Vitis **52** (2), 61–67 (2013)

Effect of pre-harvest calcium chloride and ethanol spray on quality of 'El-Bayadi' table grapes during storage

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Summary

Grapes (*Vitis vinifera* L.) are highly perishable due to postharvest fungal decay and softening. The effects of pre-harvest calcium chloride (CC) (at 1 or 2 %) and ethanol (at 10 or 20 %) spray at 30 and 7 days before harvest on quality of 'El-Bayadi' table grapes during cold storage at 0 °C ± 1 plus 1 day of shelf life at 20 °C were evaluated. Pre-harvest spray of CC and ethanol at both low and high concentrations significantly decreased berry decay percentage during storage compared to control. The combination between CC and ethanol also decreased decay compared to control but was less effective than each one alone. In this respect, there were no significant differences between low and high concentration of CC and ethanol. In all treatments, decay was recorded after 30 days of storage and significantly increased to reach 26.3 % after 50 days. CC spray alone, at both concentrations, increased weight loss percentage compared to control and most other treatments. However ethanol spray especially at 20 % decreased weight loss compared to other treatments except for 10 % ethanol spray. The combination between CC and ethanol, however, increased weight loss compared to control except for, 1 % CC plus 20 % ethanol and 2 % CC plus 10 % ethanol. Weight loss percentage increased during storage to reach 2.30 % after 50 days of storage. However, the overall quality characteristics of berries as firmness, TSS, acidity, TSS/acid ratio, pH, vitamin C, total phenols and soluble tannins were not negatively affected by both CC and ethanol spray treatments. Also, both CC and ethanol spray caused neither foliar damage on the vines nor significant changes in berry quality. It is concluded that pre-harvest spray of 1 % CC or 20 % ethanol could be suggested as practical alternatives to synthetic fungicides and SO_2 to decrease postharvest decay and improve quality of 'El-Bayadi' table grapes.

K e y w o r d s : Grapes, quality, storage, decay, ethanol, calcium.

Introduction

Grapes (*Vitis vinifera* L.) are grown worldwide being the world's second most grown fruit crop due to their great nutritional and economical value. In Saudi Arabia, the cultivated area has greatly increased during the last decades and mainly concentrated in Medinah, Tabouk and Taif regions. In Taif region, 'El-Bayadi' is the main table grape cultivar producing about 90 % of total table grapes production in this region. This cultivar is mid season and highly productive, and characterized by white color and large size of berries with excellent sensory quality. However, the berries have thin skin and are highly sensitive to fungal and cracking decay which limit storability and marketing. Generally, the major decay organisms of table grapes during cold storage are the fungi *Botrytis cinerea* Pers.:Fr., *Aspergillus niger* Tiegh., *Rhizopus stolonifer* (Ehrenb.:Fr.) Vuill. and *Penicillium* (Bulit and Dubos 1988, Zahavi *et al.* 2000 and Droby and Lichter 2004). The use of synthetic fungicides pre- or postharvest as well as postharvest sulfur dioxide (SO_2) fumigation (Luvisi *et al.* 1992, Droby and Lichter 2004) are restricted due to concerns for the environment and human health (Taylor 1993, Zahavi *et al.* 2000). Thus, alternative treatments that can reduce decay and maintain grapes quality without negative impact on both consumers and the environment are critically required. Several inorganic salts possess antimicrobial activity against several phytopathogenic fungi. Pre- and postharvest treatments with calcium chloride (CC), potassium carbonate, sodium bicarbonate and sodium carbonate have been proposed as safe and effective alternatives to control postharvest decay of some grape cultivars (Nigro *et al.* 2006, Chervin *et al.* 2009). Generally, low fruit calcium levels have been associated with reduced postharvest life and increased physiological disorders and softening (Wills *et al.* 1998). Nigro *et al.* (2006) assessed the activity of 19 inorganic and organic salts to control postharvest decay of table grapes *in vitro* and *in vivo*. However, only CC, potassium carbonate, sodium bicarbonate and sodium carbonate decreased the incidence of grey mould on table grape bunches ('Italia'). Changwen and Shouru (1990) reported that preharvest spray of 1.5 % calcium nitrate at 10 d before harvest reduced decay, enhanced turgor pressure of berries and decreased berry shatter of 'Taifi rose' and 'Long yan' table grape cultivars stored for 123 or 133 days at 3-5 °C in polythene bags. Also, several studies have shown that pre- or postharvest application of ethanol alone or in combination with inorganic salts such as CC and sodium bicarbonate can retard postharvest decay in grapes (Karabulut *et al.* 2003, Lurie *et al.* 2006 and Chervin *et al.* 2009) and also in other fruits e.g. citrus and stone fruit (Yuen *et al.* 1995,

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Margosan *et al.* 1997). Karabulut *et al.* (2003) reported that the yeast *Metschnikowia fructicola*, ethanol, and sodium bicarbonate, alone or in combinations, applied on organically grown 'Thompson Seedless' grape vines 24 h before harvest decreased the incidence of postharvest decay. Chervin *et al.* (2009) found that preharvest applications of a 16 % ethanol solution, containing 1 % calcium chloride, reduced gray mold development in 'Chasselas' table grapes cultivar. Decay in bunches decreased from 15 % in control to 5 % in grapes treated with ethanol plus calcium chloride. Over 6 weeks cold storage, the losses due to gray mold rots were reduced by 50 % in ethanol plus CC treated bunches, compared to control. Romanazzi *et al.* (2007) reported that the combination of low doses of chitosan, a natural biopolymer with antifungal and eliciting properties, and ethanol as a postharvest dipping improved the control of gray mold of table grapes compared to their use alone. They found no difference in effectiveness between the combination of 0.5 % chitosan plus 10 % ethanol and 0.5 % chitosan plus 20 % ethanol. Moreover, ethanol had no negative impact on fruit quality e.g. appearance and taste in contrast to SO_2 (Sholberg *et al.* 1996, Lichter *et al.* 2002 and 2003). Therefore the aim of this experiment is to investigate the response of 'El-Bayadi' table grapes to pre-harvest application of CC and ethanol applied either alone or in combination in order to maintain quality during storage.

Material and Methods

Plant materials and experimental procedure: A commercial drip irrigated vineyard of 'El-Bayadi' table grape was selected in Taif region. Uniform vines were selected for the application of CC at 1 or 2 % and ethanol at 10 and 20 % solutions either alone or in combination. Both leaves and bunches were covered by the spray solutions with a plastic hand sprayer (Matabi Style 1,5 Sprayer-1L, Goizper, Spain). The spraying schedule was twice (30 and 7 d before commercial harvest). The experimental design was a randomized complete block with three replicates/treatment and each replicate contained three vines. A control treatment was included in which the vines were sprayed with water and surfactant. A non ionic wetting agent (Tween 20 surfactant) at 0.01 % was included in all foliar applications. The grape vines received the regular cultural practices. At harvest, samples of bunches from each replicate/treatment were collected for initial quality measurement. Additional samples (about 15 bunches (400-500g·bunch^{-1}) per replicate) were stored in perforated polyethylene bags inside perforated cartons for 50 d at 0 °C ±1 and about 95 % relative humidity for quality measurement at 10-d intervals during cold storage plus 1 d of shelf life at 20 °C.

Decay incidence and weight loss determination: The decay incidence by storage rot and cracking was recorded. The total loss in weight was calculated on initial weight basis using separates fruit samples.

Firmness, TSS, titratable acidity, vitamin C and pH determinations: Berry firmness was recorded independently in each of the 15 berries per replicate by a digital basic force gauge, model BFG 50N (Mecmesin, Sterling, Virginia, USA) supplemented with a probe of 11 mm diameter that measure the force required just to break the berry and the results expressed as Newton. A homogeneous sample was prepared from these 15 berries per replicate for measuring total soluble solids (TSS), acidity, vitamin C, total phenols, and soluble tannins. TSS was measured as Brix % in fruit juice with a digital refractometer (DR 6000, A. Kruss Optronic GmbH, Hamburg, Germany).

Titratable acidity was determined in distilled water diluted berry juice (1: 19) by titrating with 0.1 N sodium hydroxide up to pH 8.2, and the results expressed as a percentage of tartaric acid (g of tartaric acid per 100 ml grape juice). Ascorbic acid (vitamin C) was measured by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye and the results expressed as mg/100 ml grape juice (Ranganna 1979). The pH was determined in fruit juice samples with a pH meter (WTW 82382, Weilheim, Germany).

Estimation of the total phenols by the Folin-Ciocalteu test: Total phenols were measured according to Velioglu *et al.* (1998) using Folin-Ciocalteu reagent. Two hundred milligrams of berry tissue were extracted with 2 ml of 50 % methanol for 2 h at ambient temperature. The mixture was centrifuged for 10 min and the supernatant decanted into 4 ml vials. 200 µL of the extract were mixed with 1.5 mL Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand for 5 min before the addition of 1.5 mL 20 % sodium carbonate. After 90 min, absorbance was measured at 750 nm using a UV-Vis Spectrophotometer. The blank contained only water and the reagents. Total phenols were quantified from a calibration curve obtained by measuring the absorbance of known concentrations of gallic acid.

Estimation of the soluble tannins by the Folin-Ciocalteu test: Soluble tannins were measured according to Taira (1996). Five grams of berry tissue were homogenised with 25 mL of 80 % methanol in a blender and then centrifuged. The supernatant was collected and the precipitant re-extracted with 80 % methanol and centrifuged. The combined supernatant was brought to 100 mL with distilled water. One ml of sample solution was mixed with 6 mL distilled water and 0.5 mL Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water). After 3 min, 1 mL of saturated sodium carbonate and 1.5 mL of distilled water was added and kept for 1 h at ambient temperature before measuring absorbance at 750 nm using a UV-Vis Spectrophotometer. The blank contained only water and the reagents. Soluble tannins were quantified from a calibration curve obtained by measuring the absorbance of known concentrations of gallic acid.

Statistical analysis of data: The data were statistically analyzed as a randomized complete block design experiment with three replicates by analysis of variance (ANOVA) using the statistical package software SAS (SAS Institute Inc., 2000, Cary, NC., USA). Comparisons between means were made by Fisher's the least significant difference (LSD) test at $P < 0.05$ level.

Results

Pre-harvest spray of CC and ethanol at both low and high concentrations significantly decreased berry decay percentage during storage at 0 °C ±1 plus one day of shelf life at 20 °C compared to control (Tab. 1). The combination between CC and ethanol also significantly decreased decay compared to control but was less effective than each one alone. In this respect, there were no significant differences between the low and the high concentration of CC and ethanol (Tab. 1). In all the treatments, decay recorded after 30 d of storage significantly increased to 26.3 % after 50 d (Tab. 1). There were significant interaction effects on decay percentage between treatment and storage period (Tab. 2). The fungi *Penicillium*, and *Rhizopus spp.* were the most frequent decay organisms of 'El-Bayadi' table grape during storage. The application of CC alone, at both concentrations, significantly increased weight loss compared to control and most other treatments (Tab. 1). However, ethanol spray especially at 20 % significantly decreased weight loss compared to control and the other treatments except for 10 % ethanol spray. The combination between CC and ethanol, however, increased weight loss compared to control except for, 1 % CC plus 20 % ethanol and 2 % CC plus 10 % ethanol treatments. Weight loss significantly increased during storage to 2.30 % after 50 d of storage (Tab. 1). There were significant interaction effects on weight loss percentage between treatment and storage period (Tab. 3). Berry firmness was significantly higher at both CC concentrations either alone or in combination with ethanol except for, 1 % CC plus 10 % ethanol treatment than all other treatments including control (Tab. 1). During storage, berry firmness was not changed during the first month but significantly decreased after 40 and 50 d of storage. TSS was significantly higher in the CC spray treatment at both low and high concentration than control (Tab. 4). However, ethanol spray had no significant effect on TSS. The combination between 1 % CC plus 20 % ethanol had higher TSS than control. During storage, TSS decreased during the first 20 d followed by an increase after 50 d of storage. The CC and ethanol spray either alone or in combination had no significant effect on titratable acidity, except for the 2 % Ca and plus 20 % ethanol that showed significantly higher acidity than the control and all other treatments (Tab. 4). During storage, acidity gradually increased to a maximum (0.68) after 30 d and then decreased but remains higher than the initial concentration (Tab. 4). The TSS/acid ratio was not significantly affected by CC and ethanol spray, except for the 2 % Ca plus 20 % ethanol treatment that lowered TSS/acid ratio more than all other treatments. The pH was not significantly affected by the applied treatments, slightly fluctuated during storage, but was significantly higher than the initial value (Tab. 4). The concentration of vitamin C was significantly lower at 10 % ethanol spray treatment than control. During storage, vitamin C was significantly higher at all storage periods than the initial level and showed a maximum level (2.03 mg·100 mL^{-1} juice) after 50 d of storage (Tab. 4). In this respect, there were no significant interaction effects between treatment and storage period on berry quality characteristics.

Table 1

Decay and weight loss percentage and firmness of 'El-Bayadi' table grapes during cold storage as affected by pre-harvest calcium chloride and ethanol spray

Treatments	Decay (%)	Weight loss (%)	Firmness (N)
Treatment (T)			
Control	10.0a	0.94ef	12.4b
Ca 1 %	4.5c	1.82a	14.1a
Ca 2 %	4.7c	1.44b	14.3a
Ethanol 10 %	6.0 bc	0.76fg	11.7b
Ethanol 20 %	5.0c	0.68g	12.2b
Ca 1 % + Ethanol 10 %	7.6b	1.34b	12.3b
Ca 1 % + Ethanol 20 %	7.8b	0.91ef	14.0a
Ca 2 % + Ethanol 10 %	7.3 b	1.03de	13.8a
Ca 2 % + Ethanol 20 %	7.8b	1.17cd	13.9a
F-test	***	***	***
LSD (0.05)	*2.17*	*0.21*	*1.17*
Storage period (SP, days)			
0	0.0d	0.0f	13.3a
10	0.0d	0.53e	13.2a
20	0.0d	0.83d	13.2a
30	7.0c	1.37c	12.9ab
40	12.4b	1.71b	12.2b
50	26.3a	2.30a	11.9b
F-test	***	***	***
LSD (0.05)	*1.77*	*0.17*	*0.96*
T X SP			
F-test	***	***	*NS*

Measurements were carried out after each storage period plus 1 d at 20 °C. Means within each column followed by the same letter are not significantly different at level $P = 0.05$. (**) and (***) significant at $P = 0.01$ and 0.001 respectively; (NS), not significant.

Total phenols concentration was significantly higher at the 1 % Ca plus 20 % ethanol treatment than control. Total phenols concentration was significantly lower than the initial value and fluctuated during storage (Tab. 5). Soluble tannins concentration was significantly higher at 1 % Ca plus 20 % ethanol treatment than control. Soluble tannins concentration was significantly higher after 20 d than all other storage periods but decreased to a similar level of the initial (Tab. 5). In this respect, there were no significant interaction effects between treatment and storage period on both total phenols and soluble tannins concentration of berry (Tab. 5).

Discussion

'El-Bayadi' table grape cultivar is characterized by relatively high sugar content, as well as the thin skin of berry. Thus bunches are highly perishable during storage due to

Table 2

The interaction effect between treatments and storage periods on decay percentage of 'El-Bayadi' table grapes during cold storage

Treatments	Storage period (days)					
	0	10	20	30	40	50
Decay (%)						
Control	0.0k	0.0k	0.0k	7.2 ij	16.2de	35.9a
Ca 1 %	0.0k	0.0k	0.0k	5.1ijk	5.4ij	16.3de
Ca 2 %	0.0k	0.0k	0.0k	7.2ij	8.6ghij	18.4d
Ethanol 10 %	0.0k	0.0k	0.0k	7.8hij	12.9efgh	27.3bc
Ethanol 20 %	0.0k	0.0k	0.0k	3.4jk	8.7ghij	23.8c
Ca 1 % + Ethanol 10 %	0.0k	0.0k	0.0k	7.5ij	13.6defg	30.5b
Ca 1 % + Ethanol 20 %	0.0k	0.0k	0.0k	8.3ijk	15.0def	29.3b
Ca 2 % + Ethanol 10 %	0.0k	0.0k	0.0k	6.3ij	14.3def	29.1bc
Ca 2 % + Ethanol 20 %	0.0k	0.0k	0.0k	10.1fghi	16.9de	25.7bc

Measurements were carried out after each storage period plus 1 d at 20 °C. Means within and between columns followed by the same letter are not significantly different at level $P = 0.05$.

Table 3

The interaction effect between treatments and storage periods on weight loss percentage of 'El-Bayadi' table grapes during cold storage

Treatments	Storage period (days)					
	0	10	20	30	40	50
Weight loss (%)						
Control	0.0u	0.36stu	0.59tqspro	1.1,jlnpko	1,5hijk	2.0defg
Ca 1 %	0.0u	0.71rstnopq	1.56ghijk	2.3cde	2.8bc	3.5a
Ca 2 %	0.0u	0.71rstnopq	1.0lmnoqrlnp	1.8efghi	2.1def	2.9b
Ethanol 10 %	0.0u	0.26tu	0.44stu	0.88mqsnpro	1.2jklmn	1.8efghi
Ethanol 20 %	0.0u	0.27tu	0.47stu	0.69 tqsnpro	1.0klmnopq	1.6hijk
Ca 1 % + Ethanol 10 %	0.0u	0.83rsnopq	1.1klmnop	1.7fghi	2.1defg	2.3cde
Ca 1 % + Ethanol 20 %	0.0u	0.48rstu	0.73tqsnpro	1.1mjlnpko	1.4ijkl	1.7fghi
Ca 2 % + Ethanol 10 %	0.0u	0.53rstq	0.74qsnpro	1.1mjlnpko	1.4ijklm	2.4cd
Ca 2 % + Ethanol 20 %	0.0u	0.58rstpq	0.88qsnpro	1.5ijkl	1.7fghi	2.3cde

Measurements were carried out after each storage period plus 1 day at 20 °C. Means within and between columns followed by the same letter are not significantly different at level $P = 0.05$.

fungal decay, softening, cracking as well as rachis browning. In our study, the fungi *Penicillium*, and *Rhizopus spp.* were the most frequent decay organisms of 'El-Bayadi' table grape during storage. In this study, pre-harvest spray of both CC and ethanol at low and high concentrations either alone or in combinations at 30 and 7 d before harvest significantly decreased berry decay during storage compared to control (Tab. 1). However, in this respect, CC spray alone especially at the low concentration (1 %) was most effective compared to other treatments. Our results confirm those of Nigro *et al.* (2006) and Chervin *et al.* (2009) where pre-harvest spray of 1 % CC and some other salts alone or in combination with ethanol provided similar or higher levels of protection compared to conventional fungicides. The repeated application of CC spray (21 and 5 d before harvest) was more effective than a single one made 5 d before harvest (Nigro *et al.* 2006). Furthermore, early applications (90 and 30 d before harvest) of CC provided better control of field rots (Nigro *et al.* 2006). In our study, CC spray would have increased the level of Ca in berries, providing firmer berries. Indeed, CC treated berries were significantly firmer than control (Tab. 1). In another study, pre-harvest CC spray increased the Ca level of table grape berries (Miceli *et al.* 1999). The exact mechanism of CC in decreasing decay is not completely clear. Calcium is known to accumulate mostly in the middle lamella of the

Table 4

Quality characteristics of 'El-Bayadi' table grapes during cold storage as affected by pre-harvest calcium chloride and ethanol spray

Treatments	TSS (°Brix %)	Acidity (%)	TSS/Acidity (ratio)	pH	Vitamin C (mg·100 mL^{-1} juice)
Treatment (T)					
Control	17.0d	0.60bcd	28.7ab	3.51	1.87a
Ca 1 %	18.1a	0.62bc	29.4ab	3.55	1.79ab
Ca 2 %	17.9ab	0.59cd	30.5a	3.58	1.75ab
Ethanol 10 %	16.8d	0.60bcd	28.0b	3.55	1.58b
Ethanol 20 %	17.3cd	0.57d	30.2a	3.48	1.79ab
Ca 1 % + Ethanol 10 %	17.8bcd	0.59cd	30.8a	3.53	1.83a
Ca 1 % + Ethanol 20 %	18.0ab	0.64b	28.5ab	3.53	1.83a
Ca 2 % + Ethanol 10 %	17.1d	0.57d	30.3a	3.51	1.79ab
Ca 2 % + Ethanol 20 %	17.4bcd	0.70a	25.4c	3.45	1.83a
F-test	***	***	***	*NS*	***
LSD (0.05)	*0.65*	*0.038*	*2.24*	-	*0.22*
Storage period (SP, days)					
0	18.2a	0.54d	34.1a	3.40c	1.30c
10	17.6b	0.57c	30.8b	3.51b	1.75c
20	16.3c	0.60b	27.5cd	3.53ab	1.94ab
30	18.4a	0.68a	27.6cd	3.60a	1.55d
40	16.4c	0.64b	25.8d	3.56ab	1.83bc
50	18.0ab	0.63b	28.7c	3.52b	2.03a
F-test	***	***	***	***	***
LSD (0.05)	*0.53*	*0.031*	*1.83*	*0.07*	*0.18*
T X SP					
F-test	*NS*	*NS*	*NS*	*NS*	*NS*

Measurements were carried out after each storage period plus 1 d at 20 °C. Means within each column followed by the same letter are not significantly different at level $P = 0.05$. (***) significant at $P = 0.001$ respectively; (NS), not significant; (-), not calculated.

cell wall, forming ionic bridges between and within pectic polysaccharides and providing firmer fruit (Wills *et al.* 1998, Huang *et al.* 2005). Thus, the cell wall might become more resistant to hydrolytic enzymes produced by decay organisms (Tobias *et al.* 1993). Nigro *et al.* (2006) reported that CC spray affected pathogens directly by inhibiting the activity of polygalacturonase enzyme. The combination between CC and ethanol also significantly decreased decay compared to control but was less effective than each one alone (Tab. 1). These results partially contradict with those of Chervin *et al.* (2009) in which the combination between 1 % CC plus 16 % ethanol was more effective in decreasing postharvest decay than each one alone. Several studies have shown that pre or postharvest application of ethanol alone or in combination with inorganic salts such as CC and sodium bicarbonate decreased postharvest decay in different grape cultivars (Karabulut *et al.* 2003, Lurie *et al.* 2006 and Chervin *et al.* 2009) and also in other fruits e.g. citrus and stone fruit (Yuen *et al.* 1995, Margosan *et al.* 1997). The mode of action of ethanol on fungi was attributed mainly to increasing fungal membrane stress, denaturation of proteins and induction of water stress (Larson and Morton 1991, Mishra 1993). Weight loss was higher in the CC spray at both low and high rate than control and most other treatments (Tab. 1). The maximum weight loss of berries reached 2.30 % (Tab. 1) and rachis showed severe browning as a result of desiccation in all treatments including the control after 50 d of storage (data not shown). Deng *et al.* (2005) reported that the normal acceptable limit for weight loss is 5 % for 'Kyoho' table grapes cultivar. However, Arts-Hernndez *et al.* (2004) reported that 9.7 % weight loss of 'Autumn seedless' grape cultivar was accompanied by extreme rachis browning. During storage, berry firmness was not changed during the first month but, decreased after 40 and 50 d of storage (Tab. 1). Also, acidity, pH and vitamin C concentration increased during storage compared to the initial values (Tab. 4). These results partially contradict those of Deng *et al.* (2005). They reported lower levels of firmness, TSS, acidity and vitamin C of 'Kyoho' table grapes cultivar stored either in air or in modified atmosphere storage. In another study TSS, titratable acidity, individual sugars and organic acids did not change but

Table 5

Total phenols and soluble tannins concentration of 'El-Bayadi' table grapes during cold storage as affected by pre-harvest calcium chloride and ethanol spray

Treatments	Phenols ($mg \cdot g^{-1}$ fw)	Soluble tannins ($mg \cdot g^{-1}$ fw)
Treatment (T)		
Control	0.11b	0.52bc
Ca 1 %	0.10.b	0.53bc
Ca 2 %	0.11ab	0.51bc
Ethanol 10 %	0.12ab	0.45c
Ethanol 20 %	0.11ab	0.48bc
Ca 1 % + Ethanol 10 %	0.12ab	0.52bc
Ca 1 % + Ethanol 20 %	0.14a	0.68a
Ca 2 % + Ethanol 10 %	0.13ab	0.53bc
Ca 2 % + Ethanol 20 %	0.11b	0.56b
F-test	**	***
LSD (0.05)	*0.027*	*0.08*
Storage period (SP, days)		
0	0.25a	0.43c
10	0.12b	0.47bc
20	0.06d	0.88a
30	0.06d	0.46bc
40	0.10.c	0.51b
50	0.11bc	0.44c
F-test	***	***
LSD (0.05)	*0.022*	*0.07*
T X SP		
F-test	*NS*	*NS*

Measurements were carried out after each storage period plus 1 d at 20 °C. Means within each column followed by the same letter are not significantly different at level $P = 0.05$. (**) and (***) significant at $P = 0.01$ and 0.001 respectively; (NS), not significant.

total phenol content increased during storage of 'Muscadine' grapes at three different temperatures (20 °C, 4.5 °C and 0 °C) (Takeda *et al.* 1983). In the current experiment, however, the overall quality characteristics of berries were not negatively affected by both CC and ethanol spray treatments (Tabs 1, 2, 3, 4 and 5). Also, both CC and ethanol spray caused neither foliar damage on the vines nor significant changes in berry quality. Also this cultivar seems to be not sensitive to berry shatter. Most of the dropped berries were infected with fungi and/or cracked. Therefore this cultivar is not suitable for studying the effect of calcium and ethanol on berry shatter. In conclusion, CC and ethanol are natural substances present in many food products and more save on both human and the environment than synthetic fungicides and SO_2, because of their low mammalian toxicity (Karabulut *et al.* 2003). Accordingly, CC spray at 1 % or ethanol spray at 20 % could be suggested as practical alternatives to synthetic fungicides and SO_2 to decrease postharvest decay and improve quality of 'El-Bayadi' table grapes.

Acknowledgements

This project was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under grant no 337/155/1432**.** The authors, therefore, acknowledge with thanks DSR technical and financial support. The authors would like to thank PhD. M. I. Elsayed, MSc. N. El-Masoudi and El-Saied Sabry at the Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Saudi Arabia, for their indispensable technical support.

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Received October 15, 2012