)Effect of two orchard locations and postharvest calcium chloride treatments on fruit firmness (Lb/inch2) of Anna apple fruits under cold storage during seasons 2004 and 2005.

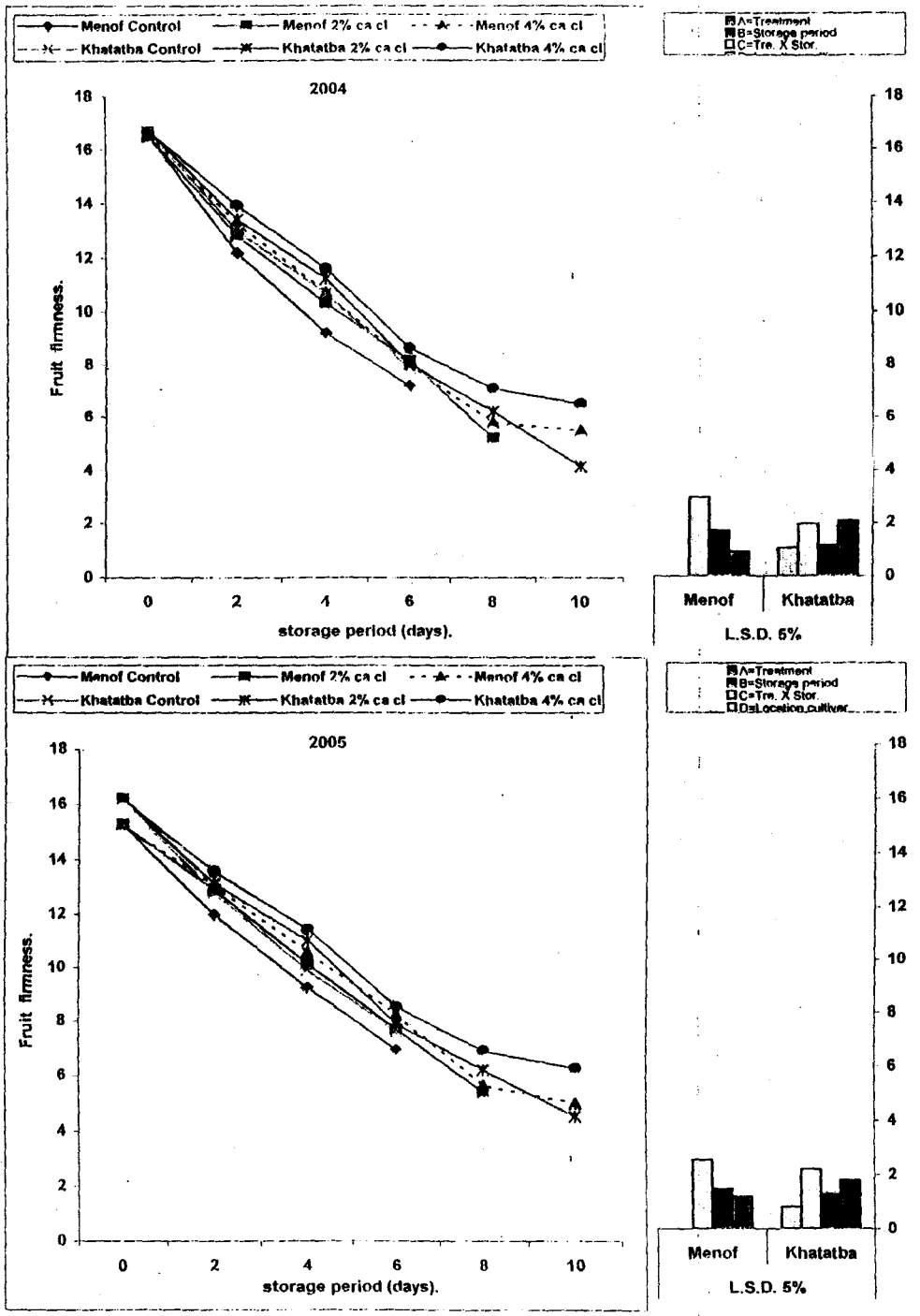

Fig. (6)Effect of two orchard locations and postharvest calcium chloride treatments on fruit firmness (Lb/inch2) of Anna apple fruits under room condition during seasons 2004 and 2005.

The fruits treated with 4% $CaCl_2$ collected from Khatataba location appeared the higher fruit firmness (6.27 – 6.51 Lb / $inch^2$) than those treated previously by 2% $CaCl_2$ and than that of Monof location (5.00 – 5.50 Lb / $inch^2$) . Differences among $CaCl_2$ treatments were insignificant.

It could be concluded that apple fruits dipped in $CaCl_2$ showed an increase in flesh firmness, compared to control fruits. Calcium salts can depress or even accelerate the senescence-related processes, depending on calcium concentration (Saftner *et al.*, 1998) .

Chardonnet *et al.*, (2003) worked on apple and Manganris *et al.*, (2007) worked on peach, found that the increase in cell wall-bound calcium of calcium-treated apple and peaches was related to both calcium concentration and time of storage.

2. Effect on chemical characteristics:

2.1. Total soluble solids (T.S.S.%)

A: Under cold storage:

Data in Fig.(7) showed that, T.S.S.% of fruit juice gradually increased in the storage beginning with fruit storage age 45 days up to 105 days (end of the storage period). T.S.S.% of fruits previously dipped in 4% $CaCl_2$ solution was higher than those previously treated with 2% $CaCl_2$ and control (untreated) .

The increase in T.S.S.% may be due to evaporation of water from fruits during storage, thus the previously treated fruits with $CaCl_2$ contained the higher T.S.S.% in fruit juice than those of control (untreated) (Abdel- Hamid, 2000). Differences among treatments and locations were insignificant.

B: T.S.S.% under room temperature:

Fig.(8) showed that, when the fruits were stored for 10 days under room condition, the T.S.S.% of the fruit juice gradually increased for 10 days in all treatments, except in control in the two locations and 8 days in fruits treated with 2% $CaCl_2$ in Monof location, as the fruits completely deteriorated after 6 and 8 days in the storage. T.S.S.% of fruits treated with 4% $CaCl_2$ were significantly higher than those of control.

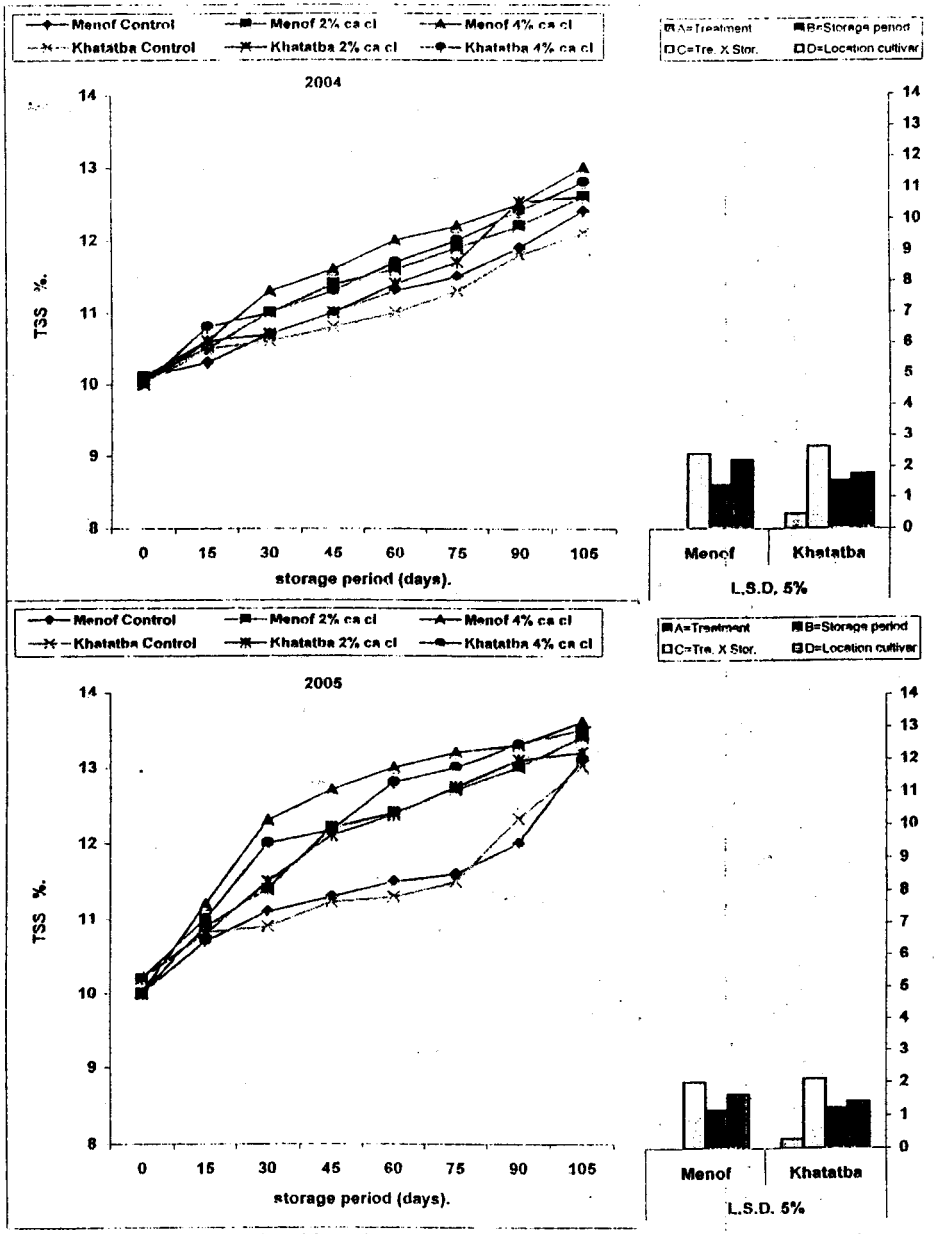

Fig. (7)Effect of two orchard locations and postharvest calcium chloride treatments on TSS % of Anna apple fruits under cold storage during seasons 2004 and 2005.

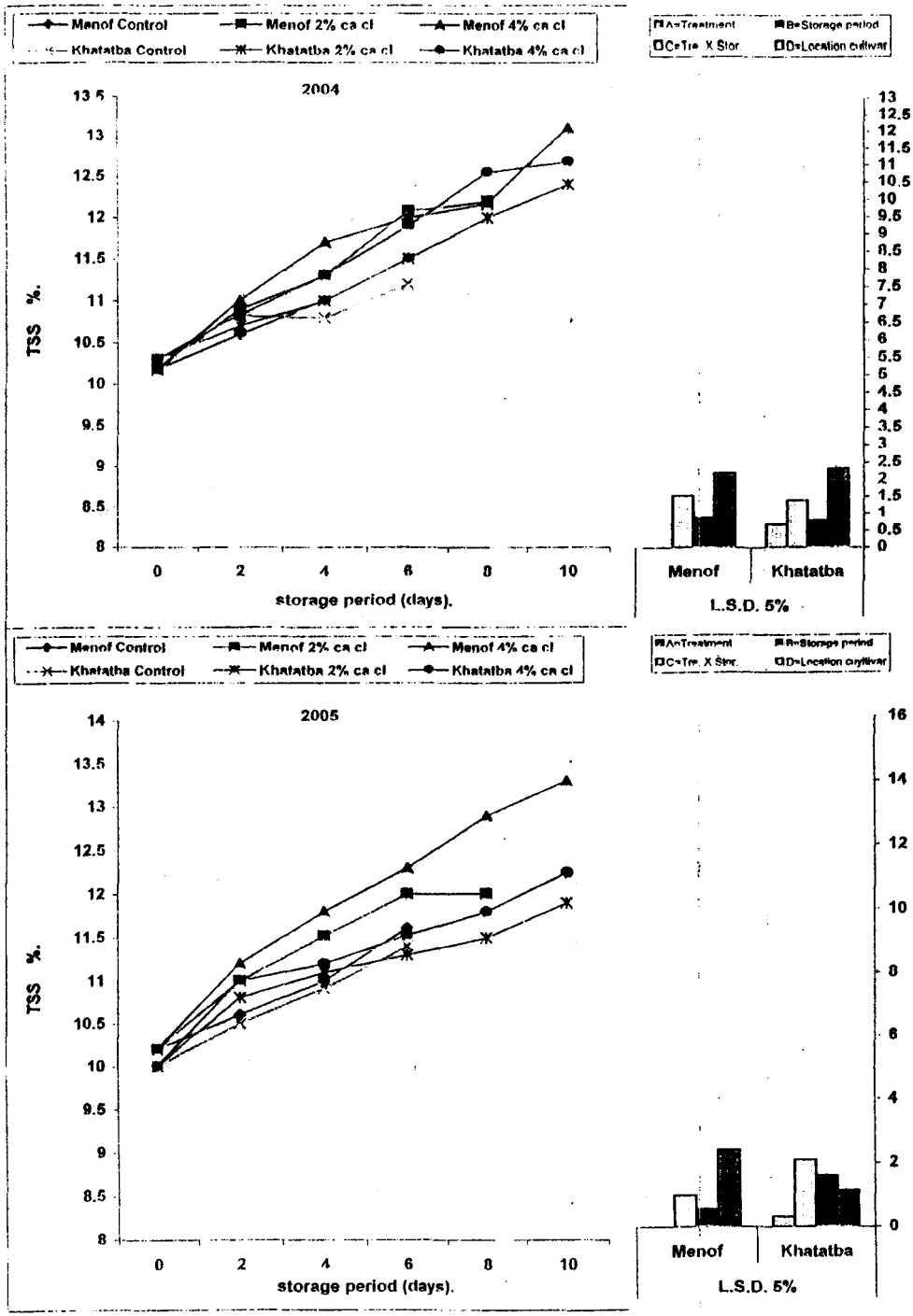

Fig. (8)Effect of two orchard locations and postharvest calcium chloride treatments on TSS % of Anna apple fruits under room condition during seasons 2004 and 2005.

Tsantili *et al.*, (2002) worked on lemon and found that $CaCl_2$ treatments decreased respiration rate and increased T.S.S.% . These results in harmony with those obtained by Reis *et al.*, (2004) and Yin *et al.*, (2005) worked on apple and found that, T.S.S.% content of fruits juice was increased by storage period.

2.2. Total acidity (as malic acid)

A: Under cold storage:

Data in Fig.(9) illustrated that, total acidity of the fruit juice gradually decreased to very low value at the end of storage period for treated and untreated "Anna" apple fruits during the two seasons of study. The lowest percentage of fruit juice acidity was recorded at $CaCl_2$ treatments as compared to the control. Differences among $CaCl_2$ treatments and control were significant in the first season for two locations. Abdel-Hamid (2000) found that grape fruits consumed higher rates of total fruit acidity under cold storage.

B: Under room temperature:

Fruits stored at room temperature for 10 days Fig.(10) there acidity content gradually decreased. The lowest value of acidity was obtained by 4% $CaCl_2$ at Khatatba orchard location for the two studied seasons. Differences among two locations were significant.

These results were in the same line with those obtained by Tassou *et al.*, (2007) and Yin *et al.*, (2005) who found that total acidity was decreased by increasing the storage period.

2.3. TS.S. / acid ratio

A: Under cold storage:

Results in Fig.(11) showed that, T.S.S./acid ratio gradually increased under cold storage for control and two $CaCl_2$ treatments (2% and 4%) and attained the highest value until 105 days in both orchard locations. The increase in T.S.S./acid ratio may be due to the increase of T.S.S. and decrease of total acidity by advance in the storage period.

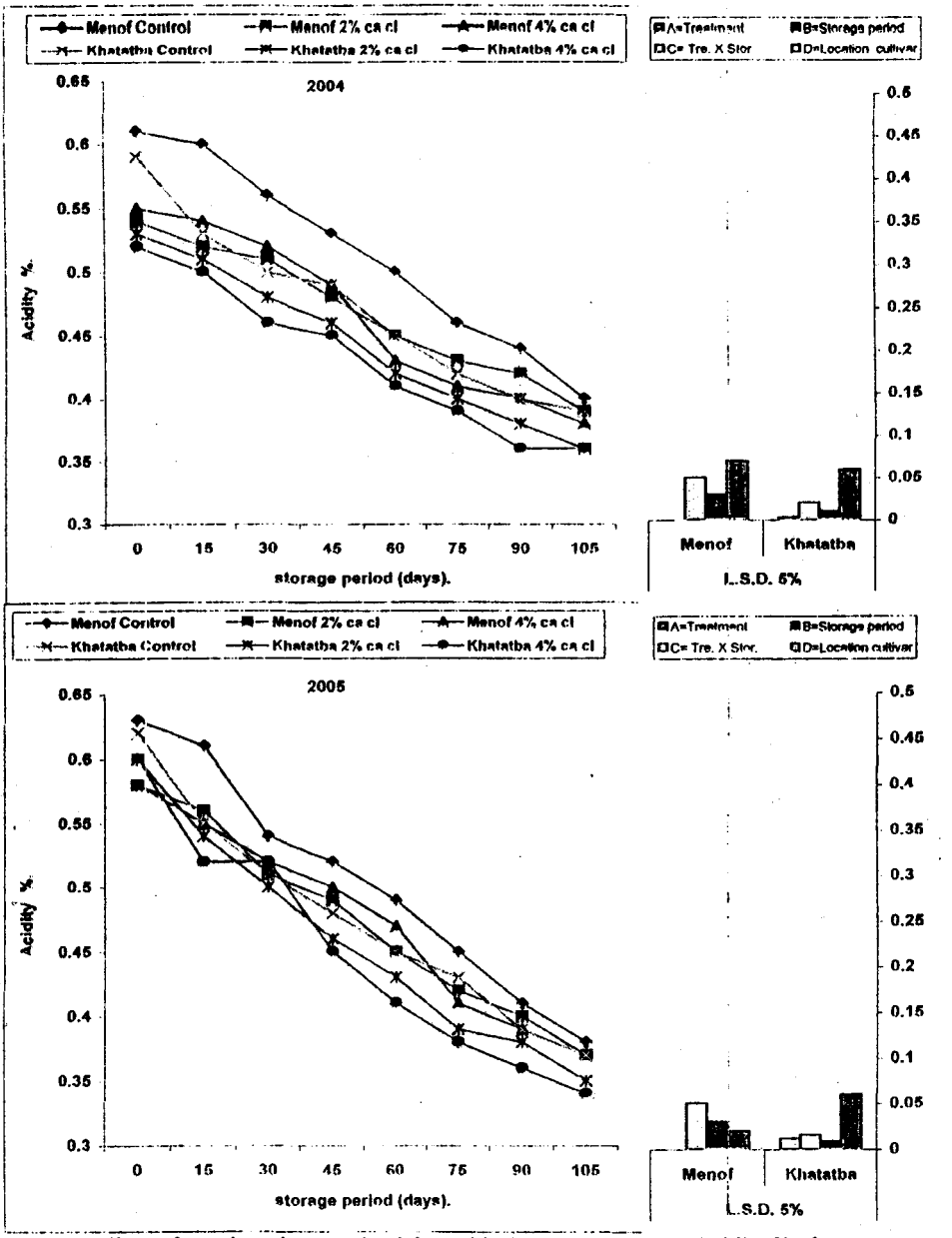

Fig. (9)Effect of two locations and calcium chloride treatments on Acidity % of Anna apple fruits under cold storage during seasons 2004 and 2005.

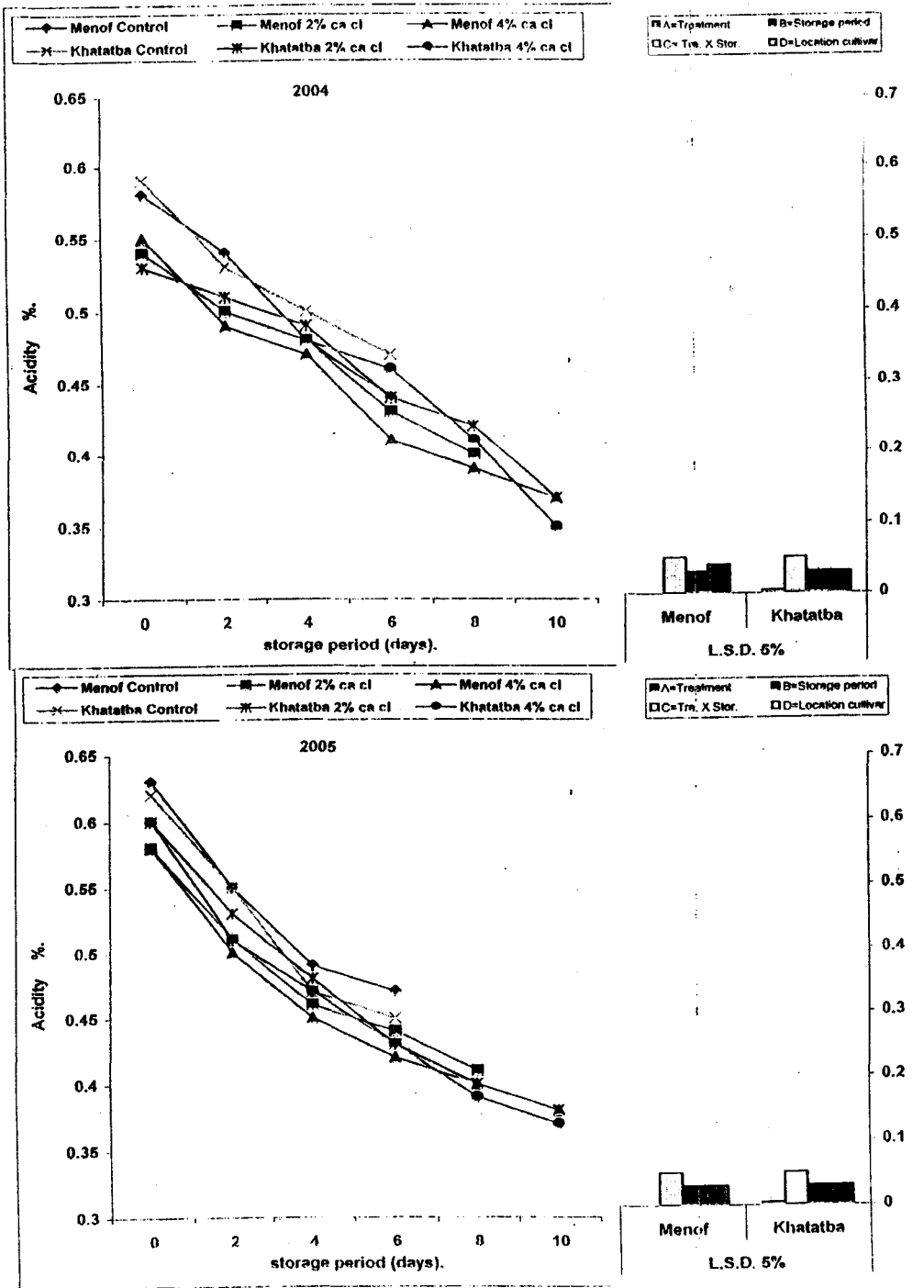

Fig. (10)Effect of two orchard locations and postharvest calcium chloride treatments on Acidity % of Anna apple fruits under room condition during seasons 2004 and 2005.

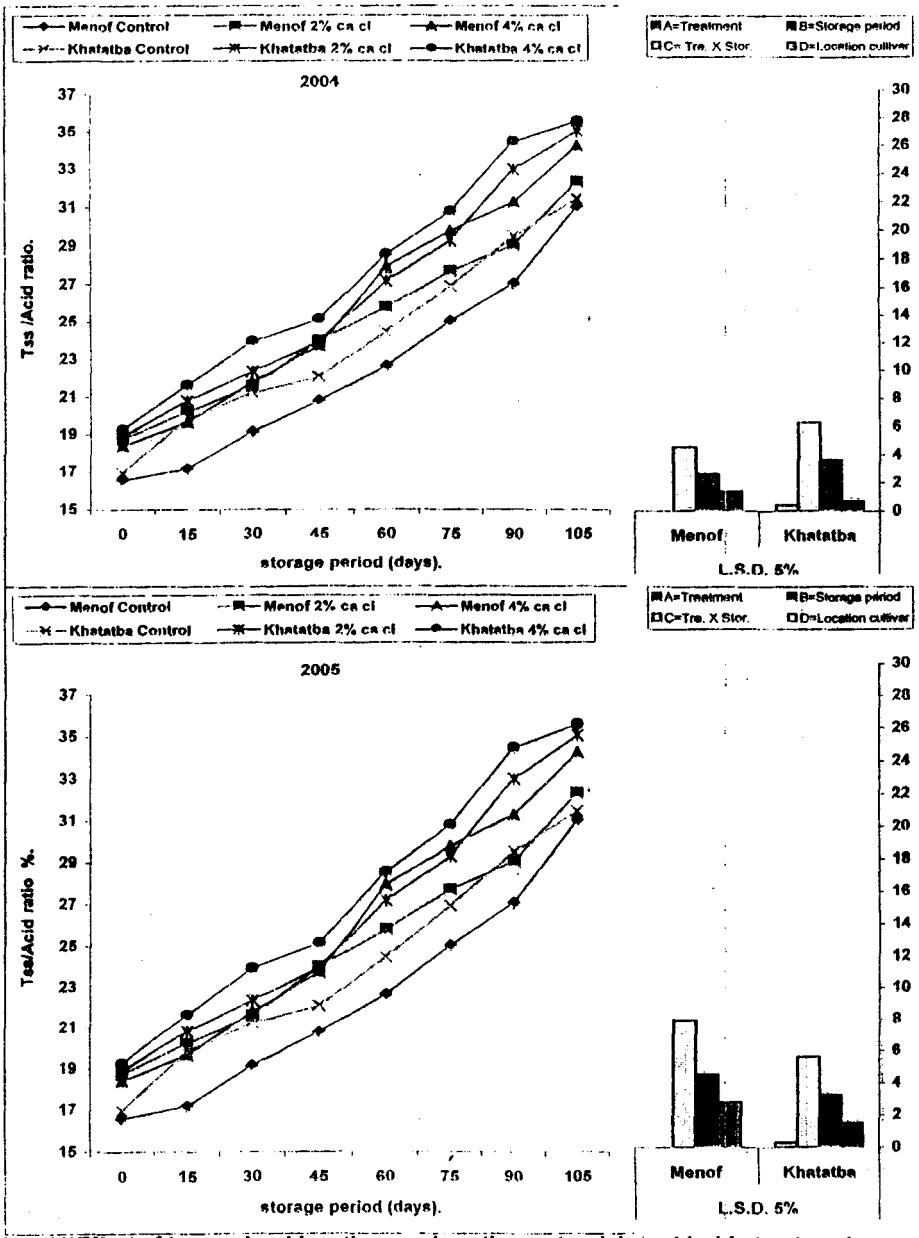

Fig. (11)Effect of two orchard locations and postharvest calcium chloride treatments on Tss /Acid ratio% of Anna apple fruits under cold storage during seasons 2004 and 2005.

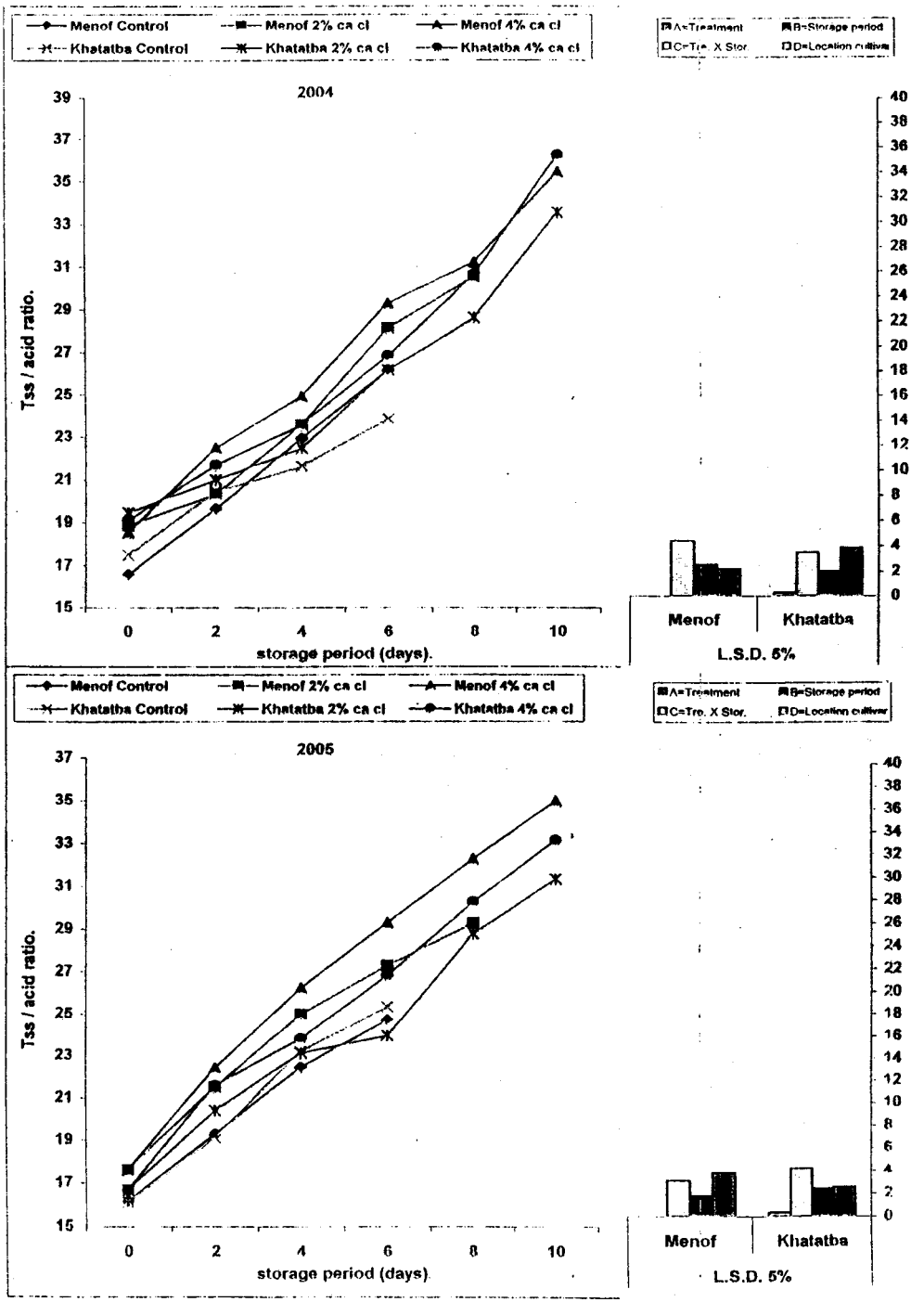

Fig. (12)Effect of two orchard locations and postharvest calcium chloride treatments on Tss/ Acid ratio of Anna apple fruits under room condition during seasons 2004 and 2005.

T.S.S./acid ratio of fruits previously dipped in 4% $CaCl_2$ was higher than those of control. Fruits collected from Khatatba orchard location induced the higher T.S.S./acid ratio than those collected from Monof location for the two studied seasons. Differences among treatments and storage period were significant.

B: Under room temperature:

Fig. (12) clearly showed that T.S.S./acid ratio gradually increased by storage period, the highest value was obtained at 10 days for fruit previously treated with 2% and 4% $CaCl_2$ solution for Khatatba location and after 10 days for fruits treated previously with 4% $CaCl_2$ solution.

Fruits of control were completely deteriorated after 6 days for two locations, while fruits collected from Monof and treated with 2% $CaCl_2$ solution were deteriorated after 8 days. Differences among treatments were insignificant.

These results were in harmony with those of Yin *et al.*, (2005) who found that T.S.S./acid ratio was increased by increasing the storage period.

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الملخص العربي

تاثير الغمس بعد الجمع للتفاح صنف أنا فى كلوريد الكالسيوم على جودة الثمار تحت ظروف التخزين البارد

أحمد محمد عبد الرازق وجمال عبد ربه السيد

قسم البساتين – كلية الزراعة – جامعة الأزهر – القاهرة

أجريت هذه الدراسة خلال موسمين ناجحين هما ٢٠٠٤-٢٠٠٥ على أشجار تفاح أنا مطعومة على أصل مالينج ١٠٦ . وكانت الأشجار منزرعة على مسافة ٤X٣ متر وأختيرت مزرعتين في موقعين مختلفين هما الخطاطبة على طريق الاسكندرية الصحراوي كم٨٤ من القاهرة حيث التربة (طمييية رملية) والموقع الاخر في منوف (محافظة المنوفية) حيث التربة (طمييية طينية) .

وأجريت هذه التجربة لدراسة تأثير غمس الثمارمكتملة النمو في تركيزات مختلفة من كلوريد الكالسيوم (٠ ،٢، ٤ %) على جودة ومقدرة ثمار التفاح أنا التخزينية من موقعين مختلفين . وخزنت الثمار على درجة صفر منوي ورطوبة نسبية ٩٨% .

وأظهرت النتائج أن غمس الثمار المكتملة النمو في محلول كلوريد الكالسيوم بتركيز ٤% قلل من الفقد في وزن الثمار والنسبة المئوية للتالف منها وأظهرت أعلى صلابة وزاد محتواها من المواد الصلبة الذائبة لتصل الى ١٣,٦% .

أما فيما يتعلق بموقع الزراعة فقد أظهرت النتائج أن الثمار الناتجة من الخطاطبة كانت أفضل في صفاتها وقدرتها التخزينية عن الثمار الناتجة من المنوفية .