Trends in Horticultural Research

ISSN 1996-0735

Academic Journals Inc.

www.academicjournals.com

Trends in Horticultural Research 2 (2): 14-27, 2012
ISSN 1996-0735 / DOI: 10.3923/thr.2012.14.27

Effect of Fumigation with Some Volatile Substances on Peach Fruits During Cold Storage

M.E. Tarabih, E.E. EL-Eryan and M.N. Tourky
Horticulture Research Institute, Agriculture Research Center, Egypt

Corresponding Author: M.E. Tarabih, Horticulture Research Institute, Agriculture Research Center, Egypt

ABSTRACT

Peach fruits (*Prunus persica*) can stored for several weeks before sold and consumed through cold storage, which has been used to increase the postharvest life. Low temperature storage is the preferred method of preserving peach fruits although under these conditions the fruits are subject to decay by several plant pathogens. Herein, the efficiency of fumigation with acetic acid (4%), ethanol vapor (20%) and acetaldehyde (2%) on the reduction of fruit losses and against decay of "Swelling" peach were examined under 30 days of cold storage at 2°C±1 with 90% relative humidity. Results showed that ethanol vapor gave the highest reduction in weight losses, decayed fruits and total loss percentage in fruit. As well, kept the quality of fruit appearance significantly (good fruit appearance), moderate to slight off-flavor and anthocyanin accumulation in the skin of fruits during cold storage at 2°C for 30 days compared with the other treatments or the control. Acetaldehyde offered more pronounced effect on fruit firmness than the other treatments, enhanced soluble solids content (SSC) and total acidity. However, gave the lowest value of fruit flavor (extreme off-flavor), had severe defects on appearance quality. Also, it bleaching decreased the total anthocyanin assessments and maintained lower vitamin C content during cold storage. Acetic acid vapor reduced the postharvest loss weight, decayed fruits percentage, have fair to slight effects on appearance quality and the maximum fruit flavor (slight off to fair flavor) of peach fruits during the storage period of the two seasons.

Key words: Peach, *Prunus persica*, volatile substances, fumigation, acetic acid, acetaldehyde, ethanol postharvest, cold storage, decay, fruit quality

INTRODUCTION

Postharvest losses of perishable crops have been estimated can reach 50% or more of the harvest. Losses in peaches after harvest are usually owing to injury of brown rot and rhizopus rot, caused by *Monilinia fructicola* and *Rhizopus stolonifer*, respectively (Forster *et al*., 2007).

Individual damaging peach in a container can infect many other fruits in a few days. Since these yeasts is a hurt parasite, breaks in the skin support disease growth (Abd Alla *et al*., 2008). Post-harvest treatments with anti-fungal either spray, soaking or fumigation, prolong keeping fruits for the longest period. The evaporation of the good transactions in pest resistance, where it helps to break the materials used places between spaces that cannot be down pesticides, liquid or solid form it (Sholberg *et al*., 2004). Recently, increased the rate of use of volatile organic compounds such as ethanol, acetaldehyde and acetic acid as well as volatile substances produced biologically in the fight against pests of fruits by evaporation (Pesis, 2005).

Acetaldehyde (Aa) a natural substance found in small quantities and play an important role in the flavor and aroma of ripening fruit. Treated fruits after harvest with acetaldehyde have a clear impact on the quality standards such as the odor and flavor, acidity and color. The pyruvate decarboxylation produces from glycolosis as results of respiratory metabolism produce acetaldehyde, which in turn resulted in reduced to ethanol (Purvis, 1997).

El Sheikh *et al.* (2000) examined the effect of different aldehydes and biopesticides on peach fruit rots caused by *Botrytis cinerea*, *Monilinia fructicola*, *Mucor piriformis* and *Rhizopus stolonifer*. Steaming fruits with acetaldehyde completely prevent the growth of mycelial of the tested fungi. Applied acetaldehyde at 40 mL L^{-1} had a strong influence for controlling peach fruit rots, whereas infection caused by *M. fructicola* and *M. piriformis*. Burdon *et al.* (1996) mentioned that treated fruits after harvest by acetaldehyde led to delay the ripening process. Acetaldehyde as a vapors phase and/or liquid phase can be used as alternative of chemical fungicides to control *Rhizopus* rot diseases of apricot, apples, sweet cherry and stone fruits after harvest and during transportation, marketing and storage. In addition to the above, the aldehydes fumes are stronger and more lethal growth inhibitors of fungal spores and bacterial cells. Acetaldehyde vapor at 50 and 100 μL L^{-1} concentrations for 30 and 60 min. resulted a complete reduction of fungal mycelium growth, while at 25 μL L^{-1} (15 min.) tended to decrease of fungal growth by 23.7% (Abd Alla *et al.*, 2008).

Ethanol, a natural compound produced by plant tissue under anaerobic conditions. Also, it is collects in a short time anaerobic fruits stored without negatively affecting the quality of the fruit. Adding ethanol vapors and dips externally description to inhibit the mature fruits by hindering biosynthesis of ethylene (Karabulut *et al.*, 2004). Ethanol by 20 or 40 mL L^{-1} completely prevented the growth of *B. cinerea* and *M. fructicola*. Rising fruit in ethanol was able to kill *Escherichia coli* (Pinto *et al.*, 2006) and to avoid the growth of current on the grape skin (Lichter *et al.*, 2002). The use of ethanol has the potential to reduce microflora dependable damage without a negative effect on the respiration rate of product. Its mode of action on fungal physiology has been investigated in detail, primarily in the context of fermentation processes and under conditions of continuous and increasing stress from accumulating ethanol.

Acetic Acid (AA) has been studied extensively for antifungal and antibacterial activity. Acetic acid is considered to be a generally recognized as safe compound, which has been used for many years in the food industry to inhibit the microbial growth (Barkai, 2001). Furthermore, it is very effective for reducing postharvest decay, without any toxic residues on fruits. It capable of to reduce the injury resulting from pathogens such as *B. cinerea* and *P. expansum* after harvest as it's a good source to kill mold spores inside fruit packing. The mode of action of an acid is related to the undissociated portion of the molecule and is more important than any change in pH brought about by the addition of acid. Therefore, acetic acid is more potent as a fumigant because it exists as mixtures of undissociated monomers and dimmers (Sholberg, 2009).

Acetic acid affects the cell membrane by interfering with the transport of metabolites and maintenance of membrane potential. Sponsor inhibitory appearance owing to the conduction of protons via destroying the membrane which hinders the effort of protons. Sholberg and Gaunce (1996) reported that fumigation with acetic acid helped to eliminate brown rot and Rhizopus rot on peaches, nectarines, apricots and cherries.

The object of this study was to relate environmental and individual healthiness affable techniques to defend spotless fruit eminence during storage. The use of these treatments and techniques gave a great performance in the reduction of fruit losses and against decay of Swelling peach for extending the fruit quality.

MATERIALS AND METHODS

This study was carried out during the two successive seasons of 2011 and 2012 on Swelling peach fruits to evaluate the effect of acetic acid, ethanol vapor and acetaldehyde treatments on fruit quality and storage ability under cold storage condition. Fruits were taken from a private orchard at Aga city, Dakahlia Governorate, from eight years old trees, budded on Nemaguard rootstock. Swelling cv. had free stone and its fruits appear in mid seasons (3rd week of June). Mature peach fruits were harvested 103 days after full bloom according to Shaltout (1995).

The fruits were immediately transported to the laboratory of post-harvest at Hort. Res. Inst. Mansoura, Egypt. At harvest, Fresh fruits apparently free from physical damage and diseases were artificially wounded, additional three replicates (5 fruits of each) were collected for initial quality measurements as described below.

Vaccinated fruits were fumigated with acetic acid at 4%, ethanol vapor at 20% and acetaldehyde at 2% for 30 min in fumigation chamber then, treated and untreated samples packed using ventilated plastic bags. All bags with fruits were weighed and every three bags were packed inside ventilated carton box (50×30×12) cm. The total numbers of boxes were 36 (4 treatments×3 storage periods×3 replicates) and stored at 2°C±1 with 90% relative humidity. Fruits were fumigated as follow in Table 1.

Three carton boxes for each treatment were taken at 10 days interval to determine and analyze the following parameters:

Loss in fruit weight: The loss in fruit weight was determined according to the following equation:

$$\text{Loss in fruit weight (\%)} = \frac{\text{Initial weight} - \text{Weight at sampling date}}{\text{Initial fruit weight}} \times 100$$

Decay: The decay of fruit was determined according to the following equation:

$$\text{Decay (\%)} = \frac{\text{Weight of decayed fruits}}{\text{Initial fruit weight}} \times 100$$

Total loss in fruit: The total loss in fruits was determined according to the following equation:

$$\text{Total loss in fruit (\%)} = \text{Loss weight\%} + \text{Decayed fruits weight\%}$$

Fruit appearance: It was scored using a scale of 1-5, where 5 is excellent, 4 is good, 3 is fair, 2 is slight defects and 1 is severe defects according to Kader (2002).

Table 1: Fumigation treatments of stored peach fruits

No.	Treatments used
1	Fumigation peach fruits with Acetic acid 4%
2	Fumigation peach fruits with Ethanol vapor 20%
3	Fumigation peach fruits with Acetaldehyde 2%
4	Control (untreated)

Fruit flavor: It was estimated using a scale of 1-7 where 7 is excellent, 6 is good, 5 is fair, 4 is slight off-flavor, 3 is moderate off-flavor, 2 is severe off-flavor and 1 is extreme off- flavor according to Kader (2002).

Fruit firmness: It was measured on 10 fruits for each replicate by using a hand-held Effegi-Penetrometers supplemented with a plunger 8.1 mm tip by removing a small exocarp segment on the two opposite sides of each fruit to expose the flesh. The average was estimated as pound per square inch (Lb $inch^{-2}$).

Soluble solids content (SSC): Soluble solids content in fruit juice was measured using a Carl-Zeiss hand refractometer according to AOAC (2005).

Titratable acidity: It was determined in 10 mL of fruit juice by titrating with 0.1 N sodium hydroxide in the presence of phenolphthalein as indicator and the results were expressed as a percentage of malic acid according to AOAC (2005).

Vitamin C (mg/100 g fresh weight): Vitamin C was measured by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye and the results were expressed as mg/100 g fresh weight according to Ranganna (1979).

Total anthocyanin content (mg/100 g fresh weight): It was measured in fruit skin at 535 nm using spectrophotometer according to Hsia *et al.* (1965). The content of total anthocyanin in fruit skin was calculated using the following equations:

$$\text{Total anthocianin content (mg/100g)} = \frac{\text{Total absorbance per 100 g skin}}{98.2 (E)}$$

The (E) value for 1% solution at 535 nm is equal to 98.2. Therefore, the absorbance of a solution containing 1 mg is equal to 98.2 according to Ranganna (1979).

Statistical analysis: Data of both seasons of the study were designed (Completely Randomize Designed) by using analysis of variance (ANOVA), with two factors; time and temperature. Differences among treatment means were statistically analyzed by using the Least Significant Differences Test (LSD) at p = 0.05%, means separation using the CoStat program.

RESULTS AND DISCUSSION

This study was undertaken on Swelling peach fruits to evaluate the effect of acetic acid, ethanol vapor and acetaldehyde treatments on fruit quality and storage ability under cold storage condition at 2°C±1 with 90-95% relative humidity and the obtained results are presented as follows:

Loss in fruit weight percentage: Data from Table 2 and 3 show that the loss in fruit weight had a positive relationship with storage periods, this may be due to shrinkage of the fruit during the storage period. The data also disclose that all applied treatments significantly reduced the percent of loss in fruit weight than the control after 30 days of cold storage during the two seasons of this study. Seeing as, the percent of loss in fruit weight at the untreated ones were 3.70 and

Table 2: Effect of fumigation with some volatile substances on weight loss, decay and total loss in Swelling peach fruits under cold storage season 2011

	Weight loss (%) Storage period (day)				Decay (%) Storage period (day)				Total loss (%) Storage period (day)			
Treatments	0	10	20	30	0	10	20	30	0	10	20	30
Control (untreated)	0.0	2.36	2.80	3.70	0.0	0.0	1.16	8.43	0.0	2.36	3.96	12.13
Acetic acid at 4%	0.0	1.90	2.30	3.0	0.0	0.0	0.0	7.83	0.0	1.90	2.30	10.83
Ethanol at 20%	0.0	0.96	1.33	1.66	0.0	0.0	0.0	6.50	0.0	0.96	1.33	8.16
Acetaldehyde at 2%	0.0	1.40	1.73	2.36	0.0	0.0	0.0	7.30	0.0	1.40	1.73	9.66
Mean	0.0	1.65	2.04	2.68	0.0	0.0	0.291	7.51	0.0	1.65	2.33	10.20
LSD at 5%												
Treatment	0.133				0.445				0.557			
Time	0.091				0.456				0.467			
Treatment ×time	0.182				0.913				0.935			

Table 3: Effect of fumigation with some volatile substances on weight loss, decay and total loss in Swelling peach fruits under cold storage of season 2012

	Weight Loss (%) Storage period (day)				Decay (%) Storage period (day)				Total loss (%) Storage period (day)			
Treatments	0	10	20	30	0	10	20	30	0	10	20	30
Control (untreated)	0.0	2.03	2.63	3.10	0.0	0.0	1.56	7.10	0.0	2.03	4.20	10.20
Acetic acid at 4%	0.0	1.50	2.33	2.93	0.0	0.0	0.0	6.90	0.0	1.50	2.33	9.83
Ethanol at 20%	0.0	0.80	1.16	1.90	0.0	0.0	0.0	6.03	0.0	0.80	1.16	7.93
Acetaldehyde at 2%	0.0	1.40	1.90	2.36	0.0	0.0	1.30	6.40	0.0	1.40	3.20	8.76
Mean	0.0	1.43	2.0	2.57	0.0	0.0	0.71	6.60	0.0	1.43	2.72	9.18
LSD at 5%												
Treatment	0.136				0.941				0.980			
Time	0.085				0.746				0.771			
Treatment×time	0.171				1.490				1.540			

3.10% in both seasons, respectively. In addition, the lowest loss percentage in fruit weight were recorded significantly by ethanol vapor at 20% in both seasons after 30 days of cold storage compared with the untreated or other treated fruits, hence it presented about 1.66 and 1.90% in the two seasons, respectively.

As well, fumigation with acetaldehyde at 2% reduced loss weight percentage than acetic acid at 4% under 30 days of cold storage in both seasons. The reduction was about 2.36% for acetaldehyde in the both seasons but reached about 3.0 and 2.93% for acetic acid at 4%. Burdon *et al*. (1996) mentioned that postharvest application of acetaldehyde resulted in a delay in the ripening process. Moreover, fruit weight loss mainly as a result of water loss from the fruit tissues during storage by respiration process and metabolic activities in fruits.

In general, yield should mislay about 5% of their fresh weight before emergence is exaggerated (Kader, 2002). Common, weight loss is frequently dependent on the comparative moisture contiguous the fruit, but can be able to attach with a slight diminution in flesh firmness (Antunes *et al*., 2007). Furthermore, weight loss is grand substance since it can cause fruit shriveling and progress senescence.

Decay percentage: It is clear from Tables 2 and 3 that most of the treated fruits did not present any decayed fruits till 20 days of cold storage. Thus, the percent of decayed fruits for the untreated fruits were 8.43 and 7.10% after 30 days of cold storage in both seasons, respectively. Furthermore, ethanol vapor at 20% in both seasons after 30 days of cold storage had the lowest decay percentage (6.50 and 6.03%) respectively with the untreated or other treated fruits. Also, decay percentage had a positive relationship with storage periods, meaning that it was gradually increased as storage period prolonged. Moreover, all the applied treatments reduced significantly the percent of decayed fruits than the untreated ones in the first season. While, there is no significant deference between the treatments used during the second season of this study.

As well, acetaldehyde at 2% reduced loss weight percentage offered about 7.30 and 6.40% decayed fruits than those fumigated by acetic acid at 4% presented 7.83 and 6.90% decayed fruits under 30 days of cold storage in both seasons, respectively. Adding ethanol vapors or dips externally description to inhibit the mature fruits by hindering biosynthesis of ethylene (Karabulut *et al.*, 2004). The principal targets of ethanol action are membranes, but it has many other effects on fungal cells, including nonspecific denaturation of proteins and induction of water stress.

Several workers have demonstrated the ability of acetaldehyde to inhibit the development of postharvest rots on various crops and it was found that, aldehydes inhibited mycelium growth and spore germination of *Rhizopus stolonifer* in vitro trials by significantly rates (El Sheikh *et al.*, 2000). Therefore, acetic acid is more potent as a fumigant because it exists as mixtures of undissociated monomers and dimmers (Sholberg, 2009). It can also be used to prevent postharvest decay caused by important plant pathogens such as *B. cinerea* and *P. expansum* but is prone to damaging stone fruits. Also, effectiveness of comparatively small amounts of acetic acid applied as a vapor is due to the initial exposure of all the fruit surfaces to a sufficiently high concentration to kill all surface-borne spores. There are several advantages to use acetic acid fumigation to control postharvest diseases, it is a natural compound found throughout the biosphere, posing little or no residual hazard at the low levels required to kill fungal spores, it is a generally-regarded-as-safe compound in the United States and therefore, does not require rigorous registration procedures, it is inexpensive compared to other fumigants, such as acetaldehyde and can be used in relatively low concentrations; and it can be used to treat produce in airtight storage rooms or containers without requiring handling of the produce.

Total loss in fruit percentage: The total loss in weight, which including both loss in fruit weight due to loss in water and decayed fruits, are presented in Tables 2 and 3. It is clear that the total loss in fruit % was gradually increased at cold storage as storage period prolonged. Moreover, all the applied treatments reduced the percent of total loss in fruit significantly than the untreated ones, nevertheless the percent were 12.13 and 10.20% after 30 days of cold storage for untreated fruits in both seasons, respectively.

The ethanol vapor at 20% reduced significantly the total loss in fruit percentage than the other treatments used after 30 days from cold storage. Yet, the percentages were about 8.16 and 7.93% after 30 days of cold storage, respectively during the two seasons. Since, this treatment reduced both loss in fruit weight and was more effective for reducing the percentage of decayed fruits.

In this respect, fumigation fruits by acetaldehyde at 2% was more effective in reducing the percent of total loss in Swelling peach fruits offered about 9.66 and 8.76 % compared with acetic acid at 4% presented about 7.83 and 6.90% under 30 days of cold storage in both seasons respectively.

Ritenour *et al.* (1997) delved that the ability of ethanol to promote or inhibit the ripening of climacteric fruit seems to be dependent on a number of factors, which probably include species, cultivar, maturity applied concentration, mode of application and duration of exposure. Depending on the maturity of the fruit and the amount of ethanol applied exposure to ethanol vapor (Wu *et al.*, 1992) suggested that ethanol not only reduces ethanol production but also noncompetitively ethylene action. The rumor advise that ethanol could reduce the ripen of extensive sort of climacteric fruits. Since acetaldehyde and not ethanol appears to be the active component in promoting or inhibiting ripening due to a reduction in activity of amino cyclopropanecarboxylate oxidase (ACC), the conversion of ethanol to acetaldehyde by the tissue may be the critical factor in determining whether a certain level of ethanol exposure promote or inhibits ripening. Some fruit tissues may have insufficient constitutive alcohol dehydrogenase activity to metabolize enough ethanol to produce a physiologically active level of acetaldehyde.

Likewise, Sholberg and Gaunce (1996) revisited the use of acetic acid vapor for control of brown rot and *Rhizopus* rot on peaches, nectarines, apricots and cherries.

The mode of action of an acid is related to the undissociated portion of the molecule and is more important than any change in pH brought about by the addition of acid. Therefore, acetic acid is more potent as a fumigant because it exists as mixtures of undissociated monomers and dimmers (Sholberg, 2009).

Fruit appearance: It is clear from Tables 4 and 5 that the appearance of fruit was gradually excellent to good from 0 till 20 days at cold storage. Likewise, the severity appearance of defects fruits was obtained by acetaldehyde fumigation at 2% (1.66) in the first season and the control (1.66) in the second season under cold storage of this study, which have severe defects effect on appearance quality.

Among the treatments, ethanol vapor at 20% kept the quality of fruit appearance significantly and recorded 4.33 and 4.66 (good effect on appearance), respectively as compare to the other treatments used and the control under cold storage at 30 days. While, fumigated with acetic acid at 4% have fair to slight effects on appearance quality during the storage period that recorded 2.33 and 2.66, respectively, during cold storage at 30 days.

The fruit quality concept based only on external appearance and sweetness is obsolete. The strength of sensory evaluation allows providing a complete fruit profile that is valid for product comparison, shelf-life monitoring and the prediction of consumer acceptance. This progress tolerate weighing only factors in requisites of control mostly sensitivity (Infante *et al.*, 2008).

Four different attributes may describe the characteristics that impart distinctive quality; color, appearance, flavor (taste and aroma), texture and nutritional value. Color and appearance attract the consumer to a product and can help in impulse purchases. At the point of purchase the consumer uses appearance factors to provide an indication of freshness and flavor quality. External appearance of a whole fruit is used as an indicator of ripeness, although, it can be a misleading one (Shewfelt, 2000).

Fruit flavor: From Tables 4 and 5 fruit flavor in Swelling peach was significantly reduced from harvest till 30 days under cold storage. The maximum fruit flavor was obtained by fumigated with acetic acid at 4% recording 4.66 and 5.0 (slight off-flavor to fair) during both seasons, conversely acetaldehyde at 2% had the lowest value of fruit flavor offering 1.33 and 1.66 (extreme off-flavor) compared with the other treatments used or the control during 30 days of cold storage. Amongst

Table 4: Effect of fumigation with some volatile substances on appearance, flavor and firmness in Swelling peach fruits under cold storage season 2011

	Fruit appearance (%)				Fruit flavor (%)				Firmness (Lb inch^{-2}) (%)			
	Storage period (day)				Storage period (day)				Storage period (day)			
Treatments	0	10	20	30	0	10	20	30	0	10	20	30
Control (untreated)	5.0	4.66	3.66	2.33	7.0	5.66	4.0	2.33	10.50	9.0	8.03	6.66
Acetic acid at 4%	5.0	5.0	3.66	2.33	7.0	6.66	6.33	4.66	10.50	9.20	8.26	7.20
Ethanol at 20%	5.0	5.0	4.66	4.33	7.0	6.0	5.66	3.0	10.50	9.73	8.56	7.53
Acetaldehyde at 2%	5.0	4.0	3.33	1.66	7.0	5.66	3.33	1.33	10.50	9.93	8.60	7.70
Mean	5.0	4.66	3.83	2.66	7.0	6.0	4.83	2.83	10.50	9.46	8.36	7.27
LSD at 5%												
Treatment	0.558				0.118				0.181			
Time	0.159				0.438				0.179			
Treatment×time	0.673				0.876				0.358			

Table 5: Effect of fumigation with some volatile substances on appearance, flavor and firmness in Swelling peach fruits under cold storage season 2012

	Fruit appearance				Fruit flavor				Firmness (Lb inch^{-2})			
	Storage period (day)				Storage period (day)				Storage period (day)			
Treatments	0	10	20	30	0	10	20	30	0	10	20	30
Control (untreated)	5.0	5.0	4.0	1.66	7.0	5.33	3.66	3.0	10.76	9.03	8.33	6.9
Acetic acid at 4%	5.0	4.66	4.0	2.66	7.0	7.0	6.33	5.0	10.76	9.40	8.86	7.53
Ethanol at 20%	5.0	5.0	4.66	4.66	7.0	6.0	5.33	4.0	10.76	9.76	9.43	7.66
Acetaldehyde at 2%	5.0	4.33	3.66	2.0	7.0	5.0	3.66	1.66	10.76	10.06	9.50	8.10
Mean	7.0	5.83	4.75	3.41	7.0	5.83	4.75	3.41	10.76	9.56	9.03	7.55
LSD at 0.05%												
Treatment	0.187				0.432				0.147			
Time	0.438				0.438				0.120			
Treatment×time	0.876				0.876				0.240			

the treatments, ethanol vapor at 20% kept the quality of fruit flavor significantly, which recorded 3.0 and 4.0 (moderate to slight off-flavor), respectively under 30 days of cold storage.

The proteins are mainly linked to processes such as response to stress, cellular homeostasis, cellular component organization and carbohydrate metabolism. The drastic changes in the texture of the fruit mesocarp in the melting varieties have been associated with a massive solubilization and depolymerization of pectin-derived polyuronides. These changes correlated with the concerted action of two proteins, endopolygalacturonase (EndoPG) and pectin methylesterase (PME) (Murayama *et al*., 2009).

Fruit firmness (Lb inch^{-2}): Fruit firmness is one of the most important physical parameter to monitor the ripening progress and senescence of most fruits. For this reason is used as maturity index to indicate time to harvest or when fruits are eating ripe. Data from Tables 4 and 5 show that fruit firmness in Swelling peach was significantly reduced from harvest till 30 days under cold storage. Seeing as, all treatments used significantly increased the values of fruit firmness than the control.

Whereas, significant fruit flesh firmness (7.70 and 8.10 Lb $inch^{-2}$) were recorded by acetaldehyde vapor at 2% as compared with all treatments used or the control at 30 days of cold storage during both seasons. These results mainly due to the effect of acetaldehyde vapor at 2% in inhibiting ethylene production at peach fruit tissue during storage, this is correlated to an inhibition of the ripening process and to the high peach firmness during storage. In this respect, Burdon *et al.* (1996) mentioned that postharvest application of acetaldehyde resulted in a delay in the ripening process.

Ethanol at 20% increased the values of flesh fruit firmness, which offered 7.53 and 7.66 Lb $inch^{-2}$, respectively, compared to acetic acid treatment or the control till 30 days under cold storage during both season.

Regarding the effect of acetic acid treatment at 4%, data in the same Tables 4 and 5 show a significant increase in the value of fruit firmness (7.20 and 7.53 Lb $inch^{-2}$) than the untreated ones (6.66 and 6.90 Lb $inch^{-2}$) during the two seasons of study under cold storage.

Fruit firmness is a complex process during which a large number of proteins interact in order to achieve the physiological condition that allows fruit to accomplish its final objective, seed dispersion (Giovannoni, 2001).

Peaches are climacteric fruit that display a decrease in mesocarp texture firmness. Additionally, the physiological changes that the fruit displays during its ripening, the accumulation of soluble solids and changes in color and aroma are very relevant for consumer acceptability. These attributes are severely affected in fruit that has been exposed to low temperatures for a prolonged amount of time (Lurie and Crisosto, 2005).

Soluble solids content (SSC): From Tables 6 and 7 the percent of SSC in fruit juice was gradually increased as a storage period advanced throughout cold storage. This may be due to the losses in water through the respiration and evaporation at cold storage. The data also disclose that, all treatments significantly increased values of SSC in fruit juice than the untreated fruits during the two seasons under the study. Conversely, acetaldehyde at 2% had the highest significant SSC values (11.80 and 11.86%) during 30 days of cold storage. In contrast, minimum significant SSC values was recorded in control (11.0%) followed ethanol vapor at 20 (11.23 and 11.13%) during the two seasons under the study, regulatory.

Also, acetic acid at 4% gave a somewhat increment compared to the untreated ones or the fumigated fruits with ethanol vapor at 20% since, it averaged 13.46 and 11.53% after 30 days of cold storage in both seasons under the study.

The increase in soluble solid content is expected due to moisture evaporation (weight loss) and thereby enhancement in SSC% during storage (Ozdemir and Dundar, 2006). Peach fruits are needed to be higher with SSC (sweet) consumer acceptability (Crisosto *et al.*, 2003). It is well known that sugars and simple acids are the respiration substrates. The longer time of fruit respiration the higher rates of sugars and acids consumption.

Titratable acidity (TA): A gradual decrease for titratable acidity was found in all treatments used from harvest till 30 days at cold storage. Data from Tables (6 and 7) show that, acetaldehyde at 2% retained higher significant percent of TA in the first season which presented 0.118% while, the increment was unpronounced in the second season.

The data also disclosed that, ethanol vapor at 20% gave somewhat increment in the percent of TA, which averaged 0.110 and 0.126% also, acetic acid at 4% offered 0.111 and 0.123 after 30 days of cold storage.

Table 6: Effect of fumigation with some volatile substances on soluble solids content (SSC) and titratable acidity (TA) in Swelling peach fruits under cold storage season 2011

	SSC (%) Storage period (day)				TA (%) Storage period (day)			
Treatment	0	10	20	30	0	10	20	30
Control (untreated)	9.33	9.93	10.10	11.00	0.146	0.132	0.117	0.102
Acetic acid at 4%	9.33	10.23	10.60	11.46	0.146	0.139	0.129	0.111
Ethanol at 20%	9.33	10.03	10.36	11.23	0.146	0.133	0.122	0.110
Acetaldehyde at 2%	9.33	10.33	10.86	11.80	0.146	0.141	0.132	0.118
Mean	9.33	10.13	10.48	11.37	0.146	0.136	0.125	0.110
LSD at 5%								
Treatment	0.148				0.002			
Time	0.111				0.001			
Treatment×time	0.22				0.003			

Table 7: Effect of fumigation with some volatile substances on soluble solids content (SSC) and titratable acidity (TA) in Swelling peach fruits under cold storage season 2012

	SSC (%) Storage period (day)				TA (%) Storage period (day)			
Treatment	0	10	20	30	0	10	20	30
Control (untreated)	9.83	10.0	10.43	11.0	0.153	0.138	0.130	0.119
Acetic acid at 4%	9.83	10.50	11.13	11.53	0.153	0.141	0.137	0.123
Ethanol at 20%	9.83	10.20	10.80	11.13	0.153	0.144	0.135	0.126
Acetaldehyde at 2%	9.83	10.76	11.40	11.86	0.153	0.145	0.137	0.124
Mean	9.83	10.36	10.94	11.38	0.153	0.142	0.135	0.123
LSD at 5%								
Treatment	0.136				0.002			
Time	0.153				0.002			
Treatment×time	0.306				0.005			

Commonly, minimum percent of TA was found in untreated fruits (0.102 and 0.119%) during the two seasons under the study, regulatory when compared with all treatments used. Such a decrease in acidity indicates the maturity of the fruits (Rapisarda *et al*., 2001).

It is matter of fact that fruit taste is mainly made up of sugars and acids combination. It recommended that TA declines in fruits importance of dissolution of acids to sugars through respiration. Voca *et al*. (2008) demonstrated the association between total soluble solids and total acidity as a very essential factor in shaping fruit quality, since it offered successively on the sugar/acids sense of balance in the fruits. When, table grapes with little early sugar concentrations were fumigation by acetaldehyde (0.2/0.9%) for 24 h, the total soluble solids were increased and acidity was decreased (Pesis and Frenkel, 1989).

Vitamin C content mg/100 g fresh weight: All the treatments showed a gradual decrease in ascorbic acid level during the entire storage period (Tables 8, 9). The data also confirm that most treatments used significantly reduced values of vitamin C than the control at cold storage through the two seasons. However, acetaldehyde at 2% maintained lower vitamin C content averred 56.80

Table 8: Effect of fumigation with some volatile substances on vitamin C and anthocyanin content in Swelling peach fruits under cold storage season 2011

	Vitamin C (mg/100 g FW)				Anthocyanin (mg/100 g FW)			
	Storage period (day)				Storage period (day)			
Treatment	0	10	20	30	0	10	20	30
Control (untreated)	64.86	62.50	59.86	58.93	12.33	12.86	12.96	13.66
Acetic acid at 4%	64.86	60.13	57.63	57.56	12.33	13.20	13.43	13.90
Ethanol at 20%	64.86	60.90	58.66	57.00	12.33	13.53	13.76	14.20
Acetaldehyde at 2%	64.86	58.93	57.86	56.80	12.33	13.00	13.23	13.80
Mean	64.86	60.61	58.50	57.57	12.33	13.15	13.25	13.89
LSD at 5%								
Treatment	0.688				0.156			
Time	0.820				0.078			
Treatment×time	1.641				0.156			

Table 9: Effect of fumigation with some volatile substances on vitamin C and anthocyanin content in Swelling peach fruits under cold storage season 2012

	Vitamin C (mg/100 g FW)				Anthocyanin (mg/100 g FW)			
	Storage period (day)				Storage period (day)			
Treatments	0	10	20	30	0	10	20	30
Control (untreated)	63.06	62.33	61.10	60.30	12.76	13.10	13.23	13.60
Acetic acid at 4%	63.06	61.93	59.23	58.56	12.76	13.43	13.56	13.90
Ethanol at 20%	63.06	60.96	59.63	58.20	12.76	13.50	13.66	14.00
Acetaldehyde at 2%	63.06	60.76	58.60	57.56	12.76	13.30	13.50	13.90
Mean	63.06	61.50	59.64	58.65	12.76	13.33	13.49	13.85
LSD at 5%								
Treatment	0.259				0.094			
Time	0.942				0.110			
Treatment×time	1.885				0.221			

and 57.56 mg/100 mL juice as compared with the other treatments used or the control during both seasons, correspondingly. Since, higher significant values of vitamin C were obtained from the untreated fruits (58.93 and 60 30 mg/100 mL juice) during both seasons. In this respect, the values of vitamin C between acetic acid at 4% (57.56 and 58.56 mg/100 mL juice) and ethanol vapor at 20% (57.0 and 58.20 mg/100 mL juice) were unpronounced at cold storage in both seasons, equally.

Peach is an excellent source for Vitamin A, Vitamin C and other vitamins and also contains high concentrations of phytochemicals such as carotenoids, flavonols and anthocyanins.

Ascorbic acid (Vitamin C), carotenoids and phenolic compound characterize the minor basis of antioxidants in peaches (Hajilou and Fakhimrezaei, 2011).

Ascorbic acid is very receptive to deprivation as a result of its corrosion in organization to other nutrients through storage (Akhtar *et al.*, 2010).

Total anthocyanin content mg/100 g fresh weight: It is clear from Tables 8 and 9 that the changes in total anthocyanin content in the skin of Swelling peach fruits gradually increased from harvest till 30 days at cold storage. Furthermore, the values of anthocyanin accumulation in the skin of the fruits attributed from all treatments were almost higher than those obtained from the untreated fruits under cold storage during the two seasons of this study. Moreover, ethanol vapor at 20% increased the content of anthocyanin (14.20 and 14.0 mg/100 g fresh weight) in the skin of peach fruits than the other treatments used or the control during both seasons.

Color and appearance attract the consumer to a product and can help in impulse purchases. At the point of purchase the consumer uses appearance factors to provide an indication of freshness and flavor quality. Exterior appearance of a whole fruit is used as an indicator of ripeness, though it can be a deceptive solitary (Shewfelt, 2000). Consumers have a preferred color for a specific item. Yet, the untreated one presented the lowest values of anthocyanin (13.66 and 13.60 mg/100 g fresh weight) in the skin of peach fruits than the other treatments used after 30 days of cold storage through the both seasons. However, acetaldehyde at 2% presented lower values of anthocyanin in the fruits skin, which existing 13.80 and 13.90 mg 100 g than the other treatments used after 30 days of cold storage. Acetic acid at 4% gave a somewhat increment, since it averaged 13.90 mg/100 g fresh weight after 30 days of cold storage as means of both seasons under the study.

Since, Ezz and El-Kobbia (2000) revealed that through the storage period of Early Grand peach there was a gradual increase in both carotenoid and anthocyanin levels. This may be due to yellowing and red coloration of peach fruit appeared to be caused by chlorophyll degradation rather than by changes in carotenoid and anthocyanin levels. Moreover, the color of peach fruits shifts from green to yellow in result of decline in chlorophyll and carotenoids start increasing.

Odor and flavor were enhanced in 'Jonagored' and 'Granny Smith' apples exposed to low concentrations of Aa (40 mg Aa per 100 g apples for 24 h). Higher concentrations of Aa (710 mg Aa per 100 g apples) resulted in skin browning and inhibition of ethylene production (Vidrih *et al.*, 1999).

CONCLUSIONS

The results of present study conclusively showed that ethanol vapor at 20% had significant effect on quality parameters of peach fruits CV. Swelling 30 days after cold storage. Fruits fumigated with ethanol vapor gave the best results for reducing total loss percentage in fruit weight, keeping the quality of fruit appearance significantly, flavor and anthocyanin accumulation in the skin of fruits during cold storage at 2°C for 30 days compared with the other treatments used or the control.

REFERENCES

AOAC., 2005. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemist, Washington DC, USA.

Abd Alla, M.A., H.Z. El-Sayed and S.E.M. Riad, 2008. Control of rhizopus rot disease of apricot fruits (*Prunus armeniaca* L.) by some plant volatiles aldehydes. Res. J. Agric. Biol. Sci., 4: 424-433.

Akhtar, A., N.A. Abbasi and A. Hussain, 2010. Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. Pak. J. Bot., 42: 181-188.

Antunes, D., G. Miguel and A. Neves, 2007. Sustainable postharvest handling of horticultural products. WSEAS Trans. Environ. Dev., 3: 111-116.

Barkai, G.R., 2001. Postharvest Disease of Fruit and Vegetables: Development and Control. Elsevier Science B.V., The Netherlands, Pages: 418.

Burdon, J., S. Dori, R. Marinansky and E. Pesis, 1996. Acetaldehyde inhibition of ethylene biosynthesis in mango fruit. Postharvest Biol. Technol., 8: 153-161.

Crisosto, C.H., G.M. Crisosto and P. Metheney, 2003. Consumer acceptance of Brooks and Bing cherries is mainly dependent on fruit SSC and visual skin color. Post. Biol. Technol., 28: 159-167.

El Sheikh Aly, M.M., M.A. Baraka and A.G.E.S. Abbass, 2000. The effectiveness of fumigants and biological protection of peach against fruit rots. Assiut J. Agric. Sci., 31: 19-31.

Ezz, T.M. and A.M. El-Kobbia, 2000. Response of early grande peach to chemical thinning, ethrel, gibberellic acid and urea: II. Storage of fruits. J. Agric. Sci. Mansoura Univ., 25: 5279-5295.

Forster, H., G.F. Driever, D.C. Thompson and J.E. Adaskaveg, 2007. Postharvest decay management for stone fruit crops in California using the reduced-risk fungicides fludioxonil and fenhexamid. Plant Dis., 91: 209-215.

Giovannoni, J., 2001. Molecular biology of fruit maturation and ripening. Ann. Rev. Plant Physiol. Plant Mol. Biol., 52: 725-749.

Hajilou, J. and S. Fakhimrezaei, 2011. Evaluation of fruit physicochemical properties in some peach cultivars. Res. Plant Biol., 1: 16-21.

Hsia, G.L., B.S. Luh and C.O. Chichester, 1965. Anthocyanin in free stone peaches. J. Food Sci., 30: 5-12.

Infante, R., C. Meneses and S. Predieri, 2008. Sensory quality performance of two nectarine flesh typologies exposed to distant market conditions. J. Food Qual., 31: 526-535.

Kader, A.A., 2002. Postharvest Technology of Horticultural Crops. 3rd Edn., ANR Publications, Oakland, CA., ISBN: 9781879906518, Pages: 535.

Karabulut, O.A., F.M. Gabler, M. Mansour and J.L. Smilanick, 2004. Postharvest ethanol and hot water treatments of table grapes to control gray mold. Postharvest Biol. Technol., 34: 169-177.

Lichter, A., Y. Zutkhy, L. Sonego, O. Dvir, T. Kaplunov, P. Sarig and R. Ben-Arie, 2002. Ethanol controls postharvest decay of table grapes. Postharvest Biol. Technol., 24: 301-308.

Lurie, S. and C.H. Crisosto, 2005. Chilling injury in peach and nectarine. Postharvest Biol. Technol., 37: 195-208.

Murayama, H., M. Arikawa, Y. Sasaki, V. Dal Cin, W. Mitsuhashi and T. Toyomasu, 2009. Effect of ethylene treatment on expression of polyuronide-modifying genes and solubilization of polyuronides during ripening in two peach cultivars having different softening characteristics. Postharvest Biol. Technol., 52: 196-201.

Ozdemir, A.E. and O. Dundar, 2006. The effects of fungicide and hot water treatments on the internal quality parameters of Valencia oranges. Asian J. Plant Sci., 5: 142-146.

Pesis, E. and C. Frenkel, 1989. Acetaldehyde vapors influence postharvest quality of table grapes. Hortic. Sci., 24: 315-317.

Pesis, E., 2005. The role of the anaerobic metabolites, acetaldehyde and ethanol, in fruit ripening, enhancement of fruit quality and fruit deterioration. Postharvest Biol. Technol., 37: 1-19.

Pinto, R., A. Lichter, A. Danshin and S. Sela, 2006. The effect of an ethanol dip of table grapes on populations of *Escherichia coli*. Postharvest Biol. Technol., 39: 308-313.

Purvis, A.C., 1997. The role of adaptive enzymes in carbohydrate oxidation by stressed and senescing plant tissues. HortScience, 32: 1165-1168.

Ranganna, S., 1979. Manual of Analysis of Fruit and Vegetable Products. 2nd Edn., Tata McGraw-Hill Publ. Co. Ltd., New Delhi, India, Pages: 634.

Rapisarda, P., S.E. Bellomo and S. Intelisano, 2001. Storage temperature effects on blood orange fruit quality. Agric. Food Chem., 49: 3230-3235.

Ritenour, M.A., M.E. Mangrich, J.C. Beaulieu, A. Rab and M.E. Saltveit, 1997. Ethanol effects on the ripening of climacteric fruit. Postharvest Biol. Technol., 12: 35-42.

Shaltout, A.D., 1995. Introduction and production of some low-medium chill peach and apple cultivars in the sub-tropical climate of Egypt. Assiut J. Agric. Sci., 26: 195-206.

Shewfelt, R.L., 2000. Consumer-friendly specifications to meet the demands of a global market. Food Aust., 52: 311-314.

Sholberg, P., 2009. Control of postharvest decay by fumigation with Acetic acid or plant volatile compounds. Fresh Produce, 3: 80-86.

Sholberg, P.L. and A.P. Gaunce, 1996. Fumigation of stone fruit with acetic acid to control postharvest decay. Crop Prot., 15: 681-686.

Sholberg, P.L., T. Shephard, P. Randall and L. Moyls, 2004. Use of measured concentrations of acetic acid vapour to control postharvest decay in d'Anjou pears. Postharvest Biol. Technol., 32: 89-98.

Vidrih, R., M. Zavrtanik and J. Hribar, 1999. The influence of added acetaldehyde and ethanol on changes of aroma compounds in apples. Acta Hortic., 485: 383-388.

Voca, S., N. Dobricevic, V. Dragovic-Uzelac, B. Duralija and J. Druzic *et al.*, 2008. Fruit quality of new early ripening strawberry cultivars in Croatia. Food Technol. Biotechnol., 46: 292-298.

Wu, M.J., L. Zacarias, M.E. Saltveit and M.S. Reid, 1992. Alcohols and carnation senescence. HortScience, 27: 136-138.