MAINTAINING QUALITY OF MIXED LOAD OF FRESH FRUITS AND VEGETABLES WITH VOLATILE COMPOUNDS OF JASMINE OIL

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Abstract

Egypt produces annually about 30 million tons of fruits and vegetables. High temperature is prevailing most of the year in Egypt's climate and this hastens maturity of fresh fruits and vegetables. Keeping fresh produce in lower temperature by cooling is very important to maintain quality of these products. For economic and practical reasons, fruits and vegetables are placed sometimes together in the same refrigerated trucks during transportation. Mixed loads should be subjected to an intermediate temperature to inhibit metabolic senescence of maturation and limit ethylene formation and its effects and to avoid chilling injury of susceptible products like summer squash. This study aimed to test the effect of jasmine oil vapors, containing methyl jasmonate among other volatiles, on preserving quality of mixed load of apricot and summer squash during cold storage as a simulation of the refrigerated transport. Apricots were brought from a farm located in Noubarya district, Behaira Governorate, Egypt, while summer squash was harvested from a farm in El Sharkia Governorate Egypt. Two concentrations of jasmine oil were applied (0.025% and 0.05%) as vapor, in separate treatments, over fruits in carton boxes comprising 2 kg of squash and 2 kg of apricot mixed together in the same carton. Jasmine oil was treated by an oxidizing agent according to the method mentioned by Ben – Yehoshua, (2008), (U.S patent No7645469- B2), and kept, 20 minutes in ambient temperature before transferring to cold storage at 5°C for 9 days. Samples were taken after 3, 6, 9 days of the cold storage immediate quality parameters evaluation whereas half of these samples were kept for additional 2days at 10°C as shelf life (supermarkets conditions), and their quality parameters tested afterwards. Results showed that summer squash and apricot placed together, were intact with acceptable quality for the first 6 days at 5°C, and the quality deterioration occurred after this period at 5°C and deterioration began also after transfer to 10°C. Weight loss averaged 3.5-4 % and about 5% for both jasmine oil treated apricot and squash, respectively, after 6 days at 5°C, while weight loss in control which showed more than 5% for apricot and less than 6% for squash. Firmness of treated apricots was acceptable (5.5-6lb/in^2) after 6 days at 5 °C and was about 6.5-7 lb/in^2 for treated squash under the same conditions but control fruits were softened. Jasmine oil vapors at 5°C caused very little changes in color for apricots at 5°C after 6 days, and squash color was not affected, while at 10°C squash color was more pale and dull. Total soluble solids T.S.S %of apricots increased normally to reach 13% after 6 days at 5°C, while T.S.S %for squash decreased slowly to attain 4.7 – 5% under the same conditions compared to 4.5% for the control. Summer squash had a good and acceptable appearance till 6 days with the rate of 7, compared to the control, but it declined afterwards, and also, when transferred to 10°C. Appearance of apricot was rated by the end of storage and found in good conditions, especially with the higher concentration of jasmine oil, compared to control which had the poor note of (4.5).Exposing squash fruits to high level of jasmine oil vapors at concentration of 0.05% delayed significantly the development of chilling injury (CI) symptoms for 6days of storage at 5°C comparing with the lower level 0.025% and control which displayed CI symptoms after 3 days of storage at 5°C.

INTRODUCTION

Egypt produces annually a huge quantity of fruits and vegetables about 10million tons of fruits and 19 million tons of vegetables (FAO 2014). Fruits and vegetables are living organisms which continue their respiration and transpiration after picking, generating heat, and giving off moisture and gases. In higher temperatures, like those prevailing in Egypt actually most of the year, these biological operations occur very intensely and actively inside the fresh products. Therefore, it is important to keep these products in lower temperature by cooling them through all the steps of marketing chain. Big trucks and refrigerated vehicle are used in fresh products transportation and usually mixed lots of fruits and vegetables are placed together for economic reasons in the carrier vehicle. Some factors should be taken in consideration to preserve the quality and sanitary status of these fresh products, during transport. Adopted temperature used in the mixed lots transportation shouldn't cause damage or chilling injury for fruits or vegetables, and in the meantime it should be low enough to decrease respiration rate and other metabolic processes of transported commodities, as transit life of commodity is inversely related to its rate of respiration (Pratt, 2013). Another important factor is minimizing effects of ethylene, which is a self-generated fruit ripening regulator, and is implicated in enhancing ripening and the quick passage to senescence stage. It can affect vegetables badly, after harvest, causing shriveling, pitting, and yellowing of tissues, as in lettuce, squash, and peas ....etc. Given that the synthesis of ethylene by plant organs is stimulated by higher temperatures. Fruits are influenced also by ethylene, as some fruits like banana and apple emit sensible quantities of ethylene in the maturity stage and that may affect other commodities, present in the same place. Therefore mixed lots of fruits and vegetables when transported together in refrigerated trucks, an intermediate storage temperature should be used to accommodate the entire kinds of commodities in the truck. In the second place, ethylene and its injurious effects should be avoided and hindered, in order to keep stored products intact without physiological or appearance defects, till they reach their destination (Brian and Gregor 1987).Some methods are used traditionally to oppose the ethylene impact, by absorbing this gas, like using the pads of potassium permanganate (Kader, 1994) but their efficacy is limited. Jasmine oil derivatives is a natural alternative to synthetic compounds, and it is used now in the purposes of enhancing plant growth and strengthening their resistance to pests, insects and microorganisms because of its contents of hormonal substances; methyl jasmonate (MJ), and jasmonic acid, which exert certain beneficial and biological effects on raising plant resistance to infections and prolonging juvenility and act as an anti-ethylene. Methyl jassmonate, the effective component of jasmine oil, is alleviating chilling injury by increasing the expression of a set of defenses genes and enhancing the antioxidant capacity in horticultural crops. Zaki and Zayat (2008) found that dipping carnation cut flowers in activated jasmine oil (0.03%) was effective in prolonging their life and delaying flower bud openingby inhibiting ethylene effect. (Gonzalez-Aguilar et al .,2001)found that treatment of mango fruits (Kent) with methyl jasmonate vapors for 20 hrs at 10^{-4}M, before being stored at 5 °C (14days), reduced chilling injury symptoms and enhanced skin color development.. In this experiment apricots and summer squash were chosen to simulate mixed lots, given that they appear in the same period of summer in Egyptian markets, for the purpose of examining the effects of jasmine oil vapors on both commodities, taking into consideration that apricot produces noticeable quantities of ethylene, and squash fruits are vulnerable to ethylene and are damaged by its presence and by low temperatures chilling injury, and that mixed load transport, of these products need to be safe without losses.

MATERIALS AND METHODS

Summer squash, used in this experiment (*Cucurbitapepo* L.c.v. Eskandrani), wasgrown under greenhouse conditions in a local farm on sandy soil (Elsharkia Governorate, Egypt). Apricot fruits of Canino variety were obtained from a farm at El Nubaria district Behaira Governorate Egypt, and from trees receiving ordinary agricultural practices during the two successive seasons of 2013 and 2014. Fruits were harvested at the commercial maturity stage and transferred to the laboratory of the Vegetable Handling Department, Horticulture Research Center. In the same day, uniform fruits, in size, appearance, with no physical defects or fungal infection, were selected and placed in carton boxes. Squash and apricot fruits were packed together in the same carton boxes, each box contained 2Kg from squash fruits and 2kg of apricot fruits. Two jasmine oil concentrations i.e. of (0.025% and 0.05%) were used by placing 10 ml of solution of each concentration in an individual small beaker, with an oxidizing agent, and the beaker was placed inside the carton just before storage. The volatile compounds emanating from jasmine oil were allowed to vaporize inside the cartons spontaneously, for 20 minutes at 27°C. The method of activation of jasmine oil to vaporize its volatiles was adopted from Ben –Yehoshua U.S patent No7645469-B2. The control (untreated fruits) of both Squash and Apricot were placed separately and subjected to the same storage periods and temperatures as treated fruits. Each treatment consisted of 10 cartons.

The cartons were transferred afterwards immediately to storage at 5 °C, in a cold room. Each carton was covered individually with a loose layer of polyvinylchloride (PVC) stretch film (of a texture of large holes) and 0.09 micron thickness (pre-pack, Italy) and considered as a replicate. Ten replicates from each treatment were stored at 5°C and 90 % RH for 9 days and each treatment was placed in a separate compartment. Samples were taken at random from the three replicates and examined every 3, 6, and 9 days at 5°C.In addition, another examination was done for each sample after 2 days at 10°C+90 % RH (supermarket simulation). Samples were evaluated for the changes in the quality parameters during storage as follows:

Weight loss: Squash and apricot fruits were weighed at zero time of the storage and at 3-day intervals during the storage period. Weight loss was determined as a percentage from the original weight.

General appearance: General appearance was evaluated by submitting samples to 5-member panel experienced in judging sensory analysis of vegetables and fruits. Samples were identified with random numbers and arranged on individual plates. Each sample was rated using score system as follows: 9= excellent, 7= good, 5= fair as described by Kader et al., (1973). This scale describes fresh appearance, change of color and decay. General appearance rating of 5 was considered as the limit for acceptability and salability.

Firmness: Firmness was measured by a pressure tester (lb\inch^2), the readings were taken from two spots on the fruit surface (EFEEG1) (Abbott, 1976).

Skin color measurement: Skin color was measured using a Minolta Chroma Meter, model CR-200. Calibration was done by a white plate before use. Color changes were quantified by calculating hue angle in tested samples after cold storage and by the end of the shelf life.

Total soluble solids percentage: they were measured by the digital refractometer, "Model Abbe Leica"

Treatable acidity percentage: it was measured in the juice by titration with 0.1 NaOH and calculated as citric acid according to AOAC (1990).

The severity of chilling injury (in squash): Thiswas judged subjectively based on the extent of surface pitting, water soaked areas, and decay. The degree of injury was expressed according to a numerical scale from **1** to ***5***,with **1** = no abnormality, **2** = trace, **3** = slight, **4** = moderate, and ***5*** = severe chilling injury. Squash with a degree of injury ▯ **3**were considered marketable (Wang, 1994).

Statistical analysis:

The obtained data were subjected to analysis of variance. The mean values were compared using LSD method at 5% level. The data were tabulated and statistically analyzed according to the complete randomized design(Snedecor and Cochran ,1989).

RESULTS AND DISCUSSION

First part: Effect of jasmine oil vapors on apricot fruits during cold storage and shelf life.

1- Weight loss:

As displayed in Table 1, fruit weight loss of treated apricots was of a minor importance after6 days in cold storage (5ºC), in the range of 3.5-4% for vapors treated apricots, and≤5% for control fruits in both seasons, and this loss was tolerable after 9 days for treated fruits (less than 5% in both seasons) while control fruits lost bigger weight (over 6% in both seasons). Jasmine oil exposure caused a slower rate of maturation during cold storage, and consequently transpiration was less pronounced than control fruits. Transferring fruits at 10°C has amplified this trend of weight loss in each stage.

Table 1. Effect of apricot fruits exposure to jasmine oil vapors on weight loss (%) of fruits during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	-	3.68	3.70	4.81	4.81	5.85	7.18
	0.050%	-	3.39	3.54	4.81	3.28	7.15	8.52
	Control	-	4.30	5.13	6.37	6.55	8.77	10.54
LSD at 5 % level		-	N.S	1.22	1.08	1.08	3.85	3.47
2nd season	0.025%	-	3.31	3.58	4.46	4.42	5.48	6.37
	0.050%	-	3.61	3.98	5.18	3.41	7.38	8.64
	Control	-	4.22	5.54	6.10	8.18	8.92	10.92
LSD at 5 % level		-	N.S	N.S	1.45	2.44	5.10	3.26

Apricot fruits exposed to jasmine oil vapor had an almost similar results and less significant loss in weight as compared with control, especially by the end of storage period (9 days at 5 °C +2 days at 10 °C).The results indicate that apricots are highly perishable and lost more than 5% of their weight after 6 days as well as additional 2days in higher temperature of 10 Indicating that keeping these fruits in the coldest possible temperature is very important. In support to this result, Zolfaghar in asab and Hadian (2007) found that pomegranates evaporated with methyl jasmonate lost less weight loss than untreated control, in a significant way.

2- **Fruit firmness as affected by jasmine oil vapors:**

It is clear from Table 2 that apricot fruits firmness was declined gradually during cold storage period. This decline was greater in control fruits than fruits exposed to jasmine vapor where fruit firmness starting from 7.56 (Ib/in^2), and control fruits registered 3.66(Ib/in^2) in both 1^{st} and 2^{nd} seasons while jasmine vapors treated fruits had an average of 4.40 (Ib/in^2) after 9days in cold storage in both seasons. This displays a positive effect for jasmine oil vapors in slowing fruit maturation and inhibiting activity of pectolytic enzymes of cell walls degradation at 5°C, and that transfer to the higher temperature of 10°C caused a noticeable decline in firmness for all treatments. This result was in compliance with the conclusion of a paper published by Nejhad et al, 2013, in an experiment using Putrescine to improve apricot storability, indicating that apricot firmness decreased significantly during cold storage at 4°C and that fruit softening during storage is the main factor limiting storage and shelf life of apricots.

3- **Fruit color evaluation:**

Data in Table 3 indicate that apricot fruit color as expressed by hue angle has been markedly developed towards more yellow color during 9 days in cold storage temperature (5°C), starting from yellow green (93.37 degrees) and reaching by the end of cold storage a less greenly and yellow color with little differences between treatments and control (values ranged between 84.75,and 85.83 degrees) in the first season .After 9 days at 5°C + 2 days at 10°C, fruits color had almost similar values of hue angle with a slightly higher value for the control. In the second season, apricot fruit color did not vary greatly from the value 92.62 yellow green to reach yellow (a range of 84.70 to 88.71 degrees) by the end of cold storage. After 9days + 2 days at 10 °C, fruits had a similar pronounced yellowish color(82.09-84.09degrees).This result indicated that Jasmine oil vapor had a small enhancing effect on apricot color in a significant way at the2^{nd} season. Elzayat et al (1997) concluded in an experiment on cold storage of packaged apricot in different plastic wraps that, after 3and 5 weeks on 0 °C, and transferring fruits to ambient conditions, fruit color has been changed slightly to an almost yellow color, which is in agreement with the afore-mentioned results.

Table 2. Effect of apricot fruits exposure to jasmine oil vapors on fruit firmness (Ib/in^2) during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)							
		At 5 °C					2 days later at 10°C		
		0	3	6	9		3+2	6+2	9+2
1st season	0.025%	7.56	6.30	5.33	4.33		3.83	3.43	2.50
	0.050%	7.56	7.93	5.80	4.40		4.16	3.93	3.63
	Control	7.56	6.36	4.43	3.66		3.26	3.16	2.93
LSD at 5 % level		-	1.32	1.25	N.S		N.S	N.S	0.98
2nd season	0.025%	8.1	6.50	5.40	4.00		4.50	3.90	2.66
	0.050%	8.1	7.10	5.96	4.86		4.50	3.43	3.16
	Control	8.1	6.40	3.80	3.66		3.63	2.93	3.16
LSD at 5 % level		-	N.S	0.70	0.74		0.62	0.50	0.49

Table 3. Effect of fruit exposure to jasmine oil vapor on apricots color (hue angle) during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	93.37	87.60	84.07	85.83	87.21	84.98	84.73
	0.050%	93.37	86.42	87.67	85.68	87.37	87.70	85.14
	Control	93.37	90.97	86.86	84.75	89.53	85.68	86.16
LSD at 5 % level		-	2.44	2.84	4.19	2.50	2.56	4.86
2nd season	0.025%	92.62	87.27	86.92	84.70	89.38	86.54	82.09
	0.050%	92.62	87.21	85.71	86.31	86.57	86.29	83.93
	Control	92.62	90.47	87.66	88.71	89.33	82.94	84.09
LSD at 5 % level		-	3.02	N.S	N.S	3.81	7.6	3.37

4- Total soluble solids (TSS %):

The normal trend of increase in TSS% in apricot fruits in cold storage at 5°C is clearly displayed in Table 4. Beginning from a start value (10.80%) in the first season, all treatments reached a range of 12.80%-13.50% after 9days at5C°. Meanwhile, in the second season, treatments had almost equal TSS% values (13.47-13.60) after 9 days at5°C.Exposure of apricot fruits to jasmine oil vapor didn't affect TSS% noticeably during 9 days storage at 5°C in both seasons. But once fruits were transferred to higher temperature 10°C for 2days, all TSS% values increased after 3 days at5°C +2days at 10°C. On the other hand transferring fruits after 6days and 9 days from 5°C, to higher temperature (10°C) caused a decline in TSS % values, especially for fruits stored 9 days at 5°C. These results are in concordance with the results of Giacolone and Chiabrondo (2010), which indicated that apricot total soluble solids percentage increased during 30 days of cold storage (0°C -1°C), but when apricot transferred to 20°C, their TSS values decreased sharply from 13.470% to 11.98%.

Table 4. Effect of apricot fruits exposure to jasmine oil vapor on fruits TSS (%) during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	10.80	12.17	12.90	12.80	13.28	12.47	11.97
	0.050%	10.80	12.13	12.67	13.40	12.63	12.43	11.99
	Control	10.80	12.13	12.67	13.50	13.17	12.83	11.93
LSD at 5 % level		-	N.S	N.S	0.34	N.S	N.S	N.S
2nd season	0.025%	11.00	12.07	12.97	13.60	13.10	12.80	11.81
	0.050%	11.00	12.37	12.80	13.47	13.14	12.47	11.99
	Control	11.00	12.37	12.80	13.47	13.10	12.43	11.63
LSD at 5 % level		-	0.22	N.S.	N.S	N.S	0.24	N.S

5- Treatable acidity percentage:

Acidity percentage of all treated and control apricots decreased gradually during cold storage and starting from 2.3% , and reached an average of 1.5% and 1.4% after 6 days at 5 °C for apricots exposed to jasmine vapors in the 1st and 2nd seasons ,respectively, against an average of 1.6% and 1.5% for control .Transferring fruits to higher temperatures of 10°C caused a slight decline in acidity without noticeable differences among treatments or between the 1st and 2nd season (an average of 1.3% after 9days at 5 °C +2days at10 °C for both seasons). These values (higher or equal to 1.3%) are reasonable because of the short period of the storage (the longest period is 11 days) and it seems that jasmine oil vapors has not affected the metabolism of organic acids in apricots. Consequently, the metabolism of the acids in apricots may be considered independent of ethylene.Valdes et al, (2009) has reached the same conclusion on their work related to apricots treated with 1-MCP and AVG as anti-ethylene compounds.

Table 5. Effect of apricot fruits exposure to jasmine oil vapor on fruits acidity (%) during 9 days of cold storage at 5 °C and an additional two days stay at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)							
		At 5 °C					2 days later at 10°C		
		0	3	6	9		3+2	6+2	9+2
1st season	0.025%	2.27	1.61	1.51	1.47		1.36	1.36	1.32
	0.050%	2.27	1.60	1.49	1.38		1.53	1.44	1.36
	Control	2.27	1.65	1.62	1.60		1.58	1.33	1.31
LSD at 5 % level		-	N.S	N.S	N.S		0.12	0.10	N.S
2nd season	0.025%	2.21	1.55	1.50	1.40		1.42	1.27	1.25
	0.050%	2.21	1.65	1.55	1.42		1.44	1.49	1.38
	Control	2.21	1.68	1.55	1.44		1.56	1.31	1.29
LSD at 5 % level		-	N.S	N.S	N.S		0.10	0.12	0.07

6- General appearance:

It is clear from table 6, that data taken at the end of the longest period of storage in this experiment (9 days at 5°C and an additional two days at 10°C) that apricot fruits treated with 0. 05% jasmine oil vapor had the best appearance values in both seasons followed by treatment of 0.025% (Table 6).Meantime, control apricots had a dull and unacceptable appearance, indicating the absence of freshness and hardly acceptable or unacceptable appearance for marketing. Vapors of jasmine oil had a certain beneficial impact on opposing senescence effects of ethylene and keep freshness of the product in agreement with Gross-Keneth (1998). Zolfagharinasab and Hadian (2007) had reported similar results on pomegranate, by applying methyl jasmonate to alleviate chilling injury on this fruit when stored at 2°C for 3 months.

Table 6. Effect of apricot fruits exposure to jasmine oil vapor on general appearance of fruits at the end of storage during 9 days of cold storage at 5°C and an additional two days at 10°C during 2013 and 2014 seasons.

Oil conc.	1st season	2nd season
0.025%	6.20	6.66
0.050%	8.00	7.66
Control	4.50	4.33
LSD at 5 % level	2.40	2.72

*9= excellent, 7= good, 5= fair, 3=poor

Second part: Effect of jasmine oil vapors on summer squash fruits during cold Storage and shelf life.

7-Weight loss percentage:

As shown in Table 7, there was a continuous increase in weight loss percentage of summer squash fruits (cv Escandrani) as the storage period was prolonged. This loss in weight is mainly associated with respiration and moisture evaporation. Exposing squash fruits to jasmine oil vapor at concentration of 0.05% was the most effective treatment in reducing squash weight loss after 9 days at 5 °C in both seasons. On the other hand, treated squash fruits with jasmine vapors did not lose much weight as control after6 days of shelf life at10 °C where those treated with jasmine oil vapor at concentration of 0.05% gave the best results in all stages of storage whereas the control fruits recorded the highest weight loss. The present results mentioned and present in this table, and as the base line of quality is 5% weight loss, it is better to keep squash no more than 6 days at 5°C in the case of applying jasmine oil vapors. In support to this result, Wang (1998) found that treated radish with methyl jasmonate by dipping for 3 minutes before being transferred to storage on 15°C was effective in reducing weight loss and shriveling and maintain better quality of radish after 7 days of storage at 0 °C or 15 °C.

8- Fruit firmness:

From Table 8 it is clear that after an initial decline in firmness in the first 3 days of cold storage, treated summer squash fruits with Jasmine oil vapor at concentration of 0.025% and 0.05% maintained better fruit firmness than control in all the stages of the cold storage at 5°C and even when transferred to 10 °C for additional two days. Squash firmness did not drop remarkably when squash transferred to10°C, because this temperature (10°C) does not encourage activity of degrading wall enzymes, but firmness values in the whole period of shelf life 10°Cwere nearly similar for both treatments. On the contrary control fruits had the lowest values without significant difference in the 1st season. These results indicate a certain effect of jasmine oil vapors in slowing softening.

Table 7. Effect of summer squash fruits exposure to jasmine oil vapor on weight loss % of fruits during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	-	5.14	5.52	7.25	8.98	9.23	12.18
	0.050%	-	4.62	5.23	5.71	8.56	8.88	9.98
	Control	-	5.74	6.24	7.99	9.81	10.12	12.27
LSD at 5 % level		-	N.S	N.S	1.07	N.S	N.S	N.S
2nd season	0.025%	-	4.74	5.48	8.68	8.59	8.87	12.84
	0.050%	-	4.66	5.36	6.26	8.71	9.66	10.84
	Control	-	5.77	5.96	8.09	9.50	9.83	14.22
LSD at 5 % level		-	0.60	N.S	0.82	N.S	N.S	2.62

Table 8. Effect of summer squash fruits exposure to jasmine oil vapor on fruit firmness (lb/in2) during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	9.13	7.43	6.56	6.33	6.50	6.30	6.00
	0.050%	9.13	7.45	6.86	6.52	6.80	6.33	6.12
	Control	9.13	6.90	5.46	5.23	5.70	5.50	5.20
LSD at 5 % level		N.S	N.S	0.61	N.S	N.S	N.S	N.S
2nd season	0.025%	9.54	6.63	6.43	6.16	6.60	5.83	5.96
	0.050%	9.54	7.93	6.70	6.33	7.03	6.30	6.26
	Control	9.54	6.26	5.83	5.75	5.99	5.13	5.00
LSD at 5 % level		N.S	1.41	N.S	N.S	N.S	0.47	0.68

9-Fruit brightness of squash:

Jasmine oil vapor effectively maintained squash fruit brightness for 9 days during cold storage period, as jasmine vapor exposed fruits displayed more shiny and bright appearance than control fruits, but without significant difference between their values (Table 9). These results were similar in both seasons. The same results were noticed after transferring squash fruits to shelf life at 10°C, for two days and the differences in freshness values were generally insignificant except when control fruits were transferred to10°C after 6 and 9 days in 5°C storage where they had a significant dull appearance. Ranjbar (2007) found that appearance of pomegranates, known for its susceptibility to chilling temperatures, was greatly enhanced by application of Methyl jasmonate in concentrations of 8, 16, and 24 micro liter/liter on these fruits before subjecting them to cold storage.

Table 9. Effect of summer squash fruits exposure to jasmine oil vapor on fruit brightness* during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	64.13	63.47	62.85	62.61	60.26	58.97	58.31
	0.050%	64.13	63.82	63.30	62.72	60.74	59.58	59.39
	Control	64.13	63.25	62.99	60.94	60.24	57.06	53.54
LSD at 5 % level		-	N.S	N.S	1.54	N.S	2.47	4.43
2nd season	0.025%	64.61	63.28	62.75	61.59	60.64	60.54	58.07
	0.050%	64.61	64.42	63.01	61.95	61.24	60.83	59.58
	Control	64.61	63.04	62.42	60.33	61.55	60.35	54.72
LSD at 5 % level		-	1.35	N.S	0.78	N.S	N.S	0.89

*The decrease in values indicate a change towards dullness of appearance

10 –Fruit color evaluation (hue angle):

There is a slow change in color towards a warm green color during 9 days at 5°C and after 2 days in 10 °C, as appeared in Table 10. All values of hue angle decreased very slowly for all treated and non-treatedsquash, (values moved in a narrow range, from 114.5degrees to about 110by the end of the experiment in 1st season and from 115 to 111 in 2nd season by the end of 9days at 5°C +2days at 10°C. Transfer to 10°C did not cause a noticeable change in color. It seemed that Jasmine oil vapors did not show a remarkable effect on the color development of squash. The results of this study are similar to those carried out by Junmatong *et.al* (2012) who dipped mango fruit in salicylic acid and in MJ of concentrations of 0.1 and 1 mM for 10 minutes and stored them at 5±1 °C for 42 days and noticed alleviated chilling injury without affecting skin color.

Table 10. Effect of summer squash fruits exposure to jasmine oil vapor on fruit color (hue angle) during 9 days of cold storage at 5°C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	114.59	112.90	112.36	111.01	111.93	111.54	110.37
	0.050%	114.59	112.92	112.39	111.46	112.12	111.78	110.48
	Control	114.59	112.89	112.01	110.70	111.72	111.29	110.21
LSD at 5 % level		N.S	N.S	N.S	0.68	N.S	N.S	N.S
2nd season	0.025%	115.01	113.52	112.42	111.59	112.56	110.85	110.21
	0.050%	115.01	113.46	112.83	112.42	112.77	111.94	110.83
	Control	115.01	113.28	112.33	111.21	112.07	110.62	110.07
LSD at 5 % level		N.S	N.S	0.69	N.S	N.S	1.14	N.S

11-Titratable acidity (TA) %:

As presented in Table11, squash fruits exposed to jasmine oil vapor at concentration of 0.05% and mixed loaded with apricot fruits recorded a sharp decrease in acidity values after 3 days at 5°C and 95% RH. But, during the remaining period at 5°C, the acidity decreased slightly to reach an average value of 0.25% in the 1st season and 0.26% in the 2nd season, with no significant differences between treatments. Transferring squash fruits to 10°C for two days caused a quick drop in acidity for all treatments in both seasons. It seemed that jasmine oil vapor had no clear effect on the acidity of squash fruits under these conditions. Wang *et al* (2009) found that Methyl jasmonate was effective in reducing decay of Chinese bayberries and raising its total phenols, but it had no effect on acidity.

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

As shown in Table 12, all T.S.S %values decreased slowly in the cold storage at 5°C, but exposing fruits to 0.05% jasmine oil vapor slowed the drop inT.S.S% or sweetness of squash fruit. This drop reached its maximum value after 9 days at 5°C and in all cases control fruits had the highest decrease. The same trend was observed when squash was transferred to high temperature (10°C), which caused a severe loss in T.S.S% after 9days cold storage at 5°C + 2 days at 10 5°C and especially in control fruits. It can be concluded that squash fruits should not stay more than 6 days at 5C° in order to keep T.S.S% in acceptable levels and maintain its taste. Wang (1994) reached similar conclusions after subjecting squash to a liquid MJ solution and storing at 5°C as it was reported a gradual and substantial decrease in content of fructose in MJ treated squash , from 25 mg /g at the beginning to nearly 15 mg/g of fruit after 6 days in that temperature.

Table 11. Effect of summer squash fruits exposure to jasmine oil vapor on fruit acidity during 9 days of cold storage at 5 °C and an additional two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	0.66	0.37	0.26	0.25	0.25	0.13	0.08
	0.050%	0.66	0.40	0.28	0.25	0.25	0.15	0.08
	Control	0.66	0.36	0.26	0.25	0.25	0.13	0.06
LSD at 5 % level		N.S	0.02	N.S	N.S	N.S	N.S	N.S
2nd season	0.025%	0.67	0.38	0.26	0.26	0.28	0.16	0.10
	0.050%	0.67	0.42	0.28	0.26	0.28	0.16	0.10
	Control	0.67	0.38	0.26	0.26	0.26	0.15	0.08
LSD at 5 % level		N.S	0.02	N.S	N.S	N.S	N.S	N.S

Table 12. Effect of summer squash fruits exposure to jasmine oil vapor on fruit TSS% during 9 days of cold storage at 5°C and an addition two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	5.20	5.10	4.90	4.40	5.00	4.97	3.53
	0.050%	5.20	5.13	5.00	4.50	5.03	5.00	3.63
	Control	5.20	5.00	4.60	4.10	5.00	4.06	3.30
LSD at 5 % level		-	N.S	0.30	0.02	N.S	0.07	0.25
2nd season	0.025%	5.13	4.83	4.70	4.33	5.00	4.53	3.46
	0.050%	5.13	4.90	4.83	4.33	5.10	5.10	3.46
	Control	5.13	4.80	4.20	4.00	4.80	4.00	3.20
LSD at 5 % level		-	N.S	0.59	N.S	0.20	0.58	0.57

13-Chilling injury (CI) development:

Chilling injury symptoms of squash fruits, subjected to jasmine oil vapors at concentration of 0.05% started to develop as pitting on the fruit surface after 9 days of storage at 5°C as compared with the other treatments. Furthermore, by the end of storage period.High level of jasmine oil (0.05%), caused traces of CI symptoms (2.16 and 2.00) compared with the lower level (0.025%) which showed slight CI symptoms (3.16 and 3.33), and control fruits which showed higher CI symptoms (3.66 and 3.58) in the first and second season, respectively. The severity of CI symptoms markedly increased in squash fruits after transferring to shelf life as shown in Table 13. By the end of storage period (9days at 5°C + 2 days shelf life at10°C) treated fruits recorded moderate CI symptoms as compared to control fruits which recorded sever symptoms (Table, 13). Our results are in complete agreement with the results of Wang (2006), who indicated that application of methyl jasmonate (MJ) to mangoes, papayas, peppers, tomatoes, and zucchini squashes enhanced the resistance of tissues to chilling injury by increasing the gene expression of heat shock proteins, pathogenesis-related proteins, and alternative oxidase, in addition to increasing antioxidant capacities, antioxidant enzyme activities, and free radical scavenging capacities in the tissues. Also, he mentioned that MJ can act to prevent chilling injury by a mechanism which involves protecting tissues from free radical injury.

Table 13. Effect of exposure summer squash fruits to jasmine oil vapor on chilling injury* during 9 days of cold storage at 5 °C and an addition two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	1.00	2.00	3.00	3.16	2.66	3.00	4.50
	0.050%	1.00	1.00	1.00	2.16	2.00	3.00	3.66
	Control	1.00	2.33	3.50	3.66	3.33	4.33	5.00
LSD at 5 % level		N.S	0.75	0.99	1.13	1.30	0.75	0.99
2nd season	0.025%	1.00	2.00	2.00	3.33	2.33	2.66	4.00
	0.050%	1.00	1.00	1.00	2.00	2.00	2.66	3.83
	Control	1.00	2.00	3.00	3.50	3.00	4.00	5.00
LSD at 5 % level		N.S	0.07	0.07	1.19	0.75	1.19	0.99

1** = no abnormality, **2** = trace, **3** = slight, **4** = moderate, and ***5 = severe chilling injury. Squash with a degree of injury ≤ **3**were considered marketable (Wang, 1994).

14-General appearance:

Data in Table14 revealed that all treatments showed that squash fruits had an excellent appearance after 3 days storage at 5°C. Afterwards, a decline in good appearance was detected in control fruits as compared to the treated ones which had an acceptable appearance by the end of storage period (9 days at 5°C). Our results in agreement with Wang and Buta (1999) who found that the use of exogenous application of methyl jasmonate at 0.1mM concentration as immersing treatment reduce losses of sugars and organic acids and maintain better quality of zucchini squash during storage. Transferring squash fruits to shelf life at10°C and 95% RH significantly accelerated the decline rate of squash fruits appearance, and recorded a hardly acceptable appearance after 3 days storage and poor appearance after 6 days storage at 5C° + 2 days shelf life at 10°C. On the other hand, control fruits were not totally acceptable as compared with treated fruits after 9 days storage at 5°C + 2 days shelf life. This result indicated a clear positive effect of jasmine vapors on preserving squash fruit appearance and preventing shape defects caused by low temperatures.

Table 14. Effect of exposure summer squash fruits to jasmine oil vapor on general appearance* during 9 days of cold storage at 5°C and an addition two days at 10°C during 2013 and 2014 seasons.

Season	Oil conc.	Storage period (days)						
		At 5 °C				2 days later at 10°C		
		0	3	6	9	3+2	6+2	9+2
1st season	0.025%	9.00	9.00	7.00	5.66	7.00	5.66	3.00
	0.050%	9.00	9.00	7.66	7.00	7.33	6.00	4.00
	Control	9.00	9.00	6.00	4.66	5.66	3.00	1.00
LSD at 5 % level		N.S	N.S	0.75	2.00	1.25	0.75	1.02
2nd season	0.025%	9.00	9.00	7.33	6.00	7.33	5.33	3.33
	0.050%	9.00	9.00	8.00	7.66	7.66	6.33	4.00
	Control	9.00	9.00	7.00	5.33	6.00	3.66	1.66
LSD at 5 % level		N.S	N.S	0.75	1.25	1.25	2.00	1.30

*9= excellent, 7= good, 5= fair, 3=poor, 1=unsealable

CONCLUSION

It can be concluded that, Jasmine oil vapors was effective in keeping good quality, and preserving appearance of both summer squash and apricot Fruit and preventing chilling injury of summer squash when squash and apricots were placed together for 6 days at 5°C. It is recommended to use this technique in transit storage (wholesale markets) or long distance transportation that does not exceed 6 days and to continue more experiments using more combinations of temperature and time and also with other commodities.

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الحفاظ على جودة الحمولات المختلطة من ثمار الخضر والفاكهة الطازجة باستخدام المركبات الطيارة لزيت الياسمين

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تنتج مصر سنويا حوالى ٣٠ مليون طن من الفاكهة والخضر . وتسود درجات الحرارة العالية معظم أوقات السنة في مصر حاليا ، وهو ما يسرع بنضج هذه المنتجات الطازجة .ويعتبر تخزين الخضر والفاكهة الطازجة في درجات حرارة منخفضة بالتبريد أمرا هاما للمحافظة على جودة هذه المنتجات وتوضع هذه المنتجات مع بعضها سويا في الشاحنات المبردة لاسباب أقتصادية خلال عملية النقل . وينبغى تعرض الحمولة المختلطة لدرجات حرارة منخفضة إلى حدا ما من أجل تثبيط عمليات النضج الحيوية وإعاقة تكوين غاز الأيثلثين وإيقاف تأثيرة مع تجنب وقوع أضرار البرودة للمنتجات الحساسة لذلك مثل الكوسة الصيفي. تهدف هذه الدارسة إلى أختبار تأثير أبخرة زيت الياسمين والمحتوية على مادة ميثيل جاسمونيت بين مواد طيارة اخرى على حفظ جودة حمولة مختلطة من المشمش والكوسة خلال التخزين المبرد في محاكاه للنقل المبرد . وأجريت هذه الدارسة عامى ٢٠١٣ ، ٢٠١٤ حيث تم إحضار المشمش من منطقة النوبارية والكوسة من مزرعة بمحافظة الشرقية . وتم استخدام أبخرة زيت الياسمين في تركزين منفصلين ٠.٠٢٥ % و٠.٠٠٥ % على الكوسة والمشمش في معاملات مستقلة حيث تم خلط ٢ كجم كوسة مع ٢ كجم مشمش في نفس الكرتونة . وتمت معاملة زيت الياسمين بعامل مؤكسد طبقا للطريقة المذكورة في براءة أختراع – بن يوشع ٢٠٠٨ (براءة أمريكية رقم 7645469 – B2) – (١٠ ملليتر في كأس صغير داخل نفس الكروتونة) للحث على خروج أبخرة الزيت وتركت كل الكراتين المعاملة لمدة ٢٠ دقيقة في الجو العادي قبل نقلها إلى غرفة مبردة على ٥ درجة مئوية لمدة ٩ أيام والتى تم خلالها أخذ عينات بعد ٣ أيام وبعد ٦ أيام وبعد ٩ أيام من أجل تقييم عوامل الجودة ، وقد خصص ثمار نصف كل عينة لكى تحفظ على درجة ١٠ مئوية (درجة الحفظ في السوبر ماركت) لمدة يومين ليتم تقييم عوامل الجودة بعد ذلك . وأظهرت النتائج أن الكوسة الصيفى والمشمش الموجودين سويا كانا في حالة سليمة وحالة جودة مقبولة لمدة ٦ أيام على ٥ درجة مئوية وأن بداية تدهور الجودة وقعت بعد مرور هذه الفترة على ٥ درجة مئوية كما بدأ تدهور الجودة بالنقل إلى ١٠ درجة مئوية وكان الفقد في الوزن حوالى ٣.٥–٤ % و ٥% لكلا من المشمش والكوسة المعرضين لابخرة زيت الياسمين على التوالى على عكس ثمار المقارنة حيث كان الفقد أكبر من ٥ % للمشمش وأكبر من ٦ % للكوسة

بعد هذه الفترة . كانت صلابة المشمش المعامل مقبولة (٥.٥ – ٦ رطل / بوصة ٢) بعد ٦ أيام على ٥ درجة مئوية وحوالى ٦ – ٧ رطل / بوصة ٢ للكوسة المعاملة في نفس الظروف ولكن ثمار المقارنة كان طرية . وتسببت ابخرة زيت الياسمين في تغيير طفيف جدا في لون المشمش على ٥ درجة مئوية لمدة ٦ أيام ولم يتأثر لون الكوسة بينما على ١٠ درجة مئوية فقد كان لون الكوسة باهتا وغير جذاب . زادت المواد الصلبة الذائبة الكلية للمشمش بشكل عادى لتصل إلى١٣ % بعد ٦ أيام على ٥ درجة مئوية بينما تناقصت المواد الصلبة الذائبة الكلية للكوسة بشكل بطئ ووصلت إلى ٤.٧ – ٥ % في نفس الظروف عكس ثمار المقارنة التى كانت ٤.٥ % . تميزت ثمار الكوسه بأنها ذات مظهر عام مقبول حتى فترة ٦ أيام (درجة تقييم ٧) عكس المقارنة ولكن المظهر تدهور بعد ذلك وعند النقل إلى ١٠ درجة مئوية . وعندما تم تقييم المظهر العام للمشمش في نهاية التخزين وجد أنه في حالة مقبوله وعلى الأخص مع التركيز العالى من زيت الياسمين بينما كان مظهر ثمار المقارنة ضعيفا (درجة تقييم ٤.٥) .كما ادى تعرض ثمار الكوسة الى التركيز العالى من زيت الياسمين٠.٠٠٥ % الى تأخير ظهور اعراض الاصابة باضرار البرودة لمدة ٦ ايام من التخزين على ٥ درجة مئوية مقارنة بالثمار المعرضة للتركيز المنخفض من زيت الياسمين ٠.٠٢٥ % او ثمار المقارنة (الكنترول) التى اظهرت اعراض الاصابه باضرار البرودة بعد ٣ ايام من التخزين.