BROWNING INCIDENCE OF SOUND ANNA APPLE FRUITS AND THAT AFFECTED BY BRUISING DURING COLD STORAGE AND MARKITING

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ABSTRACT

The pre-storage initial appearance of bruised areas on Anna apple fruit surface was characterized by a slightly darker color than the rest of fruit surface. After one week of storage at 0° C, those bruised areas became darker and had water-soaked appearance with a little grove and the disconnecting of fruit peel in those areas. When the bruised area was peeled, brown tissue area was noticed under the outer one. Scanning electron microscopic (SEM) studied showed that the flesh cells lost its turgidity which became greater with the progress of the storage period after 3 weeks associated with the pressuring of cells under bruised area with the disconnection of the flesh cells. The above grove increased with the progress of the storage period (3 weeks) with the increasing of the browning of the bruised areas. Sound Anna apples were stored for 13, 7 and 4 weeks at 0, 5 and 10° C, respectively, while the fruits cannot be kept more than 1 week at Room temperature (RT) at 20° C. Stored fruits at 0° C had the lowest weight loss during storage in both seasons followed by fruits stored at 5° C. Fruits stored at 0° C had the highest value of firmness, SSC, malic acid and total phenols during the storage period and the same results were obtained with shelf life fruits. Fruits stored at 10° C had the highest activities of peroxidase (POD) and polyphenoloxidae (PPO) enzymes and the lowest ones were at 0° C. The obtained results of POD and PPO enzyme activities showed a continuous increase with higher temperature and advanced storage period.

INTRODUCTION

Fruit bruising is one of the major surface defects of soft fruits and vegetables. It is usually caused by mechanical damage (impacts with hard surfaces or other fruits) during harvest, transport and handling (Ragni, 1997; Blahovec and Paprštein, 2005 and Xing *et al.*, 2003 and 2005). The damage is manifested as water-soaked tissue that subtended the point of impact (Quintana and Paull, 1993) and a tissue discoloration some times extending to the under-epidermic cells (Meheriuk *et al.*, 1994; Berardinelli *et al.*, 2005 and Xing *et al.*, 2005). Fruit turgidity and firmness have been shown to influence impact bruise susceptibility in fruits. Stresses in the tissues are higher in turgid fruit so they are more susceptible to bruising (Garcia *et al.*, 1995). Also, fruits picked in the morning (Viljoen *et al.*, 1996) and large fruits (Ericsson and Tahir, 1996) are more bruisable. Bruising can result in a lower grade for any apple fruit and can lead to qualitative and quantitative losses (Xing *et al.*, 2005). Since the customer's buying behavior is mostly determined by the visual appearance of the fruit, it is useful to be able to discriminate and sort the bruised apples from the healthy ones before sale (Xing *et al.*, 2003 and 2005).

Storage conditions (temperature and humidity) maybe used to ameliorate or delay disorder development or, in some cases, they can result in greater disorder expression (Ferguson *et al.*, 1999). Temperature has a direct effect on the respiration rates of fruits and on the activity of decay organisms. The respiration rate is an index of the rate at which the fruit is using its stored reserves and is, therefore, an index of the loss in shelf life. In general, the respiration rate increases two to four times for each 10° C increase in temperature. So, storage at optimum temperature and humidity is required to maintain the fruits at good quality.

The objectives of the present investigation were to:

1- Study the bruising characteristics of Anna apple fruits that occurred during harvest, handling and transport and its changes during storage.
2- Study the storage potential of full sound Anna apples in response to the different storage temperatures (0, 5, 10° C and Room temperature (RT) at 20° C) and the following kept in RT.
3- Study the effect of different storage temperatures and the following storage at RT on the physical (weight loss and firmness) and the chemical (SSC, titratable acidity, flesh total phenols and POD and PPO activity) fruit characteristics.

MATERIALS AND METHODS

The present study was carried out during 20034and 2005 seasons on mature Anna apple fruits (50-75 % red color) harvested from a private orchard in El-Nobaria, Alexandria Province and immediately transported to the Post-harvest Center of Horticulture Crops, Faculty of Agriculture (El-Shatby), Alexandria University and its initial quality is tabulated in table 1.

Table (1): The initial quality of Anna apple fruits on 2004 and 2005 seasons.

Parameters	2004 season	2005 season
Fruit weight (gm)	199.52	196.78
Fruit size (cm):		
Highness	8.06	7.72
Diameter	7.70	7.58
Firmness (lb/in^2)	8.18	7.88
SSC (%)	12.64	12.42
Acidity (%)	0.82	0.88

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Sound selected apple fruits (uniform in size and free of mechanical damage or pathological disorders) were washed then dried. Another sorting was done to eliminate the bruised fruits that had any small surface areas of pressured cells from handling fingers or from the fruit impacts with each other. The eliminated fruits were used in the first experiment to record the visual changes in the damaged bruised areas during the storage period and the case of cells under those areas. The above changes were followed also by the electron microscope (histological studies).

Preparation of apple fruits for scanning electron microscopic (SEM) studies (histological studies) was carried out as follows: 1- Tissue samples consisting of small fragments of apple fruits were fixed in universal E.M. (McDowell and Trump, 1976) and after dissection they were kept at 4°C till processing. 2- Rinsing twice in 0.1 M phosphate buffer for 10 min. 3- Post fixation in 1%, 0.2 % M phosphate buffered osmium tetroxide for 1 hour at 4°C. 4- Rinsing with phosphate buffer for 8 min, then dehydration started in 50, 70, 95 then 100 % ethyl alcohol changed twice for 10, 8, 10 and 15 min, respectively with continuous shaking in every step. 5- Drying to the critical point. 6- Thin coating of gold was done under vacuum using Sputterer coater JEOL.JFC-1100E. 7- Examining with scanning electron microscop 5300 JEOL.

The full sound Anna apple fruits were used for the second experiment. The fruits were divided to four sections (150 fruits for each of the first three ones and 20 fruits for the fourth one). The first three sections were respectively stored at 0, 5 and 10 °C with 85-90 % RH. The fourth one was stored at the room temperature (RT) at 20°C.

The physio-chemical properties of the above fruits were determined initially and were followed up in 7 days intervals throughout the storage period (10 fruits were used for each treatment). Another 10 fruits for each treatment were transported to RT to study its shelf life characteristics.

15 apple labeled fruits in each section were initially weighed to calculate fruit weight loss percent during the storage period in relation to its original weight.

Patches of skin were peeled from two opposite sides of the fruit to measure flesh firmness by using the Effegi pressure tester with an eight-mm plunger (Effegi, 48011 Alfosine, Italy).

Two opposite segments from the rose to the stem end were taken and each of them was squeezed and the obtained juice was used to determine the percentage of soluble solid content (SSC) by the use of a hand refractometer (Chen and Mellenthin, 1981).

Another two segments were taken and three samples of juice were obtained to determine the titratable acidity as g. malic acid / 100 ml fruit juice (Chen and Mellenthin, 1981).

Three samples of one g fruit flesh were taken from each treatment to determine its total phenol contents according to the colourmetric method of Resenblatt and Peluso (1941). The extraction was carried out by 95 % ethanol at 25 °C on a hotplate then the colorimetric determination was carried and the optical density of the samples was read at 725 nm and the amount of total phenol percentages were calculated against a standard curve of tannic acid.

Oxidizing enzymes activity was determined in crude enzyme extracts of fruit flesh of each treatment. One gm of fruit flesh tissues was homogenized by hand homogenizer for 3 min in 5 ml of 0.1 M sodium phosphate buffer at pH of 7. The resulting extract was filtered and kept in ice path until it was used to remain cold (Brenneman and Black, 1979).

Peroxidase activity (POD) was determined according to Chance and Maehly (1955). The method was based on the fact that POD catalyzes oxidation of pyrogallol to purpuregallin in the presence of hydrogen peroxide. The optical density (OD) of the reaction mixture at 420 nm was determined by the spectrophot-ometer over a period of 4 min, at 15 seconds intervals. POD activity was expressed as change in absorbance per min.

Polyphenoloxidase activity (PPO) was measured by following the oxidation of catechol at 495 nm (Matta and Dimond, 1963). PPO activity was measured spectrophotometrically by estimating the OD of the reaction mixture for 4 min at 15-second intervals. PPO activity was expressed as change in absorbance per min.

The termination of the experiment was done when fruits firmness reached the average of 3 lb/ in^2. All data were statistically analyzed according to Snedecor and Cochran (1980). The individual comparisons were carried out by using the Least Significant Difference (LSD) according to SAS Institute (1985). Simple regression coefficient between storage period and studied properties was calculated as referred by SAS Institute (1985).

RESULS AND DISCUSSION

Fruit bruising characteristics:

The pre-storage initial appearance of bruised areas on apple fruit surface was characterized by a slightly darker color than the other fruit surface (fig 1). After one week of storage at 0° C, those bruised areas became darker and had water-soaked appearance with a little grove and the disconnecting of fruit peel in those areas. The above groove increased with the progress of the storage period (3 weeks) with the increasing of the browning of the bruised areas (fig 2). When the bruised area was peeled brown tissue area was noticed under the outer one (fig 3). The above findings are associated with those of Xing *et al.*, 2003 and Berardinelli *et al.*, 2005. The discoloration is due

Figures

Fig (1): Prestorage initial appearance of bruised area.

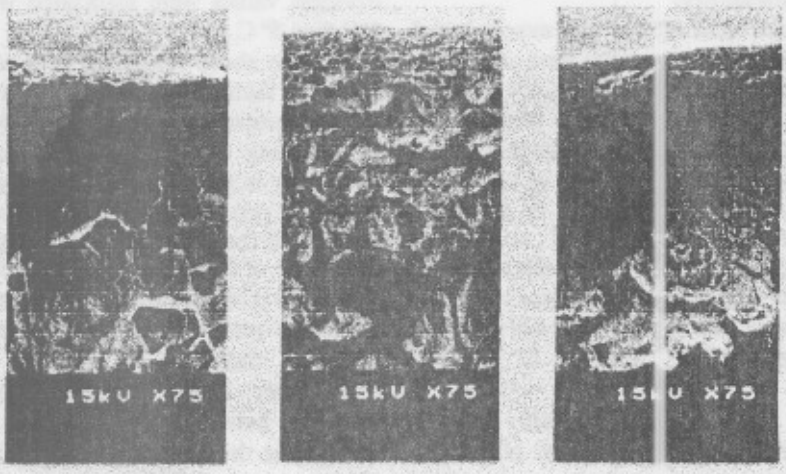
Fig (2): The appearance of bruised area after 3 weeks of storage at 0°C

Fig (3): The brown col under the bruised are

Fig (4): Sound flesh cells of Anna apple fruits by EMS.

Fig (5): Initial appearance of bruised area.

Fig (6): Bruised area after one week at 0°C.



A B C

Fig (7): Bruisod area after 3 weeks at 0°C.

to a combination of physical stress and biochemical reactions (Wang and Mellenthin, 1973). This darkening phenomenon of the stressed skin is caused by oxidation of the phenolic compounds. This oxidative reaction is catalyzed by polyphenoloxidase (Berardinelli *et al.*, 2005).

The electron microscope scanning (EMS) showed the injured flesh cells in comparison with the sound cells of apples flesh (fig 4). The initial appearance of bruised area (fig 5) revealed the little groove on the fruit surface and the slightly pressed cells under that groove. After one week of storage at 0° C (fig 6) the flesh cells lost its turgidity which became greater with the progress of the storage period after 3 weeks (fig 7-A) associated with the pressuring of cells under bruised area with the disconnecting of the flesh cells (fig 7-B). The above findings are associated with those of Kim and Hung (1990) on Rome Beauty apples. Also, some flesh cells lost its shape making grooves in the flesh (fig 7-C). The above results agree with those of Rodríguez *et al.*, (1990) on Granny Smith apples.

The results also showed that bruising is one of the most important and prevalent surface defects in apples and it is a frequent cause of value loss in marketed and processed apples (Shewfelt and Prussia, 1993; Xing *et al.*, 2003 and 2005 and Berardinelli *et al.*, 2005). Schulte *et al.*, 1991 found that the picker was the most significant factor in reducing bruising damage. A 6-7 % increase in sound fruit resulted from the use of either a deluxe padded picking bucket or a cushioned bin bottom. The use of gloves reduced the bruised-free fruit by 6 %. Also, Hyde, 1997 reported that bruising could be reduced by decreasing effective drop heights, eliminating unnecessary drops and very slightly dehydrating fruits to improve the bruise threshold.

Fruit quality and storability:

The tabulated data of the two experimental seasons showed that Anna apple fruits were stored for 13, 7 and 4 weeks at 0, 5 and 10° C, respectively while the fruits cannot be stored more than 1 week at RT because of the high weight loss percentage and the fruits lost its good appearance as a result of shriveling and the browning of its rose end due to advanced ripening. The stored fruits at 0° C retained a significantly good appearance than those stored at 5 or 10° C which lost its brightness and began to shrink with the incidence of cracking of some fruits from the rose end and that began after 2 weeks at 10° C and 6 weeks at 5° C.

Temperature has a direct effect on the respiration rates of fruits which is an index of the loss in fruit stored reserves of sugar and other metabolites and as a result the loss of its shelf life period. The respiration rate increases two to four times for each 10° C increase in temperature, so storage at optimum temperature is required to maintain the fruit quality and prolong its storage period. The above data and associated discussion are in agreement with those of Rasmussen (1990) on Gloster, Jonagold and Mutsu apples; Jahangir *et al.* (1993) on Red Delicious apples; El-Seidy (1994) on Le Conte pears and Lau and Lane (1998) on Sunrise apples.

Fruit weight loss (%):

There was a significant effect of different storage temperature on the percentage of weight loss of Anna apples (table 2). Stored fruits at 0° C had the lowest weight loss during the storage period in both seasons then the fruits stored at 5° C. So, the weight loss was related to temperature. Also, the percentage of fruit weight loss increased with the progress of storage time (r^2 values were highly significant) and the changes were most rapid at higher temperatures.

The weight loss is mainly a result of water loss from the fruit tissues and partially of the respiration process. The higher the storage temperature the higher the respiration rate and the higher the weight loss is. The higher the air temperature, the more water loss because of its capacity to evaporate water, also the higher the temperature of the fruit the greater is its tendency to lose moisture (Gac, 1955).

The later results and associated discussions agree with those reported by Abd El-Migid (1986) on pears; Rasmussen (1990) on apples and El-Seidy (1994) on pears.

Fruit firmness (lb/in^2):

Storage temperature affected fruit firmness of Anna apples (table 3) where the fruits stored at 0° C had the highest value of firmness during the storage period and the loss in fruit firmness was higher at the higher temperature. The above results were obtained also for shelf life fruits (table 4) where the best firmness values were associated with fruits stored at 0°C then 5° C.

The above results in both seasons showed that the fruit firmness decreased with the increasing of storage temperature, which resulted in the increasing of softening enzyme activities, and as a result the increasing in the degradation of insoluble protopectins to soluble pectins as reported by Haller (1941). So, the changes in fruit firmness were temperature dependent. The trend of fruit firmness showed that fruit firmness decreased (r^2 values were significant) with the progress of storage period at all temperatures as a result of the progress increase of pectine esterase activity (Ponomarev, 1968). Also, the enzymatic cleavage of linkages between himicelluloses and pectins is involved in the softening of apple fruits during storage (Siddiqui *et al.*, 1996).

The above results and discussions are agree with those of Meresz *et al.* (1994); Ingham *et al.* (1998) and Lau and Lane (1998).

SSC %:

Apple fruits that were stored at 0° C had the highest values (not significant) of SSC during the storage period followed by fruits stored at 5 and 10° C (table 5). SSC values of stored fruits at all temperatures increased with the increasing of the storage period and decreased again by the end of the storage period at 0° C. When the fruits were transported to RT (for 3 days) SSC percentages of all treatments increased and also, the highest values were that of the fruits stored at 0° C (table 6).

The highest SSC content of stored fruits at 0° C may be due to the effect of the low temperature on regulate respiration and perhaps other metabolic processes during storage. The gradual increase in SSC with time and translation to RT could be due to the degradation of complex insoluble compounds like starch to soluble ones like sugars that are the major component of SSC content in fruits that accumulate with time. These results and related discussions are in agreement with those of Abd El-Migid (1986) on pears; El-Seidy (1994) on pears; Mahajan (1994) on apples and Dris (1999) on apples.

Titratable acidity (%):

Storage temperature had a significant effect on malic acid content of Anna apples where the fruits stored at 0° C had the significant highest values in both seasons (table 7). The same effect was found in shelf life fruits (table 8). Malic acid percentages declined in both seasons with the advancing of time and by the translation of fruits to RT.

The highest acidity content of apple fruits that were stored at 0° C could be due to the low respiration rate and the other metabolic processes of those fruits and then low consumption of malic acid. The decrease in malic acid content during storage period at different temperatures and after translation to RT could be due to the increase of its consumption in respiration activities as an organic substrate. The results obtained herien and related discussions agree with those reported by Chen and Mellenthin (1981); Abd El-Migid (1986); Lovász *et al.* (1993); El-Seidy (1994); Mahajan (1994) and Dris (1999).

Flesh total phenols (%):

From the obtained data (table 9 and 10) in two seasons it was noticed that the apple fruits stored at 0° C had the highest total phenol contents compared with the other treatments where those values increased with the higher storage temperature. Also, total phenols decreased when the fruits were stored at RT after cold storage (shelf life) and with the progress of the storage period (r^2 values were not significant for all treatments).

The highest phenols content of the fruits stored at 0° C could be due to the low activity of polyphenoloxidase (PPO) enzyme that resulted in the accumulation of phenolic compounds. These results and its discussions agree with those of El-Seidy (1994) on pears; Mahajan (1994) on apples; Murata *et al.* (1995) on apples and Ilzarbe *et al.* (1997).

Flesh enzymes activity (OD):

Storage temperature had no significant effect on peroxidase (POD) activity in apple fruit flesh (table 11) but generally the fruits stored at 10° C had the highest activities while the lowest ones were at 0° C and the significant differences were in the 6th week in the first season and in the 4th week in the second one. When the fruits were transported to RT, POD activities increased for all treatments (table 12) compared with the values of cooled fruits and the lowest significant values were observed for the fruits that stored at 0° C. With the advanced storage period the activities values of POD of all treatments of cooled and shelf life fruits were increased then decreased at the end of storage.

Where the same trend was observed also for polyphenoloxidase (PPO) activity, the storage temperature had no significant effect on it. The fruits stored at 0° C had the lowest values (significant differences were in the 5th week on the first season and in the 3rd and 4th weeks on the second season) and the highest significant ones were noticed for the RT stored fruits. Shelf life fruits had higher PPO activity values compared with the cooled fruits. During shelf life treatments the fruits stored at 0° C had the highest significant PPO activities. PPO activity increased at the first four weeks in both seasons then decreased with the progress of the storage period for all treatments. The finding of the present study agree with those of Kang and Lee, 1987.

The results of POD and PPO enzyme activities showed an increase with the increase in storage temperature and with the progress of the first weeks of the storage period and that involve the oxidation of many organic compounds by POD in the presence of hydrogen peroxide or the oxidation of phenolic compounds by PPO to form quinones that are lightly unstable and polymerize quickly to form brown-colored products. These results and related discussion agree with those of Ingham *et al.* (1998) on apples; El-Seidy (2000) on peaches; Tayel (2001) on peaches and El-Saedy and El-Naggar (2005) on guava.

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Table (2): Effect of different storage temperatures on weight loss (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.00a	0.40b	0.63b	0.88c	1.07c	1.40b	1.67b	1.93b	2.25	2.70	2.96	3.38	3.54	3.74	0.99**
5	0.00a	0.54b	1.05a	1.47b	1.90b	2.47a	2.94a	3.39a							0.99**
10	0.00a	0.76b	1.34a	2.07a	2.81a										0.99**
RT	0.00a	3.91a													
LSD		0.62	0.35	0.50	0.63	0.86	0.98	1.03							
2005															
0	0.00a	0.34c	0.56b	0.80b	1.00b	1.41a	1.58a	1.84a	2.08	2.48	2.72	3.06	3.37	3.72	0.99**
5	0.00a	0.42bc	0.89b	1.28b	1.67b	2.10a	2.50a	2.94a							0.99**
10	0.00a	1.12b	2.10a	3.28a	4.26a										0.99**
RT	0.00a	3.95a													
LSD		0.70	0.55	0.99	0.96	1.07	1.25	1.54							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (3): Effect of different storage temperatures on flesh firmness (lb/in^2) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	8.18a	7.57a	8.42a	5.43a	6.08a	7.00a	5.28a	5.31a	5.58	5.48	5.02	5.97	5.28	5.42	0.55**
5	8.18a	5.62ab	4.60b	5.40a	4.57ab	6.02a	4.70a	3.58b							0.45*
10	8.18a	5.08ab	4.22b	4.28a	3.45b										0.77*
RT	8.18a	2.83b													
LSD		2.91	2.16	1.65	1.80	1.18	2.50	1.60							
2005															
0	7.88a	8.23a	6.47a	6.88a	5.73a	6.28a	6.90a	7.15a	5.85	5.20	5.33	5.90	5.62	5.52	0.60**
5	7.88a	6.78ab	4.70a	5.55a	5.25ab	5.45a	4.70b	3.80b							0.71**
10	7.88a	5.43bc	4.62a	4.55a	3.85b										0.82*
RT	7.88a	3.33c													
LSD		2.46	2.46	3.68	1.41	2.81	1.62	1.27							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (4): Effect of different storage temperatures and the following kept in RT on flesh firmness (lb/in^2) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	8.18a	5.10a	6.22a	5.58a	5.15a	5.47a	5.07a	6.47a	4.60	4.50	4.83	4.05	4.82	4.97	0.43*
5	8.18a	4.73a	4.83b	4.35a	5.18a	5.10a	3.87a	2.87b							0.58*
10	8.18a	4.22a	4.93b	4.85a	4.50a										0.43
LSD		1.44	1.05	1.78	0.86	2.34	1.66	1.85							
2005															
0	7.88a	5.98a	4.73a	5.82a	4.80a	5.20a	6.05a	5.88a	5.58	5.10	4.45	5.67	4.28	4.13	0.40*
5	7.88a	4.23a	5.42a	4.70ab	5.02a	4.50a	5.30a	3.00b							0.43
10	7.88a	5.72a	4.42a	4.38b	4.05a										0.81*
LSD		2.57	1.50	1.13	1.32	3.57	1.59	2.04							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (5): Effect of different storage temperatures on flesh SSC (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	12.64a	12.20a	12.20a	13.67a	12.77a	12.70a	12.83a	12.97a	13.1	13.50	13.80	13.60	13.53	13.07	0.46**
5	12.64a	12.40a	11.83a	13.07b	12.13a	12.10a	12.60a	12.67a							0.01
10	12.64a	12.60a	12.17a	12.67c	12.03a										0.37
RT	12.64a	12.80a													
LSD		1.12	1.67	0.35	2.72	1.43	1.65	1.80							
2005															
0	12.42a	11.10b	11.60a	13.63a	12.87a	12.57a	12.80a	13.27a	13.77	13.80	12.70	12.60	12.60	12.33	0.10
5	12.42a	12.40a	11.23a	13.07a	12.73a	11.90a	12.63a	13.03a							0.11
10	12.42a	12.37a	12.07a	13.10a	12.40a										0.08
RT	12.42a	13.13a													
LSD		1.19	0.85	1.48	1.10	1.89	0.72	0.57							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (6): Effect of different storage temperatures and the following kept in RT on flesh SSC (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	12.64a	13.27a	13.63a	13.90a	12.90a	13.33a	13.47a	13.57a	13.27	13.60	12.57	12.80	11.90	11.93	0.31*
5	12.64a	13.33a	13.20a	13.10a	12.63a	12.87a	13.07a	12.57a							0.11
10	12.64a	12.80a	12.47a	13.17a	12.47a										0.001
LSD		0.99	1.56	1.05	1.28	2.15	1.47	1.03							
2005															
0	12.42a	14.00a	13.27a	13.37a	13.10a	14.37a	13.67a	13.33a	12.90	13.13	12.05	12.53	12.20	12.13	0.33*
5	12.42a	13.30a	13.07a	13.43a	12.43a	12.77a	13.30a	11.80b							0.10
10	12.42a	12.83a	12.40a	13.27a	12.30a										0.01
LSD		1.63	1.29	1.78	1.01	2.15	0.97	1.26							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (7): Effect of different storage temperatures on malic acid content (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.82a	0.69a	0.82a	0.60a	0.54a	0.69a	0.53a	0.65a	0.58	0.58	0.44	0.57	0.49	0.49	0.61**
5	0.82a	0.62a	0.61b	0.62a	0.53ab	0.63a	0.46a	0.55b							0.57*
0	0.82a	0.66a	0.53b	0.57a	0.50b										0.80*
RT	0.82a	0.40b													
LSD		0.11	0.08	0.10	0.04	0.15	0.16	0.06							
2005															
0	0.88a	0.92a	0.77a	0.62a	0.54ab	0.73a	0.57a	0.66a	0.67	0.63	0.58	0.56	0.50	0.51	0.63**
5	0.88a	0.65b	0.57b	0.56b	0.57a	0.62b	0.52b	0.50b							0.59*
10	0.88a	0.65b	0.49c	0.54b	0.48b										0.75
RT	0.88a	0.47c													
LSD		0.03	0.05	0.06	0.09	0.11	0.05	0.05							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (8): Effect of different storage temperatures and the following kept in RT on malic acid content (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.82a	0.53b	0.53a	0.65a	0.55a	0.58a	0.46a	0.54a	0.51	0.50	0.47	0.57	0.42	0.41	0.49**
5	0.82a	0.55b	0.44a	0.53b	0.43c	0.58a	0.45a	0.42a							0.43
10	0.82a	0.68a	0.44a	0.46b	0.48b										0.73
LSD		0.09	0.11	0.10	0.05	0.04	0.15	0.14							
2005															
0	0.88a	0.54a	0.58a	0.60a	0.49ab	0.57a	0.48a	0.54a	0.50	0.49	0.46	0.55	0.40	0.46	0.47**
5	0.88a	0.52a	0.55b	0.47b	0.45b	0.54b	0.46a	0.40b							0.53*
10	0.88a	0.53a	0.47c	0.48b	0.50a										0.54
LSD		0.05	0.02	0.06	0.04	0.01	0.03	0.08							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (9): Effect of different storage temperatures on flesh total phenols (%) of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.58a	0.55a	0.60a	0.18a	0.62a	0.49a	1.30a	0.95a	0.18	0.18	0.24	0.26	0.66	0.57	0.02
5	0.58a	0.54a	0.42a	0.14a	0.54a	0.39a	1.26a	0.77a							0.22
10	0.58a	0.51a	0.15b	0.15a	0.50a										0.15
RT	0.58a	0.37b													
LSD		0.09	0.20	0.06	0.27	0.39	0.95	0.37							
2005															
0	0.54a	0.54a	0.61a	0.22a	0.54a	0.52a	1.20a	1.06a	0.22	0.23	0.20	0.20	0.30	0.30	0.13
5	0.54a	0.45ab	0.43ab	0.22a	0.50a	0.47a	1.06a	0.78a							0.34
10	0.54a	0.42b	0.31b	0.29a	0.39a										0.46
RT	0.54a	0.27c													
LSD		0.11	0.19	0.08	0.24	0.48	0.41	0.35							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (10): Effect of different storage temperatures and the following kept in RT on flesh total phenols (%) of Anna apple Fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.58a	0.32a	0.45a	0.42a	0.77a	0.41a	1.44a	1.01a	0.29	0.26	0.25	0.24	0.72	0.55	0.01
5	0.58a	0.29a	0.39a	0.22b	0.67ab	0.35a	0.90b	0.74a							0.30
10	0.58a	0.31a	0.36a	0.21b	0.39a										0.31
LSD		0.23	0.19	0.16	0.33	0.35	0.42	0.28							
2005															
0	0.54a	0.43a	0.45a	0.43a	0.85a	0.56a	1.21a	0.81a	0.22	0.21	0.24	0.20	0.28	0.35	0.15
5	0.54a	0.39ab	0.45a	0.29ab	0.71a	0.37a	0.80a	0.62a							0.21
10	0.54a	0.25b	0.23b	0.21b	0.54a										0.001
LSD		0.15	0.20	0.17	0.43	0.21	0.77	0.38							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (11): Effect of different storage temperatures on POD activity of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.076a	0.109a	0.102a	0.110a	0.125a	0.152a	0.135b	0.149a	0.060	0.062	0.058	0.048	0.045	0.035	0.37*
5	0.076a	0.122a	0.116a	0.121a	0.137a	0.160a	0.203a	0.153a							0.77**
10	0.076a	0.125a	0.124a	0.124a	0.140a										0.68
RT	0.076a	0.146a													
LSD		0.051	0.033	0.029	0.058	0.045	0.056	0.022							
2005															
0	0.122a	0.101a	0.178a	0.190a	0.211b	0.240a	0.135a	0.087a	0.085	0.081	0.075	0.072	0.054	0.055	0.42*
5	0.122a	0.125a	0.184a	0.202a	0.250ab	0.290a	0.173a	0.042a							0.01
10	0.122a	0.139a	0.190a	0.231a	0.280a										0.98**
RT	0.122a	0.148a													
LSD		0.066	0.059	0.058	0.068	0.091	0.045	0.051							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (12): Effect of different storage temperatures and the following kept in RT on POD activity of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.076a	0.140a	0.131b	0.150b	0.175b	0.181a	0.190b	0.138a	0.100	0.040	0.020	0.031	0.021	0.020	0.47**
5	0.076a	0.170a	0.202a	0.208a	0.211a	0.245a	0.267a	0.161a							0.36
10	0.076a	0.172a	0.228a	0.224a	0.214a										0.66*
LSD		0.040	0.042	0.027	0.029	0.066	0.058	0.036							
2005															
0	0.122a	0.154a	0.191a	0.216b	0.231b	0.282a	0.175a	0.036a	0.040	0.038	0.021	0.025	0.023	0.011	0.54**
5	0.122a	0.158a	0.193a	0.220b	0.252b	0.320a	0.188a	0.029a							0.001
10	0.122a	0.194a	0.199a	0.250a	0.301a										0.95**
LSD		0.050	0.069	0.028	0.037	0.045	0.045	0.023							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

Table (13): Effect of different storage temperatures on PPO activity of Anna apple fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.100a	0.120b	0.130a	0.102a	0.081a	0.062b	0.041a	0.039a	0.032	0.022	0.025	0.022	0.020	0.011	0.87**
5	0.100a	0.180ab	0.179a	0.144a	0.121a	0.099a	0.049a	0.040a							0.54*
10	0.100a	0.195ab	0.182a	0.162a	0.142a										0.05
RT	0.100a	0.250a													
LSD		0.127	0.061	0.088	0.064	0.032	0.015	0.022							
2005															
0	0.120a	0.094b	0.150a	0.111b	0.090b	0.075a	0.053a	0.048a	0.035	0.034	0.031	0.020	0.020	0.021	0.81**
5	0.120a	0.120b	0.184a	0.160a	0.130ab	0.098a	0.049a	0.033a							0.51*
10	0.120a	0.150b	0.199a	0.182a	0.158a										0.32
RT	0.120a	0.280a													
LSD		0.092	0.082	0.039	0.050	0.035	0.035	0.021							

Means within columns (in same season) having a common letter are not significantly different.
^{2} =Determination coefficient.

Table (14): Effect of different storage temperatures and the following kept in RT on PPO activity of Anna apple Fruits on 2004 and 2005 seasons.

Storage Temp. (C°)	Storage period (weeks)														r^2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
2004															
0	0.100a	0.143b	0.152a	0.141b	0.121a	0.068a	0.048a	0.037a	0.035	0.028	0.026	0.027	0.024	0.018	0.78**
5	0.100a	0.199a	0.186a	0.162ab	0.135a	0.095a	0.081a	0.049a							0.47
10	0.100a	0.211a	0.193a	0.180a	0.161a										0.11
LSD		0.053	0.049	0.028	0.043	0.072	0.036	0.023							
2005															
0	0.120a	0.121b	0.152b	0.183b	0.201c	0.135a	0.142a	0.034a	0.038	0.030	0.030	0.025	0.018	0.010	0.66**
5	0.120a	0.148ab	0.160ab	0.210ab	0.240b	0.159a	0.150a	0.022a							0.09
10	0.120a	0.165a	0.185a	0.258a	0.284a										0.97**
LSD		0.035	0.028	0.049	0.026	0.058	0.036	0.023							

Means within columns (in same season) having a common letter are not significantly different.
r^2 =Determination coefficient.

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الملخص العربي

مدى حدوث التلون البني لثمار التفاح أنا السليمة و المصابة بكدمات أثناء التخزين المبرد و التسويق

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احتكاك الثمار وانضغاطها سواءاً أثناء الجمع و النقل و التداول بالأسطح الصلبة أو ببعضها البعض يتسبب فى حدوث الأضرار الميكانيكية غير الظاهرة. و المظاهر المبدئية لهذه الأضرار على سطح ثمار التفاح أنا تبدو على هيئة مساحات أدكن قليلا من باقي سطح الثمرة و لكن بعد أسبوع من التخزين على صفر ° م فان هذه المساحات تصبح ادكن و لها مظهر مائي مع حدوث انخفاض لها و انفصال لقشرة الثمرة عن اللب في هذه المناطق مع ظهور لون بني للحم الثمار تحت القشرة. و قد أوضحت الدراسة بالميكروسكوب الالكتروني أن خلايا اللحم تحت هذه المناطق تفقد امتلائها و يزداد ذلك مع تقدم فترة التخزين (٣ أسابيع) مع انضغاط الخلايا في هذه المناطق و انفصالها عن بعضها و يزيد انخفاض هذه المناطق و تلونها باللون البني مع تقدم التخزين. و قد تم تخزين ثمار التفاح أنا السليمة لمدة ١٣، ٧ و ٤ أسابيع على درجات حرارة صفر، ٥ و ١٠ ° م على التوالي بينما لم يمكن تخزينها أكثر من أسبوع على درجة حرارة الغرفة(٢٠ ° م). الثمار المخزنة على صفر ° م كان لها أقل فقد فى الوزن وكان لها أعلى نسب من الصلابة، المواد الصلبة الذائبة، حامض الماليك و الفينول الكلي خلال فترة التخزين في كلا الموسمين وقد لوحظت نفس النتائج للثمار التي تم نقلها من التخزين المبرد الى درجة حرارة الغرفة لمدة ٣ أيام. الثمار المخزنة على درجة ١٠ ° م كان لها أعلى نشاط لانزيمات البيروكسيديز و البولي فينول أوكسيديز و أقلها كان للثمار المخزنة على صفر ° م. وقد ازداد النشاط الانزيمي مع زيادة درجة حرارة التخزين و مع تقدم فترة التخزين خلال الأسابيع الأولى.