Storage studies on clusters of Taify table grape

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Abstract: Grapevine is one of the most important fruit crop grown in the world. Furthermore, Taify grapes is considered one of the most important summer fruit in Taif location.Fumigation with sulfur dioxide used as an effective treatment to reduce decay during cold storage of grapes, but it result in sulfite residues on berries. Therefore, this investigation aimed to evaluate alternative methods like Ultraviolet (UV) irradiation, fumigation with acetic acid (AA) and ethanol (Etha.) to replace fumigation with sulfur dioxide for control postharvest decay and keeping quality of cluster of taify grapes during cold storage. Furthermore, results showed that total loss in cluster weight percentage was gradually increased by storage period advanced but on the other hand berry separation force, berry firmness and total anthocyanin decreased by storage period advanced. Moreover, berry separation force and berry firmness were significantly higher by using UV irradiation, AA and Etha. fumigation compared with control during storage period. Thus, data also revealed that some increment of soluble solids content and total acidity was showed as a storage period prolonged. It can be concluded that irradiation with UV for 10 min significantly reduced the total loss in cluster weight percentage than other treatments.
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1- Introduction

Grapevine (*Vitisvinifera, L.*) is one of the most important fruit crop grown in the world. In Saudi Arabia, the cultivated area of grapevine increased recently according to **(FAO 2011)** it reached about 14287 hectares producing 139327 Tons. Moreover, Taify grapes is considered one of the most important summer fruit in Taif Location. Table grape is one of the moderately susceptible fruits to decay and subject to serious water loss during postharvest handling, rachis browning, which occurs as a consequence of water loss **(Peacock and Smilanick,1998; Crisosto et al., 2001).** Gray mold (*Botrytis cinerea*) is the most postharvest diseases of table grapes especially for late season. Other postharvest diseases such as Cladosporium, Alternaria or Stemphylium can developed during storage but their importance is minor compared to Botrytis **(Peacock and Smilanick, 1998).** Sulfur dioxide (SO_2) is effective in retarding the activity of decay causing organisms in grape including *Botrytis cinerea* **(Smilanick et al., 1996).** However, SO_2 treatment may cause damage to the grapes and result in sulfite residues that are unacceptable to some consumers**,(Yahia et al.,1983 and Lichter et al., 2005).** Several other fumigants have been evaluate to control decay over years, but have not been adapted for commercial use **(Sholberg et al., 1998).** AA vapour in pure form has been shown to be very effective treatment for reducing postharvest decay **(Moyls et al.,1996; Sholberg et al.,2000).**Also, Etha.vapors reduce Botrytis rot incidence and berry shatter **(Chervin et al., 2003).** Furthermore, UV irradiation has been used to extend the shelf life of several fresh fruits and vegetables. UV-C is a more effective biocide for surface sterilization of plastics and some food products,compared to UV-A or UV-B.UV-C (200–280 nm) radiation can act directly on fungal and bacterial spores by cross-linking DNA, or by inducing in vivo production of plant secondary metabolites that effectively block or slow spore germination in plant tissues **(Bintsis et al., 2000; Sastry et al., 2000)**. UV-C radiation has been tested as a postharvest treatment to delay fungal growth and/or senescence (softening, color change) of tomatoes, citrus, peaches, sweet potato, carrots, cherries, apples, grapes, and strawberries **(Mercier et al., 2000; Baka etal., 1999; Bintsis et al., 2000; El Ghaouth et al., 2003; Stevens et al., 1996, 1997; Liu et al., 1993)** and has been tried for control of B. cinerea, Rhizopus, Alternaria, Colletotrichum, Penicillium, and Monilinia. Generally,

the effective dosage depends on the crop and type of fungus. In tomatoes, citrus, peaches, and sweet potato, 1–4 kJ/m2 UV-C radiation decreased the incidence of *Moniliniafructicola* (brown rot), *Rhizopusstolonifer* (soft rot), and *Penicilliumdigitatum* (green mold) by 20–50% **(Stevens et al., 1997).** Strawberries, which have a thin cuticle and no peel, had reduced gray mold incidence and increased shelf life (4–5 days) after treatment with a UV-C dosage of 0.25 kJ/m2 **(Baka et al., 1999)**. Dosages of 1 or 4.1 kJ/m2 caused deleterious effects, such as calyx browning, soft spots, and loss of anthocyanin and phenolic content **(Pan et al., 2004)**.Therefore, this research was undertaken to evaluate alternative methods like UV irradiation, fumigation with AA and Etha. to replace fumigation of sulfur dioxide for control postharvest decay and keeping quality of berry and cluster of Taify grapes during cold storage.

2- Materials and Methods

Plant materials and experimental procedure:

Harvest date was determined when soluble solids in berry juice reached about 16-18 % and when berries reached full colour on the 10th of September during season 2013. Clusters were harvested from vines received common horticultural practices, undamaged berries and free from any obvious pathogen infection. Clusters were harvested and transported to the laboratory of Biology Department, Taif University. At the beginning of the experiment, samples of 12 clusters were taken to determine the initial berry and cluster properties. Clusters were sorted to remove any infected and berry damaged, then each cluster was packed using ventilation bag. All bags with clusters were weighted and every four bags were put in ventilated box (50x30x12) cm. Total boxes were 21, each treatment consisted of three boxes received one of the following treatments as shown from Table (1).

1. Treatments:

AA Fumigation

2 ml of laboratory grade glacial AA (100%) and 3 ml of diluted AA (75%) were used for fumigation treatments.

1.1. Etha. Fumigation

6 ml of Etha.100% or 9 ml of Etha. 75% was put immediately in closed flask. AA and Etha. vapors were injected through plastic tube into the chamber using small generator. Fumigation was carried out for 30 min then the exhaust port flask was opened, the air-tight seal broken to allow outside air into the chamber and the fan was turned to blow out any remaining gas.

1.2. UV irradiation

After harvest clusters were irradiated using two germicidal low pressure mercury-vapor discharge lamps (General Electric, Fairfield, CT) emitting quasi-monochromatic UV radiation at 254 nm and the exposure times is 5 and 10 min as described by **El Ghaouth et al., 2003)**.

After the treatments, carton boxes were taken and stored under cold storage at 0 ^{o}C ± 1 and 90-95 % relative humidity (R.H) for 90 days. One carton box (containing 4 bags) for each treatment was taken at 30 days intervals for the following determinations:

1- Cluster weight loss %:

Cluster with bag was weighted and the percentage of weight loss for each cluster was calculated in relation to its initial weight. Cluster weight loss was calculated for each treatment according the following equation:

Table (1): The applied used treatments

No.	Treatments
1	Control
2	Fumigation with AA (75%)
3	Fumigation with AA (100%)
4	Fumigation with Etha. (75%)
5	Fumigation with Etha. (100%)
6	Irradiation with UV for 5 min.
7	Irradiation with UV for 10 min.

$$\text{Cluster weight loss \%} = \frac{\text{Initial weight} - \text{Sample weight}}{\text{Initial cluster weight}} \times 100$$

2- Berry decay %:

It was determined by weighting the decayed berries with *Botrytis cinerea* or *Penicillium* sp. for each sample during storage and then estimated by using the initial weight of clusters.

$$\text{Berry decay \%} = \frac{\text{Weight of decayed berries}}{\text{Initial cluster weight}} \times 100$$

3- Berry shatter %:

It was determined by weighting the berries per cluster which loss from cap stem after moderate shaking and then percent of berry shatter was estimated.

$$\text{Berry shatter \%} = \frac{\text{Weight of berry shatter}}{\text{Initial cluster weight}} \times 100$$

4- Total loss in cluster weight %

It was calculated by adding the percentage of loss in cluster weight, berry shatter and decayed berries.

5- Berry separation force

It was determined by measuring the separation force from samples of 10 berries for each cluster (replicate) for each treatment and the average was estimated (gm_f).

6- Berry firmness

It was measured on 10 berries for each replicate were taken randomly for each treatment to determine berry firmness and the average was estimated as Newton Berry separation force and firmness were determined by using PHSH-Pull (Dynamometer Model DT 101) with 3/16 inch plunger).

7- Soluble solids content (SSC)%

Soluble solids content in berry juice will be measured as brix by using a hand refractometer according to **(Chen and Mellenthin, 1981).**

8- Titratable acidity

Ten ml of berry juice was titrated with 0.1 N sodium hydroxide solution using phenolephthalinas indicator. Total acidity was expressed as gm tartaric acid/100 ml juice according to **(A.O.A.C., 1980).**

9- Soluble solids/acid ratio

This ratio was calculated from the results recorded for juice SSC and titratable acidity.

10- Total anthocyanin content

Half gram of fresh skin berries was ground with 10 ml. of acidified alcohol solution, centrifuged for 3 minutes and then filtered. The extract was measured at 535 nm using Spectrophotometer according to **(Hsia et al., 1965)**.

Statistical analysis of data:

The data were statistically analysed as a factorial experiment in a completely randomized design with four replicates by analysis of variance (ANOVA) using the statistical package software SAS (SAS Institute Inc., 2000,Cary, NC., USA).

3- Results and Discussion

This study was undertaken to evaluate alternative methods such as UV irradiation, fumigation with (AA) and (Etha.) to replace fumigation of sulfur dioxide for control postharvest decay and keeping quality of berry and clusters of taify grape during cold storage.

Cluster Loss in Weight %:

It is clear from Table (2) that using fumigation with AA, Etha. and UV irradiation reduced cluster loss in weight percentage significantly than the control at the end of storage period. In this respect, the data presented that UV irradiation (10 min) gave a lower loss in weight %(5.28%) compared with other fumigations. This results is agreement with **(Promyou and Supapvanich,2012)** which found that UV-C illumination effectively reduced losses in fresh weight of yellow pepper fruit during storage. Similar results had also reported in tomato fruit **(Barka et al.,2000; Liu et al.,2009; Obande et al.,2011)** and strawberry fruit**(Erkan et al.,2008)**. **Andrade et al.(2011)** had also reported that UV-C treatment inhibited the increase in weight loss of red pepper fruit during storage.

Berry Shatter %:

It is obvious from table (2) that berry shatter % was lower than loss in cluster weight % for all treatments. However, Berry shatter % was gradually increased by storage period advanced.Thus, clusters fumigation with AA,Etha. and UV irradiation significantly reduced berry shatter % than the control at the end of storage period. In this respect, the data presented that UV irradiation significantly reduced berry shatter % (1.83-2.26%) after 90 days of cold storage compared with other fumigations. Similarly, **Sholberg et al.(1998)** mentioned that AA fumigation reduced berry shatter % significantly than the control. Since, the percent of berry shatter due to this treatment ranged about 3-5% for this treatment but about 18.7% for the control.

Table (2): Effect of fumigation with (AA), (Etha.) and irradiation with (UV) on Cluster loss in weight and Berry shatter percentage ofTaify grape during cold storage

Treatments	loss in weight % Storage Period (days)				Berry shatter % Storage Period (days)			
	0	30	60	90	0	30	60	90
Control	0p	2.75l	4.25i	8.08a	0p	1.81i	3.34e	9.14a
AA 75%	0p	2.92k	4.29hi	6.34b	0p	0.5m	1.84hi	4.68c
AA 100%	0p	2.45n	4.37gh	5.83d	0p	0.73l	2.79f	3.87d
Etha. 75%	0p	2.58m	3.83j	6.17c	0p	0.19o	1.9h	5.43b
Etha. 100%	0p	2.56m	4.46g	5.82d	0p	0.37n	1.42j	5.43b
UV 5 min	0p	2.62m	4.73g	5.86d	0p	0.13o	0.55m	2.26f
UV 10 min	0p	2.25o	4.79f	5.28e	0p	0.5m	1.27k	1.83hi

Means within and between columns followed by the same letter are not significantly different at level p = 0.05 means

Berry Decay%:

Data revealed from table (3) that fumigation with AA, Etha. and UV irradiation reduced the percent of decayed berries significantly than the control during storage period. Furthermore, UV irradiation reduced berry decayed % (1.29-1.64 %) significantly than fumigation with AA (2.96-2.99%) and Etha. (5.01-5.65%) at the end of storage period. In tomatoes, citrus, peaches and sweet potato treated with 1-4kj/cm^2 UV irradiation decreased the incidence of brown, soft rot and green mold by 20-50% **(Stevens et al.,1997).** Strawberries, which have a thin cuticle and no peel had reduced gray mold incidence and increased shelf life 4-5 days after treatment with UV-C dosage of 0.25 kj/m^2**(Baka et al.,1999).**Moreover, **Erkan et al.(2008)** found that strawberry fruit illuminated with UV-C at different illumination duration and dosages 1,5 and 10 min. and 0.43,2.15 and 4.30 kj/m^2, respectively significantly reduced the severity of decay during storage at 10 ^{0}C.

Total loss in weight %:

It is clear that total loss in cluster weight were mainly due to loss in weight %, berry shatter % and berry decay %. In this respect data showed from table (3) that the total loss in cluster weight percentage was gradually increased by storage period advanced. Similarly, **Babalar et al.(1998)** presented that the amount of decay, weight loss and shattering of seedless grape were increased by storage harvest till 135 days.Data also cleared that using UV irradiation, fumigation with AA and Etha. reduced the total loss in cluster weight percentage significantly than the control. Moreover, UV irradiation for 10 min. reduced the percent of total loss in cluster weight significantly than AA and Etha. fumigation after 90 days of storage period. **Crisosto et al.(2001)** reported that table grapes subjected to serious water losses during postharvest handling.Rachis browning which occurs as a consequence of water loss reduced table grape postharvest quality.

Table (3): Effect of fumigation with (AA), (Etha.) and irradiation with (UV) on Berry decay and Total loss percentage of Taify grape during cold storage

Treatments	Berry decay % Storage Period (days)				Total loss % Storage Period (days)			
	0	30	60	90	0	30	60	90
Control	0q	0.83l	3.30d	9.54a	0q	5.38l	10.9f	26.7a
AA 75%	0q	1.30j	2.48f	2.96e	0q	4.73m	8.61h	14.0d
AA 100%	0q	0.18p	1.38i	2.99e	0q	3.35n	8.79h	12.7e
Etha. 75%	0q	0.2p	1.92g	5.01c	0q	2.98p	7.64i	16.6c
Etha. 100%	0q	0.3o	1.88g	5.65b	0q	3.23no	7.76i	16.9b
UV 5 min	0q	0.39n	0.64m	1.29j	0q	3.14op	5.92k	9.41g
UV 10 min	0q	0.42n	1.19k	1.64h	0q	3.15nop	7.22j	8.79h

Means within and between columns followed by the same letter are not significantly different at level p = 0.05 means

Berry separation force:

It is clear from table (4) that berry separation force was gradually reduced by storage period advanced till 90 days. Data also reveled that berry separation force gave a significantly higher value by using UV irradiation, AA and Etha. fumigation than the control.The effect of these treatments on berry separation force were unpronounced. Likewise, **Ahmed and El-Rayes (2001)** found that berry separation force on Red Globe grapes decreased gradually as storage period increased.

Berry firmness:

Data from table (4) presented that berry firmness was gradually reduced by storage period advanced. UV irritation produced a higher significantly value of berry firmness than fumigation with AA and Ethanol. This result is harmony with **(Promyou and Supapvanich, 2012)** who found that yellow pepper fruit illuminated with UV-C dose of 6.6 kJ/m^2 inhibited the loss of firmness. Similar results have been also reported in tomato fruit **(Barka et al.,2000; Liu et al.,2009; Obande et al.,2011),** red pepper fruit **(Vincente et al.,2005)**, Kiwifruit **(Erkan et al.,2008)**. The higher values of firmness detected with the effect of UV-C on the reduction of cell wall degrading enzymes activity **(Barka et al.,2000; Steven et al.,2004)**.

Table (4): Effect of fumigation with (AA), (Etha.) and irradiation with (UV) on Berry separation force and Berry firmness of Taify grape during cold storage

Treatments	Berry separation force (gm_f) Storage Period (days)				Berry firmness (N) Storage Period (days)			
	0	30	60	90	0	30	60	90
Control	825a	754c	663ef	543j	815a	742d	678g	585l
AA 75%	825a	749c	670de	562gh	815a	751cd	694f	610k
AA 100%	825a	753c	665ef	552i	815a	754c	668h	615jk
Etha. 75%	825a	750c	661f	553i	815a	752c	667h	620j
Etha. 100%	825a	752c	664ef	569g	815a	745cd	672gh	609k
UV 5 min	825a	764b	673d	557hi	815a	786b	707e	641i
UV 10 min	825a	763b	676d	565g	815a	790b	688f	646i

Means within and between columns followed by the same letter are not significantly different at level p = 0.05 means

Soluble solids content (SSC) %:

Data from table (5) disclosed that soluble solids content (SSC) in berry juice tended to fluctuate with various treatments during cold storage. Yet, a somewhat increment of soluble solids content in berry juice was showed as a storage period prolonged.This result is agreement with **(Zhoulin et al.1998)** who mentioned that SSC value was higher in juice of Red Globe and Christmas Rose grapes during cold storage than at harvest time. Thus the effect of UV irradiation, fumigation with AA and Etha.on soluble solids content in berry juice was unpronounced. Since, these treatments generally gave a somewhat reduction and lower values of SSC in berry juice than the control. In this respect, **Sholberg et al.(1998)** reported that AA fumigation had no clear effect on Brix of table grape. Moreover, fumigation with Etha. had no effect on SSC of sweet cherries **(Chu et al.,2001)**.Also, UV irradiation had no effect on SSC of blueberry juice during storage **(Perkins-veazie et al.,2008)**.

Titratable Acidity %:

It is obvious from table data in Table (5) that total Acidity in berry juice tended to fluctuate, but a some increment was found as a storage period prolonged till 90 days of cold storage. Thus, all treatments produced a lower acidity in berry juice compared with the control after 90 days of cold storage. Moreover, **Babalar et al.(1998)** found that total acidity in berry juice was decreased as storage period advanced till 135 days of storage. Furthermore, **Ahmed and El-Rayes (2001)** found that total acidity decreased as a storage period advanced. Yet, the changes in total acidity was insignificant. Similar results were found by **(Chu et al., 2001)** for Etha. fumiagation.UV-C treatment had no effect on Titratable acidity during storage **(Perkins-veazie et al.,2008)**.

Table (5): Effect of fumigation with (AA), (Etha.) and irradiation with (UV) on SSC and Acidity of Taify grape during cold storage

Treatments	SSC (brix %) Storage Period (days)				Acidity % Storage Period (days)			
	0	30	60	90	0	30	60	90
Control	16.5k	17jk	17.2ij	18.8a	0.55ij	0.57h-j	0.59d-j	0.67a
AA 75%	16.5k	17.2ij	17.5g-j	18.6ab	0.55ij	0.59d-j	0.62a-f	0.62a-g
AA 100%	16.5k	17.7e-i	18.2a-f	18.8a-d	0.55ij	0.6c-i	0.59d-j	0.63a-d
Etha. 75%	16.5k	17.6f-i	18.1c-h	18.3a-e	0.55ij	0.58e-i	0.63a-e	0.65abc
Etha. 100%	16.5k	17.9d-h	18.1b-g	18.7abc	0.55ij	0.56ij	0.61b-h	0.65ab
UV 5 min	16.5k	17.5h-j	18.0d-h	18.5a-d	0.55ij	0.58f-j	0.58e-j	0.66ab
UV 10 min	16.5k	17.2ij	18.3a-e	18.7abc	0.55ij	0.55j	0.57g-j	0.66a

Means within and between columns followed by the same letter are not significantly different at level p = 0.05 means

Soluble Solid content / acid ratio:

Data from table (6) presented that SSC/ acid ratio in berry juice under various treatments tended to fluctuate during cold storage. Many studies found that very slight change on SSC and TA in berry juice during storage period **(Ahmed and El-Rayes,2001; Artes- Hernandez et al.,2006; Pretel et al.,2006)**. In contrast, a progressive increase in level of soluble

solids content was reported for Autumn seedless **(Artes- Hernandez et al.,2004)** and Autumn Royal grapes **(Valero et al., 2006)** packaged in bags with and without an So_2 pad during cold storage **(Lichter et al., 2005; Pretel et al., 2006)**.

Total Anthocyanin content:

It is cleared from Table (6) that total anthocyanin content in berry skin of Taify grapes was gradually reduced as storage period advanced from harvest till 90 days of cold storage.Furthermore, Etha. and AA fumigation produced a higher values of anthocyanin in berry skin than those obtained from UV irradiation and control during storage period.In this respect, **El-kereamy et al.(2002)** mentioned that spraying Carbernet Sauvignon grape with 5% ethanol at veraison resulted in some altered regulation of the transcription of anthocyanin biosynthesis genes compared to the control. Furthermore, postharvest ethanol vapor treatment have been shown to increase accumulation of anthocyanins in strawberries **(Ayala-Zavala et al., 2005)**, raspberries **(Chanjirakul et al.,2006),** and Chinese bayberries **(Zhang et al.,2007**) during short term storage. In agreement with our results **(Sanchez- Ballesta et al.,2007**) observed a sharp increase in total anthocyanin content in cardinal grapes after 3 days at 0^0C and then decreased by the end of 33 days of storage **(Romero et al.,2008).**

Conclusion:

It can be concluded that UV irradiation for 10 min significantly reduced the total loss in cluster weight percentage than other treatments during cold storage period but it had no effect on fruit quality. The application of UV irradiation above 10 min are subject for further investigation.

Table (6): Effect of fumigation with (AA), (Etha.) and irradiation with (UV) on SSC/ Acidity ratio and Total Anthocyanin of Taify grape during cold storage

Treatments	SSC/ Acidity ratio Storage Period (days)				Total Anthocyanin mg/100g(f.w.) Storage Period (days)			
	0	30	60	90	0	30	60	90
Control	30a-d	29.8a-d	29.3cd	28.3cd	75.5a	72.7b	67.8cd	62.9gh
AA 75%	30a-d	29.0cd	28.3d	30a-d	75.5a	72.8b	67.1cde	62.4gh
AA 100%	30a-d	29.7b-d	30.8a-c	29.8 a-d	75.5a	71.9b	65.5ef	62.9gh
Etha. 75%	30a-d	30.5a-d	29.0cd	28.5cd	75.5a	73.9ab	66.2def	64.2fg
Etha. 100%	30a-d	32.2a	29.9 a-d	29cd	75.5a	73.1b	69.0c	64.3fg
UV 5 min	30a-d	30.4a-d	30.1a-d	28.4cd	75.5a	73.1b	65.3ef	61.3h
UV 10 min	30a-d	31.8ab	32.0ab	28.4cd	75.5a	73.1b	65.3fg	61.3h

Means within and between columns followed by the same letter are not significantly different at level p = 0.05 means

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