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EFFECT OF COLD STORAGE AND INTERMITTENT WARMING ON PHYSICAL CHARACTERISTICS OF KEITT MANGO FRUITS

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ABSTRACT

Intermittent warming (IW) during storage has been used to extend the storage and shelf life periods of some tropical fruits sensitive to low temperature. Green mature Keitt mango fruits were harvested in 2009 and 2010 seasons, packed in perforated polyethylene (PPE) bags and subjected to different temperatures as follows: (1) storing fruits at 3±1°C for four days plus 16±1°C for three days (IW), (2) storing at 13±1°C and (3) storing at 3±1°C. All fruits were stored for eight weeks under 85-95% relative humidity (RH). Samples of each treatment were randomly taken after two and four weeks then taken weekly to evaluate the effect of storage periods and the tested treatments. After each interval some fruits were subjected to conditions similar to supermarket, 20±1°C and 60-70% RH as a shelf life for three and six days. Intermittent warming treatment maintained fruit firmness and green color as compared with fruits stored at 13°C., this was true during both cold storage and shelf life periods. Moreover, IW treatment decreased fresh weight losses, discarded fruit index and panel test index compared to fruits stored at 13°C during both cold storage and shelf life periods. The advance in storage period during eight weeks caused progressive increments in fresh weight losses, discarded fruit index, peel color and panel test index of the successive samples taken during cold storage and shelf life. On the contrary, the advance in cold storage period depressed fruit firmness. Chilling injury (CI) symptoms occurred on the fruits after four weeks with fruits stored under IW conditions. IW improved fruit physical characteristics more than storing at 13°C, but the occurrence of CI was not accepted in this treatment.

Key words: Intermittent warming, cold storage, keitt mango, chilling injury, storage life.

INTRODUCTION

Mango (*Mangifera indicia* L.) is a tropical fruit, with high demand and fetches a good price all over the world. Mangoes highly perishable and ripen rapidly under favorable conditions after harvest (Gomez-Lim, 1997). The mango cv. Keitt ripens late in the season, it is the commercially important cultivar in the export. It is resistant to packing and shipping stress and is heavily productive (Campbell, 1992 and Schnell *et al.*, 2006).

The climatic conditions of Egypt are favorable for growing mango trees with high fruit quality. Manipulation of storage temperature is often used to delay fruit ripening and maintain quality during long distant shipment or storage at the market (Johnson *et al.*, 1997). Chilling injury (CI) commonly develops in tropical fruits as a consequence of cold treatments, IW have been used successfully to avoid development of CI symptoms (Shellie and Mangan, 1994).

Mango fruit develop CI when stored below 10°C (Couey, 1986 and Hatton *et al.*, 1965). Due to mango sensitivity to CI, mangoes cannot be stored at low temperatures and, consequently, have a short postharvest life (McCollum *et al.*, 1993). Therefore, supplementary treatments to cold storage are very important for mango fruits to increase cold storage period and shelf life by decreasing the deterioration of fruit quality, fruit

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decay and CI. Many investigations were done in this field using several ways such as IW. The greatest difficulty in creating optimum condition with IW storage lies in the need to operate with temperatures, duration and IW frequency that may greatly change from cultivar to another, fruit maturity stage and growing conditions (Harhash and Al-Obeed, 2006).

IW reduced FWL of "Mexican" lime (Harhash and Al-Obeed, 2006). IW did not control decay of peaches cv. "Paraguayo" (Fernandez-Trujillo *et al.*, 1997), while made no differences in decay (Schirra and Cohen, 1999 on Olinda oranges), meanwhile IW reduced decay incidence (Mirdehghan and Rahemi, 2002 on pomegranate fruits, Porat *et al.*, 2003 on 'Oroblanco' mandarin, Ladaniya *et al.*, 2005 on 'Nagpur' mandarin, Galli *et al.*, 2007 on pawpaw and Seibert *et al.*, 2010 on apricots).

IW maintained fruit pulp firmness (FPF) compared with cold storage (Artes and Escriche, 1994 on tomato fruit cv. 'Dario F-150'), while IW decreased it on mango fruits cv. Nam Dokma (Anthakhaek, 1992), on nectarine (Dawson *et al.*, 1995), on peach fruits (Kluge *et al.*, 1996; Fernández-Trujillo and Artés, 1998; Wang *et al.*, 2003), on pawpaw (Galli *et al.*, 2007) and on apricots (Seibert *et al.*, 2010).

IW decreased color development compared with cold storage (Kluge *et al.*, 2003; Harhash and Al-Obeed, 2006 on 'Tahiti and Mexican' lime fruits), while IW improved color of 'Nagpur' mandarins (Ladaniya *et al.*, 2005; Ladaniya, 2011) and 'Durinta' tomatoes (Biswas *et al.*, 2010).

IW maintained panel test index (PTI) compared with cold storage (Wang *et al.*, 2003 on peach fruits; Porat *et al.*, 2003 on 'Oroblanco' mandarin; Ladaniya *et al.*, 2005 on 'Nagpur' mandarins; Biswas *et al.*, 2010 on tomatoes), while it did not affect taste of Brazilian 'Pisana' apricots (Seibert *et al.*, 2010).

IW did not reduce CI compared with cold storage (Wang *et al.*, 2003 on peach fruits; Ikeda *et al.*, 2004 on 'Kiyomi' tangor).

The main goal of this investigation was to extend the storage life of Keitt mango fruits without using harmful chemicals.

MATERIALS AND METHODS

This study has been carried out during 2009 and 2010 seasons on mango fruits (*Mangifera indica* L.) cv. Keitt. The fruits were harvested from a private mango orchard located at El-Obour city, Egypt. The trees were 5 years old, grown in sandy soil at 2×3 meters apart and received the standard horticultural care adopted in the area. Fruits at mature-green or breaker stage were picked on the same date (17th September) in both seasons using small clippers, packed in carton boxes and taken directly to Post-Harvest Laboratory in Horticulture Department, Faculty of Agriculture, Zagazig University. Fruits with any insect infestation or defects were discarded. All fruits were washed with tap water and soap and then rinsed with water to remove the residue of soap, dipped in 1000 ppm imazalil as a disinfectant for five minutes, then, air dried. A final sorting was done to recheck the fruits for any defects which were not detected at first sorting.

Each treatment was divided into three replicates, 60 uniform fruits were taken at random for each replicate and packed in perforated polyethylene 0.1% (PPE) bags to correspond one of the following treatments.

1- Storing fruits in PPE bags at 3±1°C for four days followed by three days at 16±1°C (IW).

2- Storing fruits in PPE bags at 13±1°C.

3- Storing fruits in PPE bags at 3±1°C.

All fruits were subjected to 90-95% RH. Samples of each treatment were randomly taken at weekly intervals for eight weeks, but in the first four weeks the samples were taken every two weeks to evaluate the effect of cold storage and intermittent warming (IW) on storage period.

After each storage period the fruits were subjected to conditions of 20±1°C and 60-70% RH for three and six days as a shelf life.

The following parameters were assessed

Fresh Weight Losses (FWL) (%)

The fruits were weighed before cold storage to obtain the initial weight, and then weighed after each period of storage as well as after each

shelf life period. FWL (%) were calculated according to the following equation:

$$FWL\% = \frac{Wi - Ws}{Wi} \times 100.$$

Where, Wi = fruit weight at initial date.

Ws = fruit weight at sampling date.

Discarded Fruits Index (DFI)

The fruit peel surface decay was evaluated and scored according to the following index : 0 = without decay; 2 = just necrotic spots; 3 ≥ 25% decay and 4 ≥ 50% decay.

Fruit Pulp Firmness

It was determained on five fruits per replicate; measurements were taken from each fruit using a Push Pull dynamometer (Model FD 101). The values were expressed as gram (g/cm^2).

Peel Color Index (PCI)

The color of each fruit was determined according to the following index : 0 = 100% green; 1 = 1-25% yellow; 2 = 26-50% yellow; 3 = 51-75% yellow and 4 = 76-100% yellow.

Panel Test Index (PTI)

Each replicate was judged by five persons that gave the score according to the following index: 4=exellent taste; 3 = very good taste; 2 = good taste; 1 = acceptable taste and 0 = bad taste.

Chilling Injury Index (CI)

Mango fruits were randomly sampled for determination of CI using a scale of 1–4. The degree of browning was visually assessed using the following scale: (0 = none, 1 = less than 10% of the peel or pulp are brown, 2 = 11–25% of peel or pulp are brown, 3 = 26–50%, and 4 = >50%.). The CI index was calculated according to (Concellón *et al.*, 2004):

$$CI = \frac{\sum (\text{injury classification level} \times \text{number of fruits at that level})}{\text{total number of fruits in the treatment}}$$

The CI symptoms include uneven ripening, poor color and flavor, surface pitting, grayish scald-like skin discoloration, increased susceptibility to decay, and, in severe cases, flesh browning (Medlicott *et al.*, 1990).

Expermintal Design and Statistical Analysis

The complete randomized block design with three replicates and with factorial arrangement was followed throughout the whole work (Snedecor and Cochran, 1980). The means representing the effect of tested treatments, storage period and their interaction were compared using New L.S.D test at 0.05.

RESULTS

Fresh Weight Losses (FWL) Percentage

Fresh weight losses (%) were increased with the advance of storage period. Stored fruits at 3°C showed significantly lower FWL (%) compared with fruits stored at 13°C or under IW conditions during cold storage in the two seasons (Fig.1).

The FWL (%) was decreased in the two seasons after three or six days of shelf life with the advance of storage period. No significant differences were observed between all treatments after three or six days of shelf life in the first season except between the last week in the treatments at 3°C and at 13°C. In the second season, however, fruits stored at 3°C revealed significantly higher FWL (%) compared with fruits stored at 13°C or under IW conditions after three and six days of shelf life (Figs. 2 and 3).

Discarded Fruits Index (DFI)

The DFI was increased with the advance of storage period in both seasons. During cold storage, no significant differences were observed between all treatments in the 2nd and 4th weeks, while, after four weeks, storing fruits at 3°C significantly decreased DFI compared with fruits stored at 13°C or under IW conditions as shown in Fig. 4.

After three or six days of shelf life in both seasons, DFI was increased with the advance of storage period. After three or six days of shelf life in the first season, storing fruits at 3°C significantly decreased DFI compared with other treatments except after two weeks as shown in Fig. 5. The same trend was observed in the second season except in the 2nd, 4th and 5th weeks after six days as shown in Fig. 6.

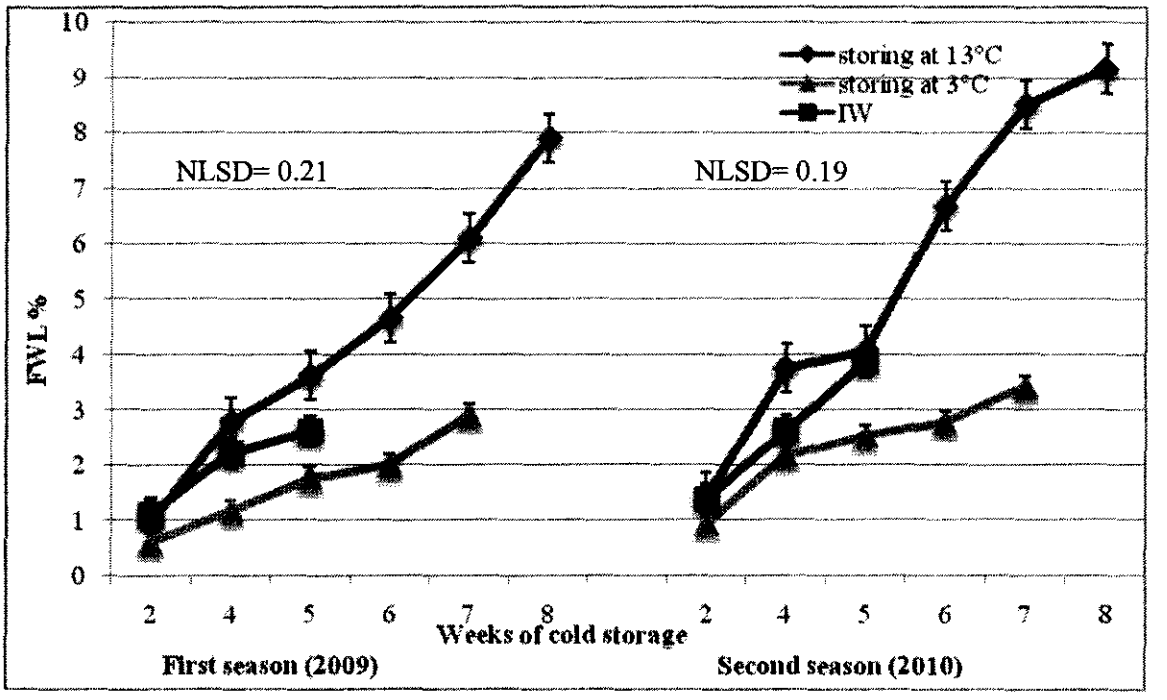


Fig. 1. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fresh weight losses (FWL) percentage of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons

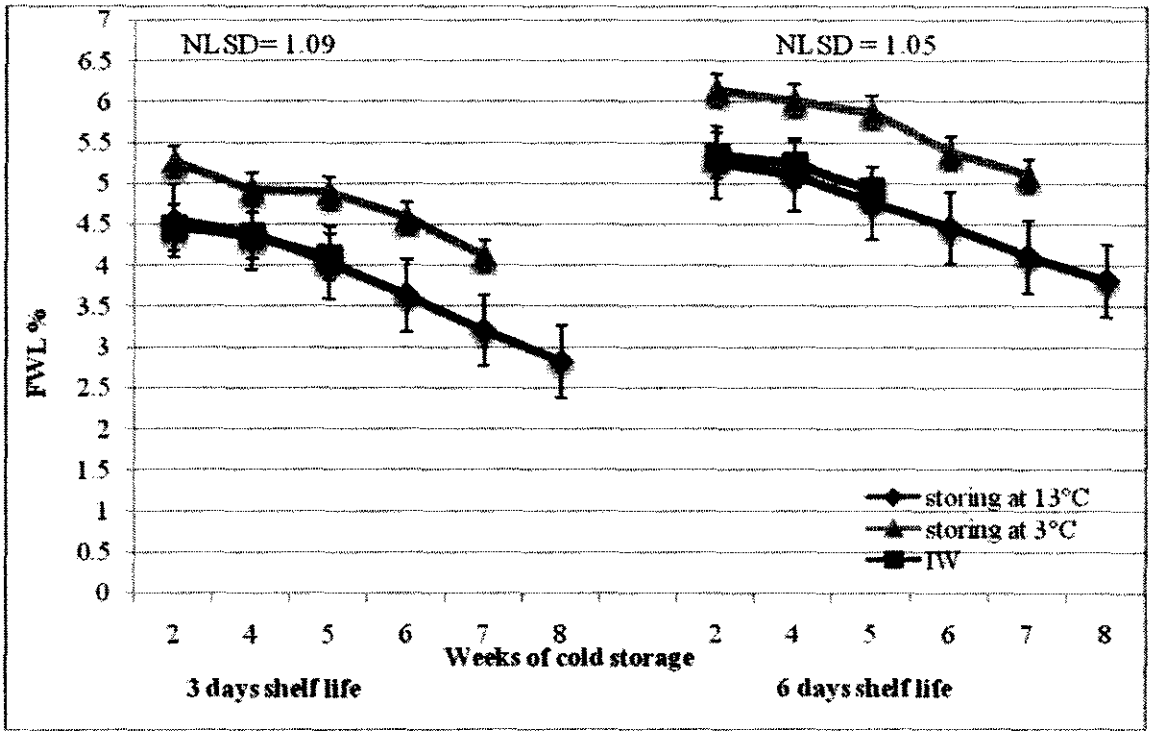


Fig. 2. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fresh weight losses (FWL) percentage of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)

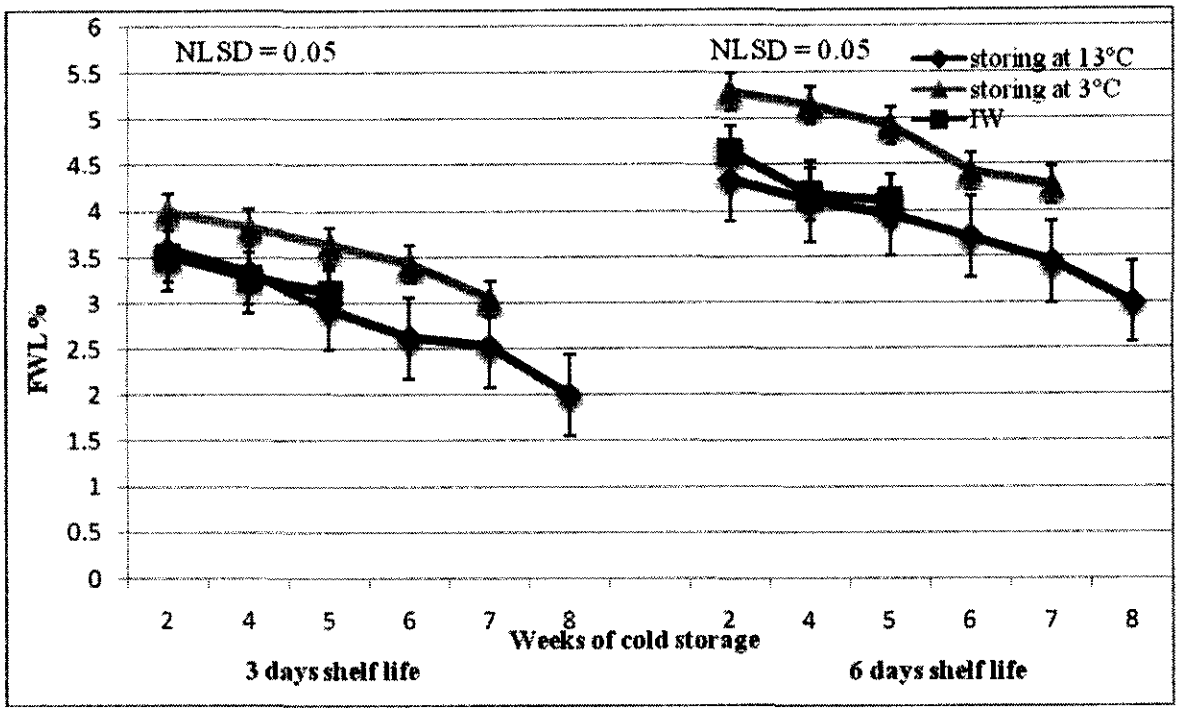
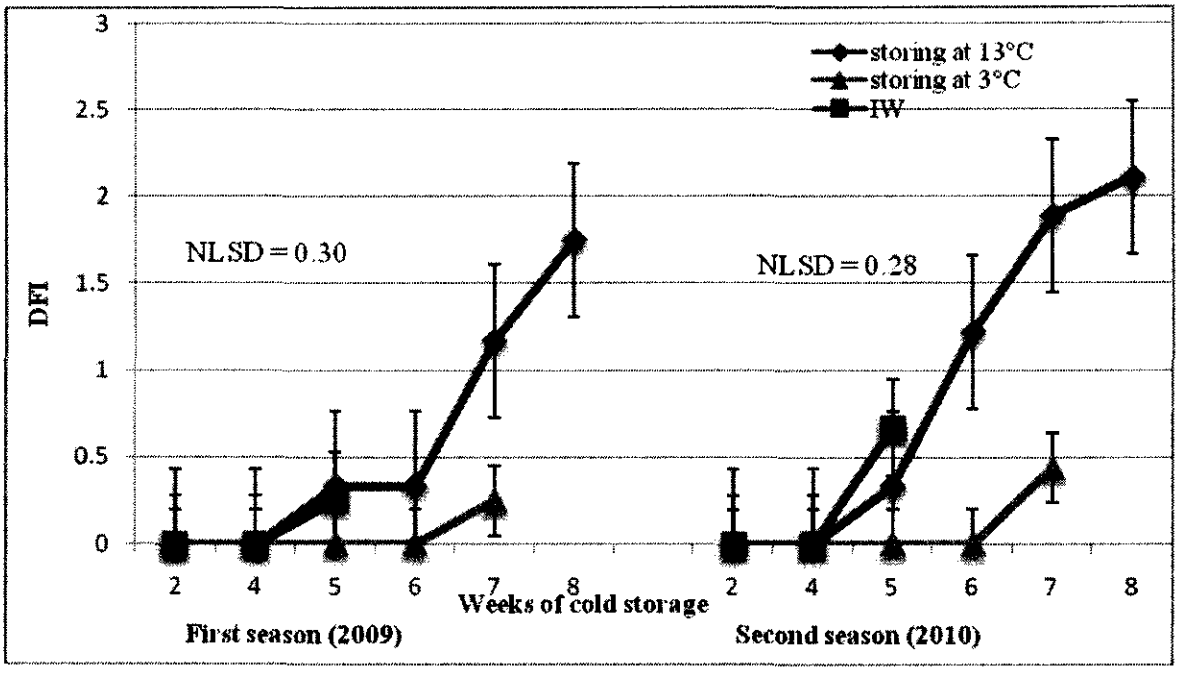
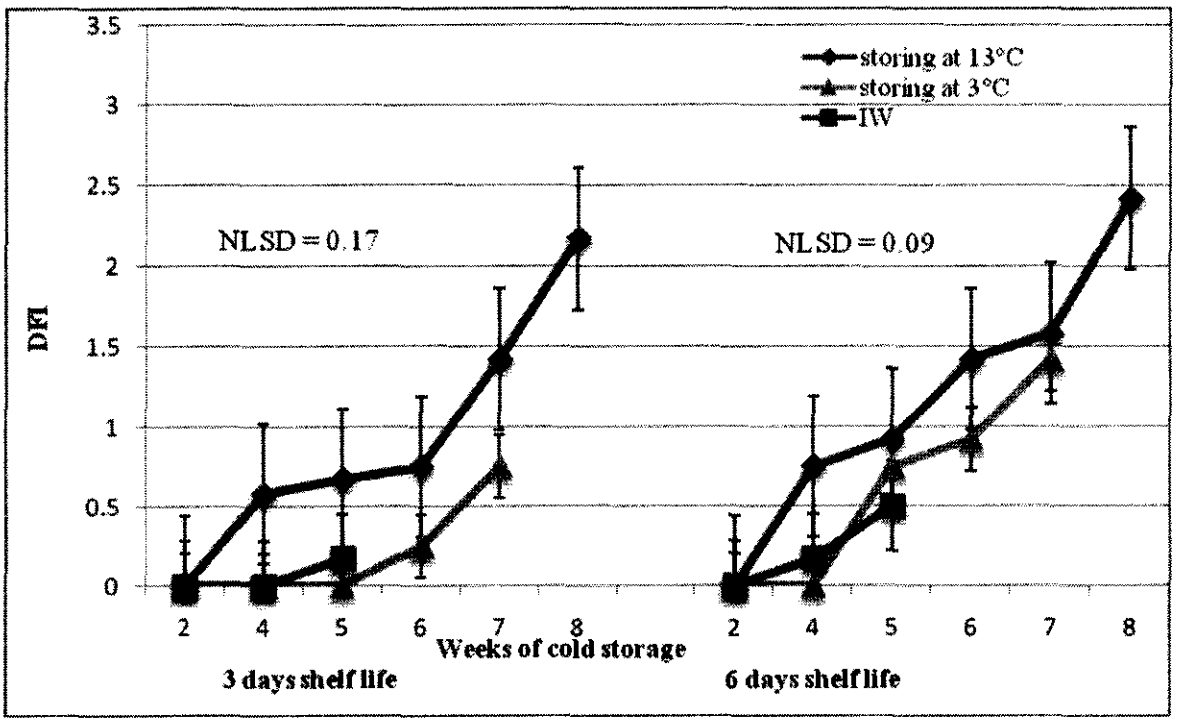


Fig.3. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fresh weight losses (FWL) percentage of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)



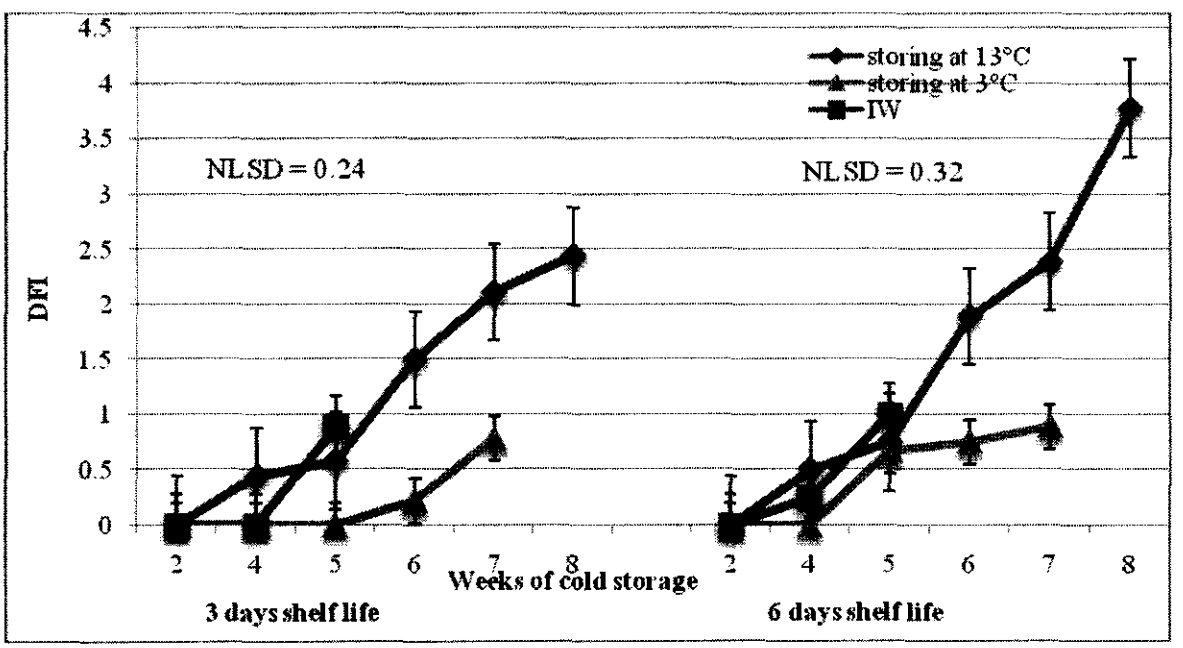
0 = without decay; 2 = just necrotic spots; 3 ≥ 25% decay and 4 ≥ 50% decay.

Fig.4. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on discarded fruits index (DFI) of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons



0 = without decay; 2 = just necrotic spots; 3 ≥ 25% decay and 4 ≥ 50% decay.

Fig.5. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on discarded fruits index (DFI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)



0 = without decay; 2 = just necrotic spots; 3 ≥ 25% decay and 4 ≥ 50% decay.

Fig.6. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on discarded fruits index (DFI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)

Fruit Pulp Firmness (FPF)

Fruit pulp firmness was decreased with the advance of storage period in the two seasons. Storing fruits at 3°C maintained significantly FPF as compared with fruits stored at 13°C or under IW conditions as shown in Fig.7.

In the first season after three and six days of shelf life, storing fruits at 3°C or under IW maintained significantly FPF compared with fruits stored at 13°C (Fig. 8).

The same trend was observed in the second season (Fig. 9).

Panel Test Index (PTI)

During cold storage, PTI was increased with the advance of storage period. In both seasons, storing fruits at 3°C reduced PTI as compared with fruits stored at 13°C or under IW conditions (Fig. 10).

In both seasons, PTI was increased with the advance of storage period after three or six days of shelf life. Storing fruits at 3°C reduced PTI as compared with fruits stored at 13°C or under IW conditions after three or six days of shelf life in both seasons (Figs. 11 and 12).

Peel color index (PCI)

During cold storage, mango fruits revealed a gradual increase in yellow color with the advance in storage period in both seasons. No significant differences were observed between fruits stored at 3°C and under IW conditions in most weeks. However, in both seasons fruits stored at 3°C revealed significant decrease in PCI compared with those stored at 13°C (Fig. 13).

In the two seasons, both three or six days shelf life gave more increase in yellow color with the advance in storage period. Also, fruits stored at 13°C gave significantly maintained more yellow color compared with other treatments (Figs. 14 and 15).

Chilling Injury Index (CI)

Data recorded in Fig. 16 reveal that, CI symptoms were increased with the advance in storage period in both seasons in the fruits under IW conditions and fruits stored at 3°C. In the two seasons, CI symptoms occurred after four weeks in the fruits stored under IW conditions while occurred after five weeks in fruits stored at 3°C. No CI symptoms were observed in the fruits stored at 13°C in both seasons.

The same trend was observed in both seasons after three or six days of shelf life but with higher values as shown in Figs. 17 and 18.

DISCUSSION

The present work revealed that FWL were increased as cold storage period was advanced; the IW treatment revealed higher FWL values compared with 3°C. The higher FWL with IW treatment was in agreement with Kluge *et al.* (1996) on Brazilian BR-6 peach, Hakim *et al.* (1997) on tomatoes cv. 'Vibelco' and Fernández-Trujillo and Artés (1998) on peaches cv. "Paraguayo". Water loss can be one of the main causes of fruit deterioration, since it is not only quantative losses, but also causes losses in appearance due to wilting and shriveling as well as in nutritional quality (Kader, 1986).

From results it is clear that DFI was increased with the advance in cold storage period; fruits stored under IW showed higher values of DFI than those stored at 3°C. The higher values in DFI with IW treatment was in agreement with Fernandez-Trujillo *et al.* (1997) on peaches cv. 'Paraguayo'. The DFI was expressed as losses of appearance and freshness due to wilting, shriveling and brown spots on the peel of decayed fruits.

Data clarified that IW treatment decreased FPF compared with fruits stored under 3°C, while, FPF was decreased with the advance in cold storage period. In this regard, many investigators pointed out that IW treatment decreased FF during storage (Fernández-Trujillo and Artés, 1998 on peaches cv. "Paraguayo"; Wang *et al.*, 2003 on peach fruits; Galli *et al.*, 2007 on pawpaw fruits; Seibert *et al.*, 2010 on Brazilian 'Pisana' apricots). Hussein *et al.* (1998) indicated that the rate of degradation of insoluble protopectins to simple soluble pectins was increased with the progress of storage time. Pectinesterase activity, also, is expected to increase progressively during storage and this led to a decrease in hardiness of peel and pulp of pear fruits during storage (Ponomarev, 1968).

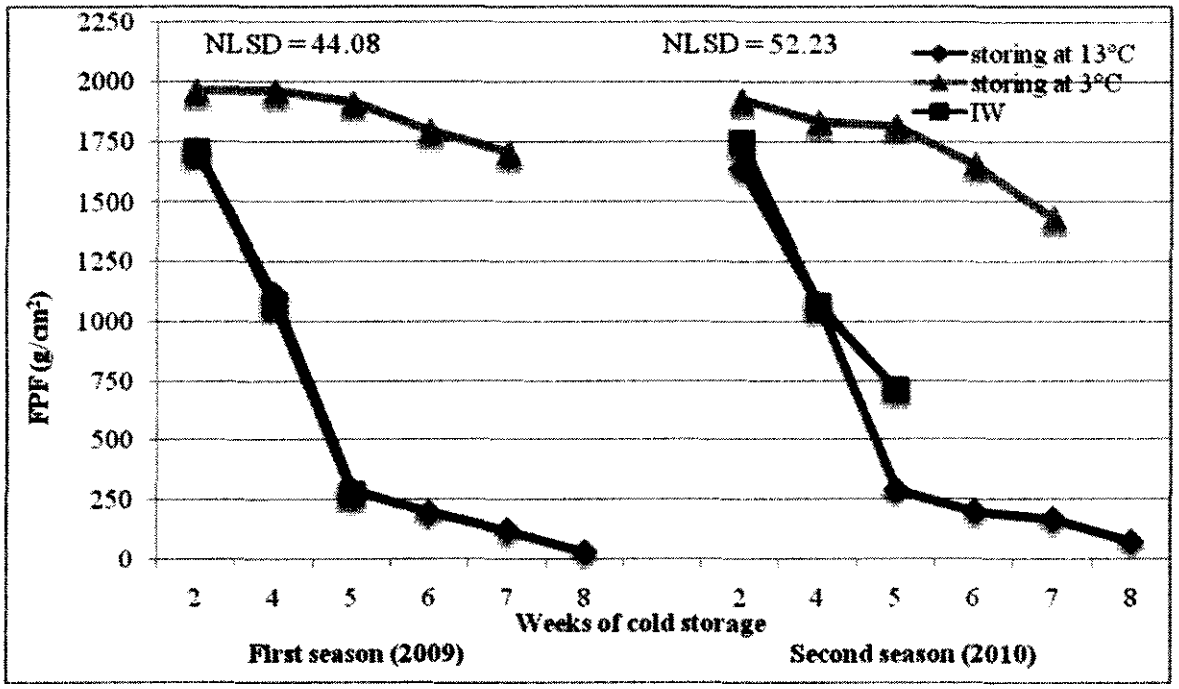


Fig. 7. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fruit pulp firmness (FPF) of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons

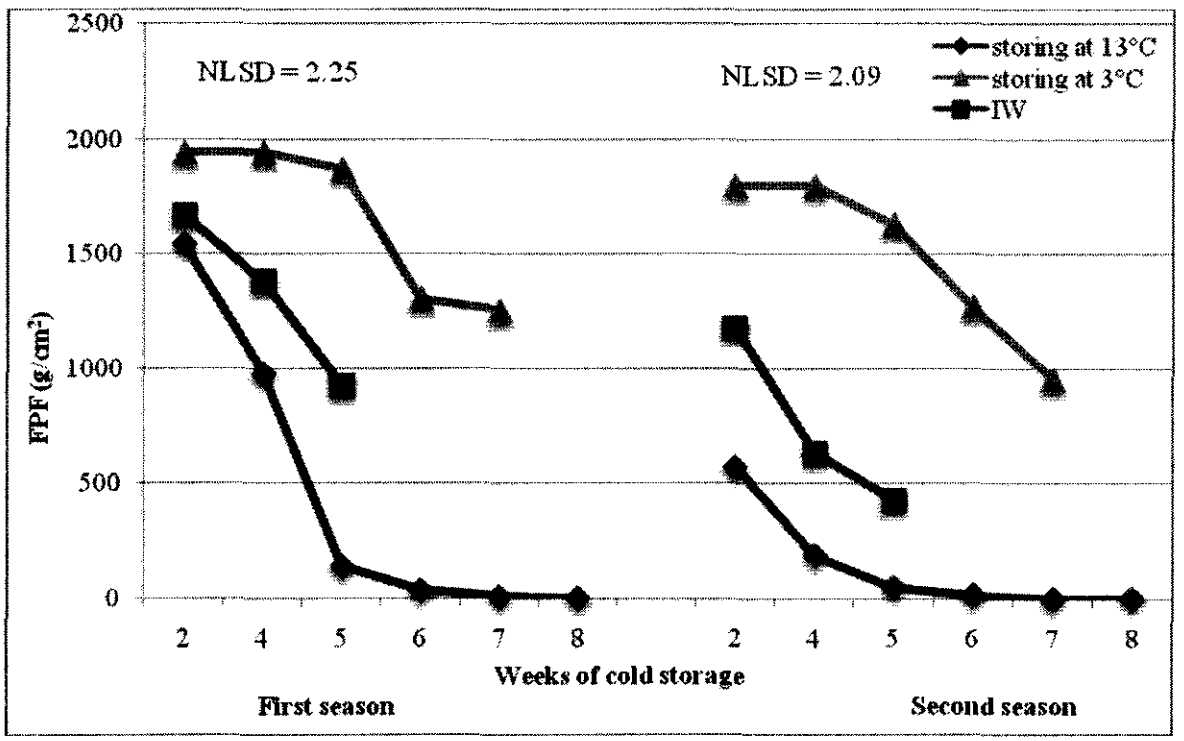


Fig. 8. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fruit pulp firmness (FPF) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)

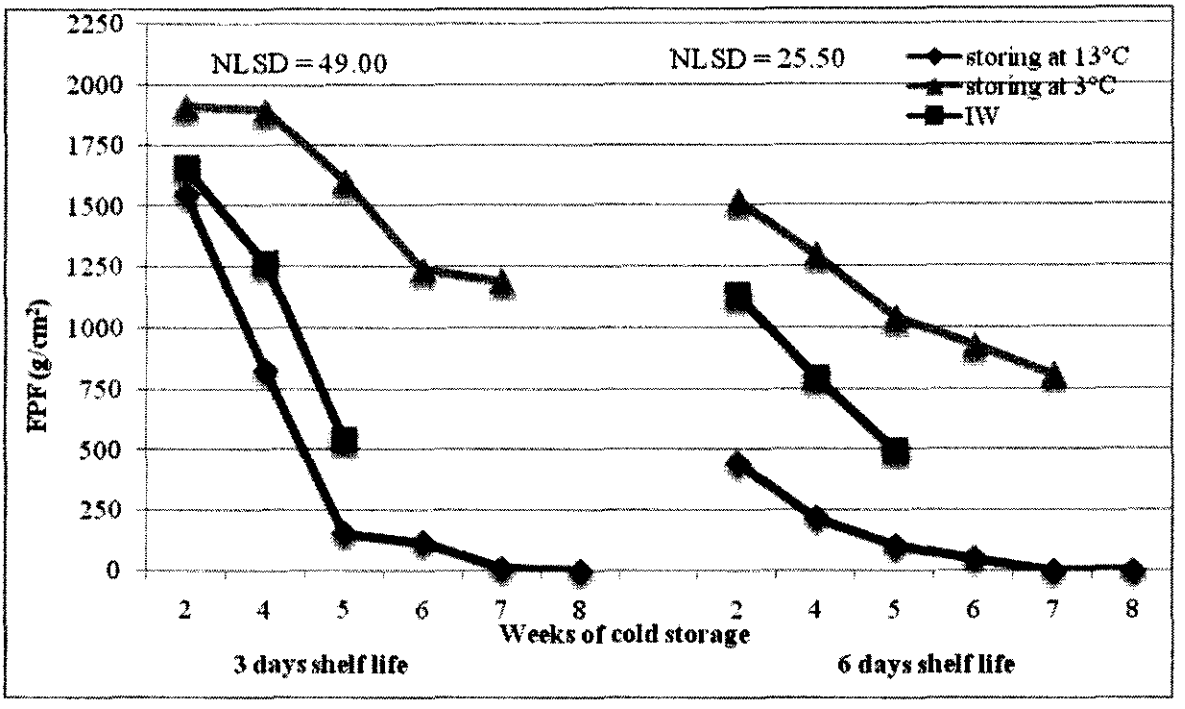
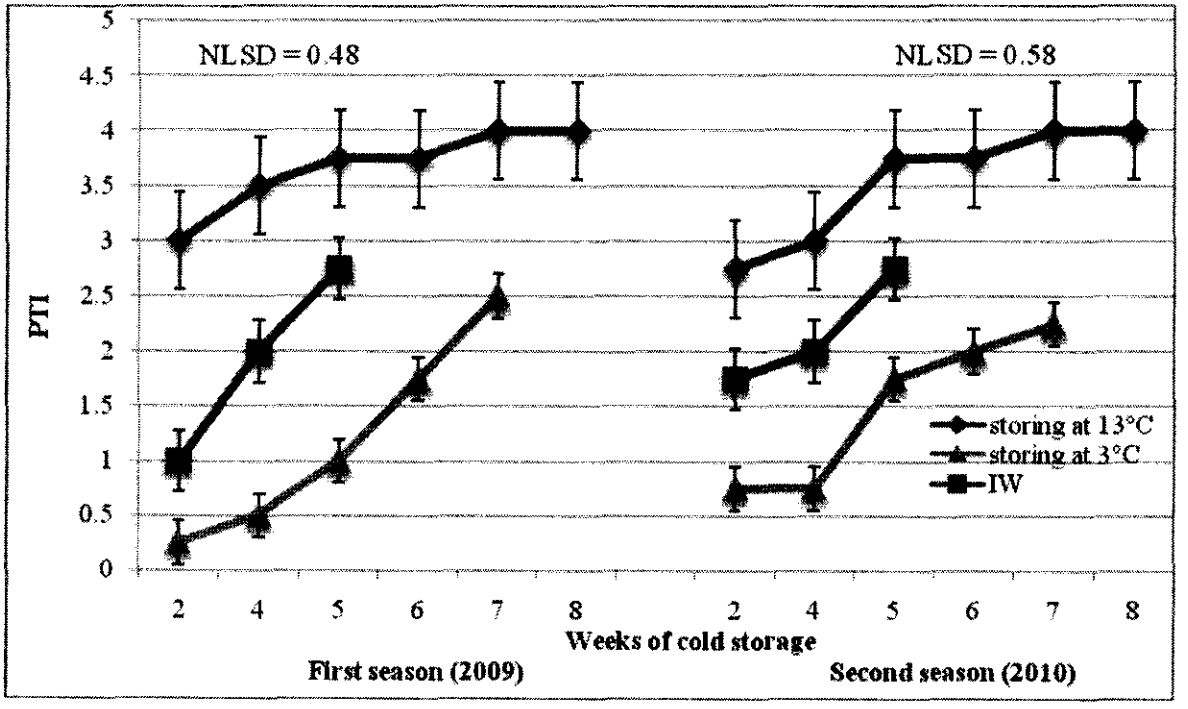
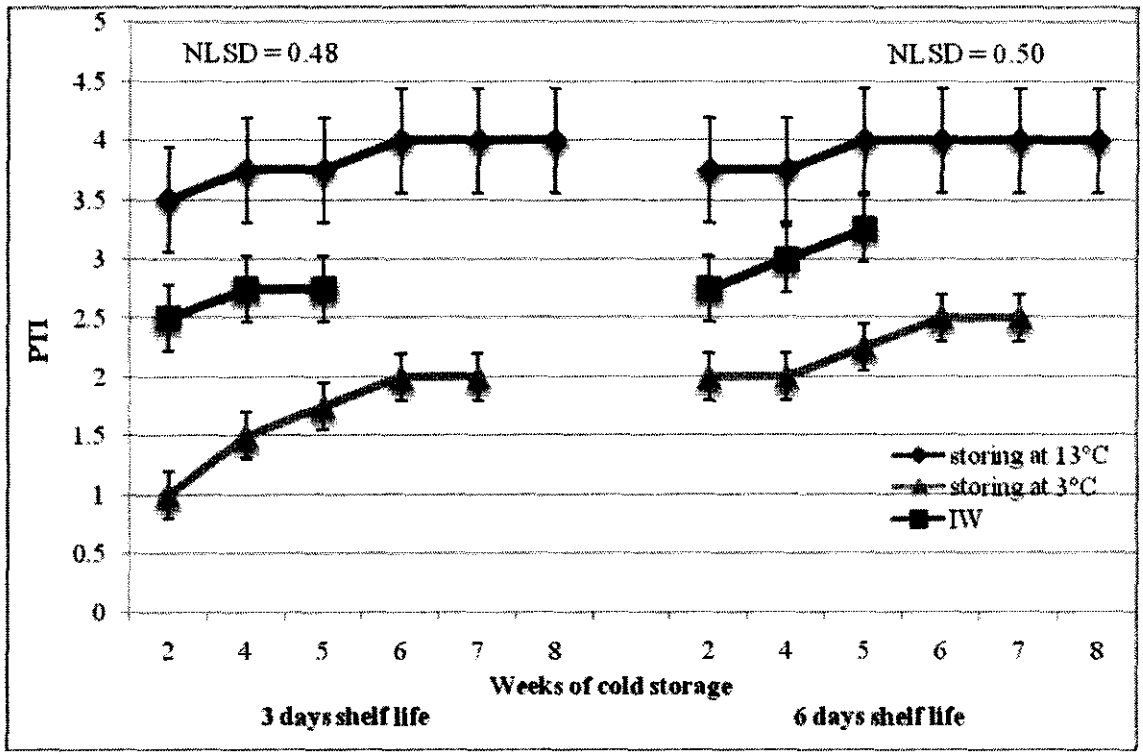


Fig. 9. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on fruit pulp firmness (FPF) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)



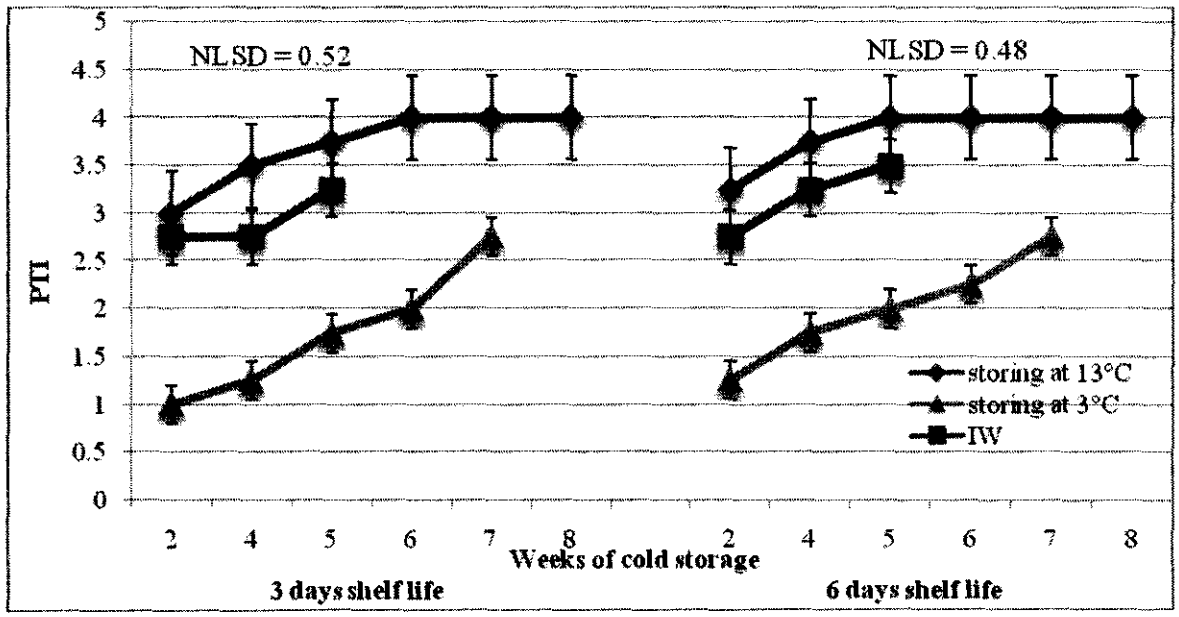
4 = Excellent taste; 3 = Very good taste; 2 = Good taste; 1 = Acceptable taste and 0 = Bad taste.

Fig.10. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on panel test index (PTI) of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons



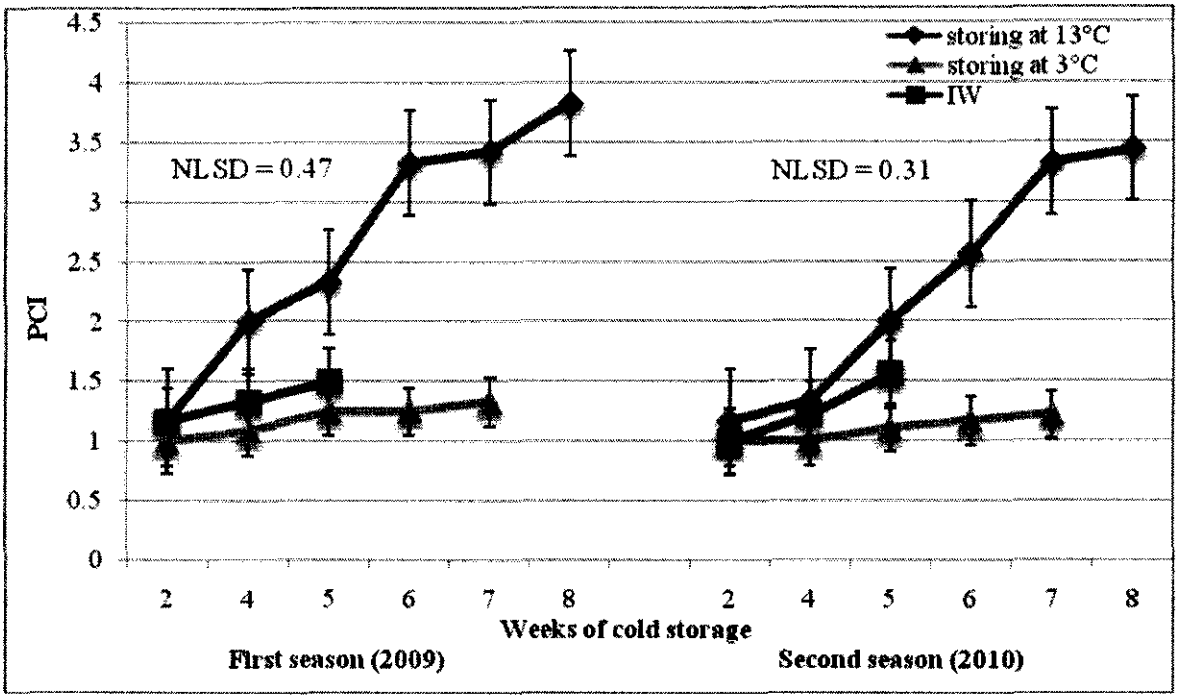
4 = Excellent taste; 3 = Very good taste; 2 = Good taste; 1 = Acceptable taste and 0 = Bad taste.

Fig.11. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on panel test index (PTI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)



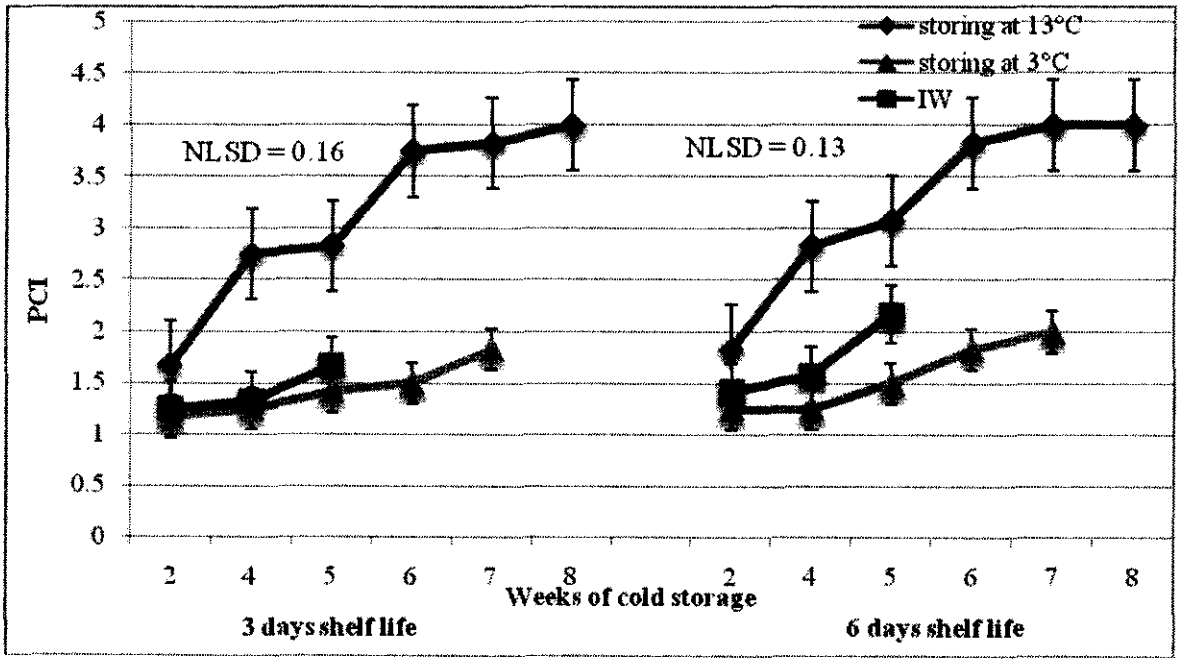
4 = Excellent taste; 3 = Very good taste; 2 = Good taste; 1 = Acceptable taste and 0 = Bad taste.

Fig.12. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on panel test index (PTI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)



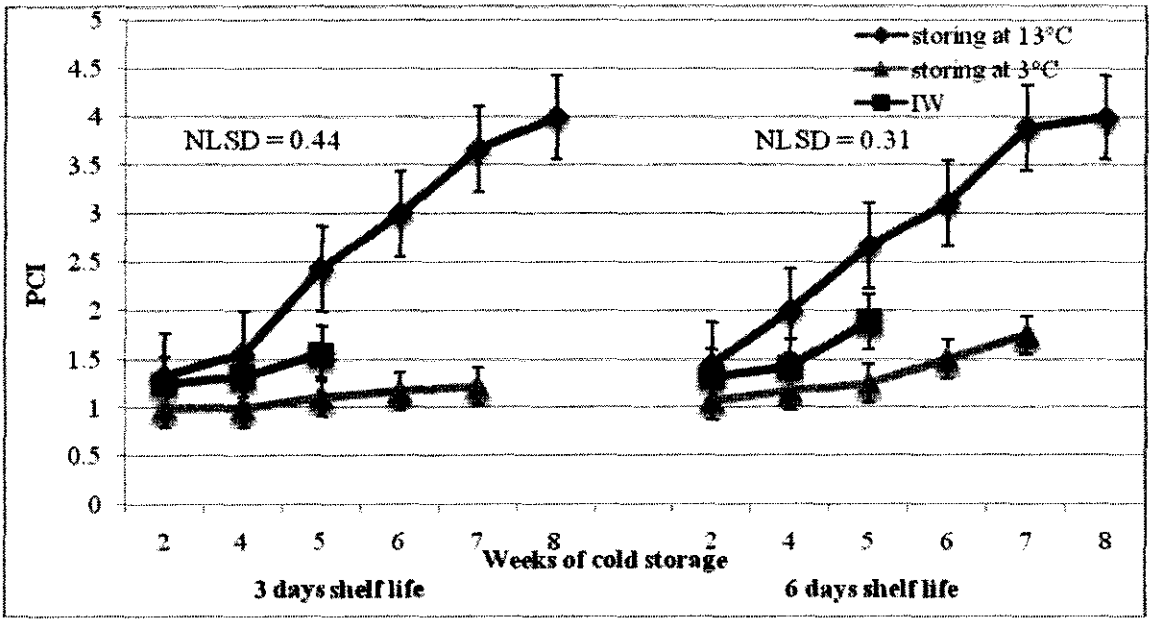
0 = 100% green; 1 = 1-25% yellow; 2 = 26-50% yellow; 3 = 51-75% yellow and 4 = 76-100% yellow.

Fig. 13. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on peel color index (PCI) of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons



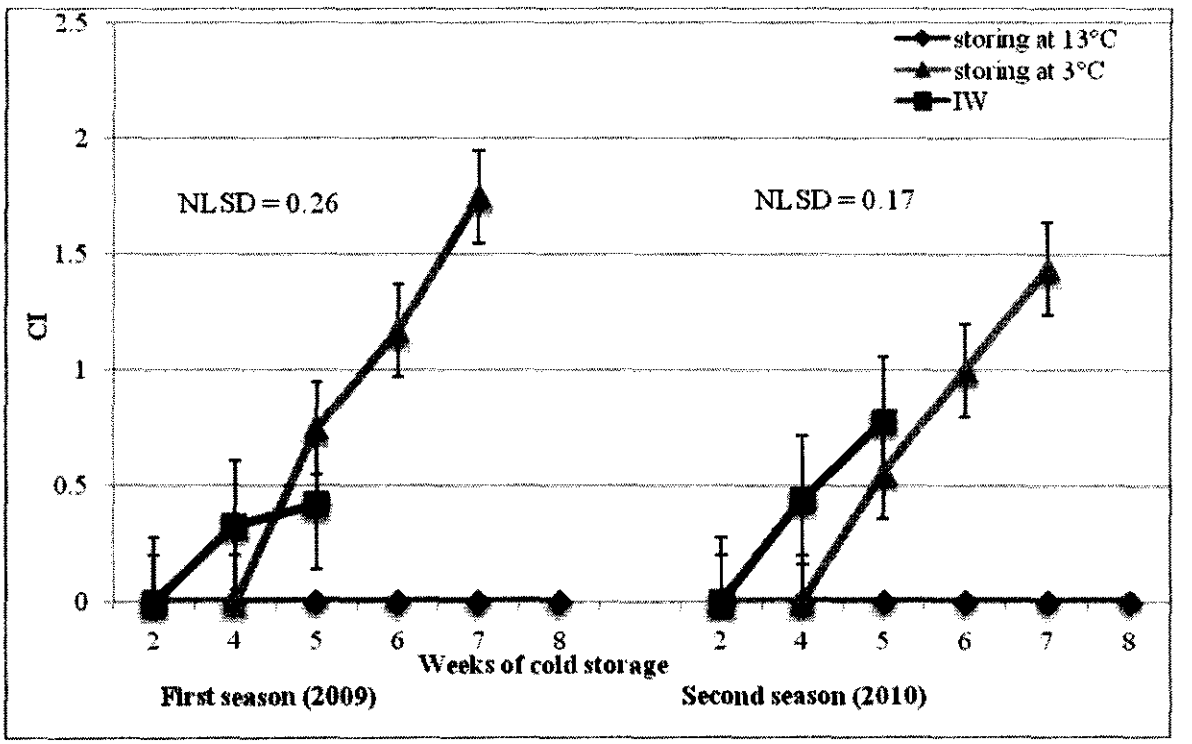
0 = 100% green; 1 = 1-25% yellow; 2 = 26-50% yellow; 3 = 51-75% yellow and 4 = 76-100% yellow.

Fig.14. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on peel color index (PCI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)



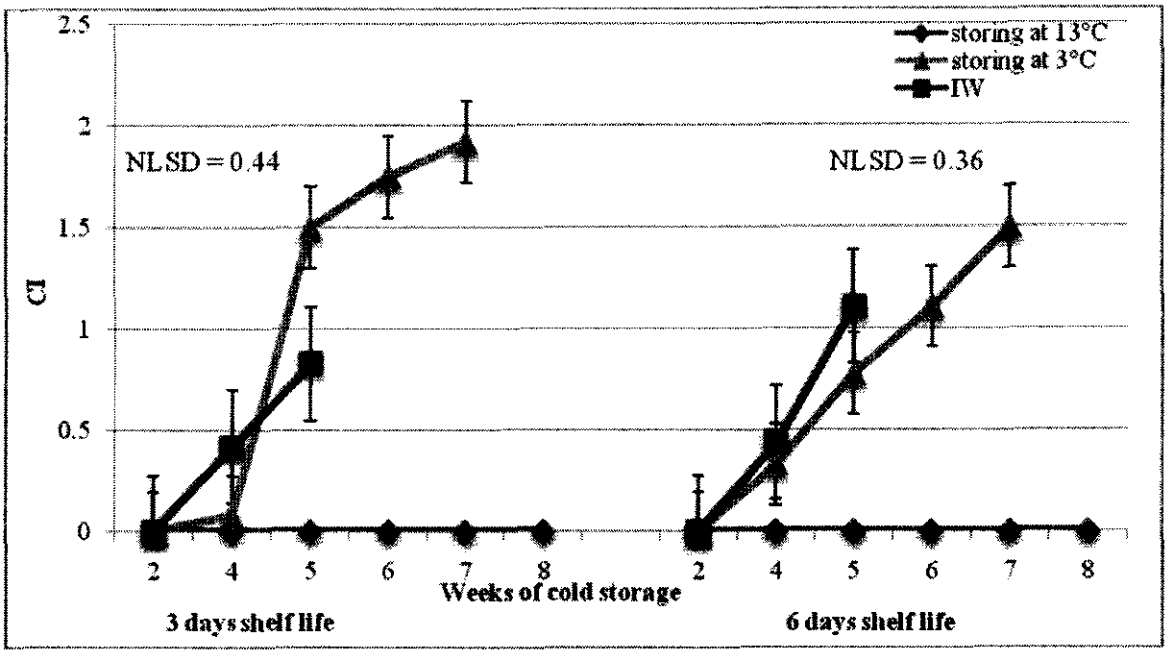
0 = 100% green; 1 = 1-25% yellow; 2 = 26-50% yellow; 3 = 51-75% yellow and 4 = 76-100% yellow.

Fig.15. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on peel color index (PCI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)



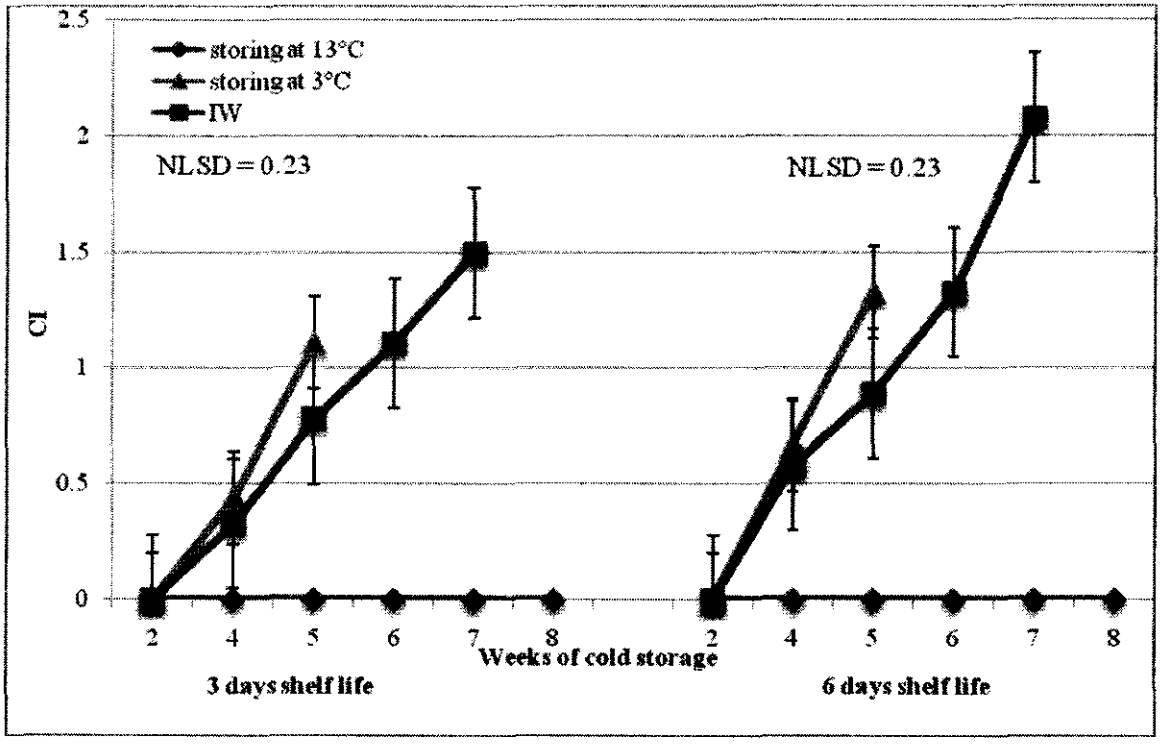
0 = none, 1 = < 10% of the peel browning, 2 = 11–25% of peel browning, 3 = 26–50%, and 4 = >50%.

Fig. 16. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on chilling injury index (CI) of Keitt mango fruits during 8 weeks of cold storage in 2009 and 2010 seasons



0 = none, 1 = < 10% of the peel browning, 2 = 11–25% of peel browning, 3 = 26–50%, and 4 = >50%.

Fig. 17. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on chilling injury index (CI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the first season (2009)



0 = none, 1 = < 10% of the peel browning, 2 = 11–25% of peel browning, 3 = 26–50%, and 4 = >50%.

Fig. 18. Effect of different storage temperatures (3 and 13°C) and intermittent warming (IW) (3°C for 4 days + 16°C for three days) on chilling injury index (CI) of Keitt mango fruits after three and six days of shelf life during 8 weeks of storage in the second season (2010)

The loss of firmness is related to the degradation of the cellular wall by polygalacturonase and pectinesterase enzymes and to the loss of water (Roe and Bruemmer, 1981 and Kays, 1991). Cool storage affects the activities of numerous cell-wall modifying enzymes (Brummell *et al.*, 2004), reduces pectin solubilisation and polymerisation (Almeida and Huber, 2008) and promotes loss of turgor (Marangoni *et al.*, 1995). Thus, exposure to CI-inducing temperatures affected cell wall metabolism of tomato fruit (Rugkong *et al.*, 2010), and altering cell wall structure may influence decay susceptibility (Collmer and Keen, 1986).

Data showed that the IW treatment recorded higher PCI compared with fruits stored under 3°C and the PCI was increased with the advance in cold storage period and the high temperature improved color compared with low temperature and IW. In this regard, many investigators mentioned that IW treatments improved color development during cold storage (Ladaniya *et al.*, 2005 on 'Nagpur' mandarins; Biswas *et al.*, 2010 on 'Durinta' tomatoes; Ladaniya, 2011 on 'Nagpur' mandarins). PCI of the fruit changes during ripening that the chloroplast in the peel is converted into chromoplasts, which has red or yellow pigments, while some cultivars show reddish blush because of anthocyanins, others remain green (Lizada, 1993). During ripening the carotenoid pigment level also varies among the cultivars. It has been reported that the level of carotenoid increased with a gradual decrease of anthocyanins in mangoes cv. Tommy Atkins (Medlicott *et al.*, 1990). All stored fruits at low temperature or IW failed to attain yellow color even after transferred to shelf life periods at 20°C which might be due to CI effects; delayed color development resulting from chilling has been reported by Sharom *et al.* (1994).

From results, it is clear that PTI values were increased in IW treatment compared with fruits stored under 3°C. meanwhile, PTI was increased with the advance in cold storage period. In this regard, many investigators mentioned that IW treatments maintained taste of mango fruits during storage period (Porat *et al.*, 2003 on peaches; Ladaniya *et al.*, 2005 on 'Oroblanco' and 'Nagpur' mandarins; Biswas *et al.*, 2010 on 'Durinta' tomatoes). Certain monoterpene hydrocarbons and lactones are responsible for mango flavor (Wilson *et al.*, 1990). At the early stage of fruit growth polyphenolic content are high and decrease with the ripening and remain fairly steady (Lakshminarayana *et al.*, 1970).

From results, it is clear that IW did not reduce CI index. In this regard, some investigators mentioned that IW did not reduce CI of mango fruits during storage period (Wang *et al.*, 2003; Ikeda *et al.*, 2004). Low temperature storage had less effect on pulp color than on PCI (Chidtragool *et al.*, 2011). Browning compounds are synthesized from free phenolic acids through phenylalanine ammonia lyase (PAL) (Camm and Towers, 1977). PAL activity in the peel was much higher than that in the pulp, which was correlated with the much higher level of total free phenolics in the peel compared with the pulp (Chidtragool *et al.*, 2011). However, no relation was found between PAL activity in the pulp of mango and pulp browning (Chidtragool *et al.*, 2011).

Superoxide dismutase (SOD) plays a key role in H_2O_2 biosynthesis, converting it from O_2, and Catalase (CAT) is involved in the degradation of H_2O_2. It was reported that higher CAT and SOD activities were related to the chilling tolerance of mandarin fruit (Sala, 1998).

There are several hypotheses concerning the mechanisms of IW. Raising the temperature temporarily could induce higher metabolic activities, which would allow tissues to metabolize excess intermediates, and replenish deficiencies that developed during chilling. Warming of chilled tissues for short periods helps to repair damage of membranes, organelles, or metabolic pathways (Lyons and Breidenach, 1987). Warming and cooling of tissues (IW) maintains high level of phospholipids, increases the degree of unsaturation of fatty acids, increases the levels of spermidine and spermine, and stimulates the activities of free radical scavenging enzymes. Heat treatment induces heat shock proteins, suppresses oxidative activity, and maintains membrane stability (Wang, 2000). All of these processes can enhance chilling tolerance of tissues and alleviate CI of fruits (Wang, 2000).

Inspite of the benefits of IW; *i.e.*, reduced FWL and maintained FPF and reduced DFI, but it increased CI values. The CI fruits is not acceptable for the consumer because of it's bad appearance. The CI symptoms include uneven ripening, poor color and flavor and it is clear that PCI and PTI were reduced in IW treatment. Low temperature caused CI in both continuous cold storage (3°C) and IW, so the best storage temperature is 13°C.

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تأثير التخزين المبرد والتدفئة المتقطعة على الصفات الطبيعية لثمار المانجو صنف كيت

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تم استخدام التدفئة المتقطعة أثناء التخزين وذلك لإطالة العمر التخزينى وفترة العرض لبعض الفاكهة الاستوائية الحساسة للحرارة المنخفضة ؛ حيث تم قطف ثمار المانجو صنف كيت خضراء مكتملة النمو وذلك خلال موسمى ٢٠٠٩ و ٢٠١٠ ثم عبئت فى أكياس من البولى إيثلين المثقب وتم تعريضها لدرجات حرارة مختلفة كما يلى: ١- تخزين الثمار على درجة حرارة ٣±١°م لمدة ٤ أيام بالإضافة إلى ١٦±١°م لمدة ٣ أيام ، ٢- تخزين الثمار على درجة حرارة ١٣±١°م ، ٣- تخزين الثمار على درجة حرارة ٣±١°م ، ثم خزنت كل الثمار لمدة ٨ أسابيع على رطوبة نسبية ٨٥-٩٥%، تم أخذ عينات عشوائية من كل معاملة بعد ٢و ٤ أسابيع ثم بعد ذلك أسبوعيا لتقييم تأثير فترات التخزين والمعاملات المختبرة ، وتم تعريض بعض الثمار بعد كل فترة زمنية لظروف مماثلة للسوبر ماركت وهى ٢٠±١°م ورطوبة نسبية ٦٠-٧٠% كفترة عرض لمدة ٣ أو ٦ أيام ، وقد حافظت معاملة التدفئة المتقطعة على صلابة الثمار ، واللون الأخضر للقشرة وذلك عند مقارنتها بالثمار المخزنة على ١٣±١°م وكان هذا متماثلا فى كل من فترة التخزين المبرد وفترات العرض ، وبالإضافة لذلك فإن التدفئة المتقطعة أدت الى تقليل الفقد فى الوزن الطازج , ودليل الثمار المستبعدة ، ودليل اختبار الطعم وذلك بالمقارنة بالثمار المخزنة على ١٣±١°م وذلك أثناء فترة التخزين المبرد وفترات العرض ، وأدى التقدم فى فترة التخزين أثناء ثمانية أسابيع إلى زيادة مضطردة فى الفقد فى الوزن الطازج , دليل الثمار المستبعدة , ودليل لون القشرة ، ودليل اختبار الطعم وذلك من العينات المأخوذة أثناء التخزين المبرد وفترة العرض ، وعلى العكس فإن التقدم فى فترة التخزين المبرد أدى إلى تقليل صلابة الثمار ، ظهرت أعراض أضرار البرودة بعد ٤ أسابيع على الثمار المخزنة تحت ظروف التدفئة المتقطعة ، وقد حسنت التدفئة المتقطعة من الخصائص الطبيعية للثمار أكثر من المخزنة على ١٣±١°م ولكن ظهور أضرار البرودة كان غير مقبولاً فى هذه المعاملة.

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