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Postharvest application of chitosan and *Thymus* essential oil increase quality of the table grape cv. 'Shahroudi'

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ABSTRACT

Purpose: Chitosan, a natural biopolymer with antifungal and eliciting properties is able to reduce postharvest decay of table grapes. Anti-fungal and anti-microbial effects of essential oils are the result of many compounds acting synergistically. In this study, the effectiveness of *Thymus* essential oil (TEO) and chitosan to control postharvest decay and quality of 'Shahroudi' table grape was investigated. **Research Method:** Grapes treated by 0.5% and 1% (w/v) solution of chitosan, 150 and 300 µl l^{-1} *Thymus* essential oil and their combination (untreated fruit were as control). At first chitosan solution prepared then *Thymus* essential oil was added it in combination solution. Harvested grapes were packed in 200g bags and stored at 0±2 ˚C and 90% ± 5 RH for 90 days. **Findings:** Differences in weight loss, color change, ripening, sensory quality and decay between grapes treated with chitosan and TEO and control fruit suggested that TEO and chitosan were both suitable coatings. Moreover, the sensory analyses revealed beneficial effects in terms of delaying rachis browning and dehydration and maintenance of the visual characteristics of the grape without detrimental effects on taste or flavors. **Research limitations:** It had no limitation to report. **Originality/Value:** TEO and chitosan might have good effects in reducing postharvest fungal rot and maintaining the quality of 'Shahroudi' table grapes which proved to be much more effective than TEO.

INTRODUCTION

Table grape is a highly perishable and non-climacteric fruit. Its shelf life is shortened by the loss of firmness, berry drop, discoloration of the stem, desiccation and fungal rots (Meng, Li, Liu & Tian, 2008). Although the use of synthetic chemical fungicide remains the primary method of controlling postharvest diseases, the global trend appears to be shifting towards reduced use of it on agricultural products. It's believed that synthetic fungicides have harmful effects on human health and could lead to fungicides resistance (Holmes & Eckert, 1999). Thus, there is a worldwide trend to explore new strategies in order to reduce the use of synthetic fungicides (Liu et al., 2006). Among these new methods, the use of natural antimicrobial compounds such as *Thymus* essential oil (TEO) could be a promising strategy. For centuries, essential oils have been confirmed as an effective antimicrobial agent (Burt, 2004). It has been shown that carvacrol was an effective tool in reducing decay of table grape during postharvest storage (Martinez-Romero et al., 2007). Valero et al. (2006) reported that by the addition of eugenol or thymol inside the packages, losses of table grape were significantly reduced. Daniel et al (2014) showed that garlic extracts and clove oil were effective *in vivo* studies when applied for the control of *Botrytis cinerea* and *Penicillium expansum* on apple. Furthermore, it's been proved that the coating of the harvested plum with chitosan can effectively preserve the quality and increase the postharvest life up to 35 days during low-temperature storage condition (Kumar et al., 2017).

Among natural compounds that are able to form a film on a surface, chitosan because of its biocompatibility, biodegradability and bioactivity have received much interest for applications in agriculture, biomedicine, biotechnology, and food industry (Wu et al., 2005). Chitosan edible coating can preserve water in the tissue of fruit and vegetables and improve their postharvest life. Quality of grapes will be improved at different concentrations of chitosan coating films (Melo et al., 2018). Chitosan coating was effective in extending the shelf life and postharvest quality of table grape (*Vitis vinifera*) cultivar 'Shahrudi' (Shiri et al., 2013). Meng et al., (2008) indicated the beneficial effects of chitosan by pre-harvest spray and/or post-harvest coating on fruit quality and resistance on fruit decay. Studies have revealed that increasing the concentration of chitosan coating can improve the beneficial effects of postharvest life and quality of the fruit (Jiang and Li, 2001). Also, It has been shown that postharvest application of chitosan in wounded tomato fruit, decreases the activity of polyphenol oxidase (PPO) and increases total protein and phenolic compounds (Badawy and Rabea, 2009). In addition, postharvest application of chitosan in sponge gourd (*Luffa cylindrica*) reduced respiration rate and weight loss, maintained firmness and visual appearance, retained the content of ascorbic acid and total phenols, and delay the increase of PPO activity (Han et al., 2014). The combination of reduced doses of chitosan and ethanol could potentially control gray mold of table grapes compared to their application alone, and the effect was at least additive and at times synergistic (Romanazzi et al., 2007). Chitosan obtained from *Cunninghamella elegans* inhibited mycelial growth and spore germination of *Botrytis cinerea* and *Penicillium expansum*, also preserved the quality of grapes (de Oliveira et al., 2014).

The purpose of this study was the evaluation of the antifungal efficacy of TEO and chitosan as natural and safe compounds, alone or combined and their effects on controlling of decay and keeping the quality of 'Shahroudi' grapes.

MATERIALS AND METHODS

Table grapes

Shahroudi' grapes (*Vitis vinifera* cv. Shahroudi) were harvested from a research orchard located in Karaj (Tehran, Iran). At harvest time, grapes were fully ripened and their total soluble solid was about 18-20%. Only fruits of uniform size, color, and shape were selected to obtain homogeneous batches, and all were without any injuries.

TEO purchased from Zardband Company (Tehran, Iran), a solution of TEO was prepared by dissolving of 150 and 300 µL L^{-1} TEO in water and 0.05% (v/v) surfactant Tween-80 was added (Valero et al., 2006)

For experimental use, the 0.5% and 1% (w/v) solution of chitosan (Sigma Company, USA) were prepared by dissolving under continuous stirring the purified chitosan in 0.5% (v/v) acetic acid. When dissolved, by using 1N NaOH, the pH of the chitosan solution was adjusted to 5.4 to improve the wetting properties of the solution, 0.05% (v/v) surfactant Tween-80 was added (Meng et al., 2010). TEO was added to chitosan (0.5 and 1%, w/v) to make the combination of 0.5 and 1% chitosan with 150 and 300 µL L^{-1} TEO. Grape bunches were dipped in the solutions for 60 seconds and then left for 2 hours at room temperature to be dried. Clusters without treatments served as controls. Treated clusters were wrapped with polyethylene stretch bags 20 × 20 cm^2 (each bag was contained 200g clusters of grape) to minimize weight loss and stem desiccation. All packages were stored at 0-2 °C and 90% ± 5 RH in darkness for 90 days. Each 10 days fruit brought out from storage and for 24 h left in the room condition (24 °C and 70% ± 5 RH) to create similar conditions with retail, after that experiment were done.

Decay index

The loss of fruit due to fungal decay was established by visual inspection in each sampling time during the storage period and results were expressed as percentage (Abdel Gayed et al., 2017).

Measurement of soluble solids content (SSC) and titratable acid (TA)

SSC in grape juice was determined by means of a refractometer (VBR-90A, Taiwan) at 20°C and the results were expressed as °Brix. TA content was titrated with phenolphthalein as indicator using 0.1 mol L^{-1} NaOH and expressed as mmol H^+ per 100 g fresh weight.

Color measurement

The color was determined by using a Minolta colorimeter CR400™ model (Konica Minolta CR-400, Japan). The individual *L** (dark-light as lightness), hue angle and chroma (color saturation) parameters were recorded and results were the mean ± S.E. of determinations made on 10 berries for each bag along the equatorial axis (n = 50) (Del-Vale et al., 2005).

Grape quality

Five clusters per treatment were removed after every 10 days of storage at 0–2 °C for quality evaluation. The quality of the fruit was examined by evaluation of berry and rachis appearance, the incidence of cracked and shattered berries, flavour and weight loss by a panel of five trained judges. The visual characteristics including berry and rachis appearance and berry firmness were scored (Xu et al., 2007). The detailed evaluation methods and the units employed are described in Table 1.

Table 1. Quality parameters and methods used to evaluate 'Shahroudi' table grape quality after postharvest treatments and storage for 90 days at 0–2 ˚C (RH > 90%)

Quality parameters	Methods of evaluation and units
Weight loss	Percentage difference between the weights of clusters before and at the end of the storage
Rachis appearance	Visual index of clusters: fresh and green, 1; green, 2; semi-dry, 3; 50% dry, 4; completely dry, 5
Berry appearance	Visual index of clusters: excellent, 1; good, 2; slightly dull, 3; <50% brownish and soft berries, 4; >50% brownish and soft berries, 5
Shatter	Number of shattered berries/kg
Cracking	Number of cracked berries/kg
Flesh firmness	Visual index of clusters: excellent, 5; good, 4; acceptable, 3; poor, 2; unacceptable, 1
Flavour	Flavour acceptability, using a five-point scale: excellent, 9; good, 7; acceptable, 5; poor, 3; unacceptable, 1

Statistical analysis

The experiment was conducted as a factorial experiment and completely randomized design (CRD) with 3 replications and 200 g clusters per replications. Data were subjected to analysis of variance (ANOVA) using SAS software. Incidence data were transformed (arcsine of the square root of the proportion of affected fruit) before analysis. Statistical significance was assessed at $P \leq 0.05$ and Duncan's multiple range tests.

RESULTS AND DISCUSSION

Loss of fruit due to visible fungal growth and visible damage

Grapes treated with chitosan or TEO had less decay compared with control (Tables 2 and 3). Fruits treated with chitosan and TEO (48.86%) showed less decay than control (20.58%), respectively (Tables 2 and 3). Results showed that all treatments (chitosan and TEO alone or together) had less decay than control (Table 4). However, chitosan treated grapes consistently had the lowest decay, whether TEO was applied or not. Xu et al., (2007) showed that the combination of grape fruit seed extract and chitosan was effective in restricting the mycelia growth of *B. cinerea*, which resulted in marked morphological changes and severe structural alterations in the fungal hyphae. It has been shown that preharvest spray with *Cryptococcus laurentii* combined with postharvest chitosan coating increased the activities of polyphenol oxidase (PPO) and phenylalanine ammonia-lyase (PAL) of fruit in storage (Meng et al., 2010). However, in this case, chitosan was the most effective controller of gray mold and TEO only showed a small effect in controlling it. The antifungal activity of chitosan might be related to the formation of a physical barrier against infection, reducing the conidial germination and mycelial growth and resulting protection of grape berries against fungus (Shiri et al., 2013). Other factors such as reduced respiration rate, weight loss, higher firmness, a higher level of protective enzymes activity and intact of the cell membrane can enhance the activity of chitosan against microbes which finally reduces fruit decay (Youwei & Yinzhe, 2013).

Soluble solids content (SSC) and titratable acid (TA)

SSC increased gradually with a maturity of the grape fruit, the fruit treated with chitosan and TEO showed an increase in SSC compared with non-treated controls (Tables 2 and 3). These results were in agreement with Meng et al. (2008). The effect of the combination treatment with both chitosan and TEO was not tested. Unlike our results, Bal (2013) obtained the highest SSC content in control of plum fruit, while the least observed in coated ones. Sucrose-phosphate synthase is a key enzyme in sucrose biosynthesis, during fruit ripening, the action of this enzyme will be increased so SSC level will be enhanced. Ethylene and the ripening process during storage life could activate this enzyme. Since organic acids are substrates of

respiration, decreasing their levels during ripening leads to increase in sweetness (Jackson, 2003).

The TA content of the grape fruit decreased over 90 days of cold storage. In treated fruit with chitosan, the level of TA was higher than control (Table 2). The response to TEO application gave the opposite result, with higher TEO treatments having lower TA values (Table 3). TA of chitosan or starch-based coated strawberries kept under cold storage has been reported to decrease over time but to a lesser extent than that of uncoated fruit (Zhang and Quantick, 1998). Meng et al. (2008) also reported a decrease in TA of control and chitosan coated grapes. Respiration rate and fungi growth can decrease by applying edible coatings on the fruit surface, resulting in a reduction of decomposition in the fruit texture and change in ascorbic acid and titratable acidity.

External color

Changes in the external color of table grapes were monitored by measuring lightness (L^*), hue angle and chroma. Chitosan-coated grapes lightened slightly as evidenced by increasing values of L^* which became significantly different ($P < 0.01$) (Table 2). Results showed that decreasing in L^* relates to water loss in fruit. It also seems that occurrence of browning in berries correlates to L^* decreasing. These results obtained from the weight loss in fruit. According to our findings, TEO application did not affect grape surface lightness, so this result was in agreement with the findings of De Souse et al., (2013) and Dehestani Ardakani and Mostofi (2018) indicating that treated grape with essential oil preserved a lighter color until end of the storage time. In general, chitosan-coated and uncoated samples showed a significant decrease in chroma and increase in hue angle. Higher hue angles were found in control fruit and treated fruit with 150 and 300 µL L^{-1} TEO (Fig. 1). But the lower amount of chroma was in control fruit and higher level was observed in fruit treated with 300 µL L^{-1} TEO (Table 4). So it revealed that edible coatings were effective in delaying fruit color change (Tanada-Palmu & Grosso, 2005). Moreover, Hernandez-Munaz et al. (2008) found that the hue angle of coated strawberries with chitosan decreased over time, but chitosan concentrations didn't show any significant difference in hue angle. In agreement with the results obtained in this study, other studies have reported that the application of chitosan and essential oils alone or in combination as a coating material improved the sensory attributes such as appearance and color during the low-temperature storage time (Dehestani Ardakani & Mostofi, 2018; de souse et al., 2013; Hernandez-Munaz et al., 2008).

Table 2. Effect of chitosan on some postharvest qualitative and quantitative characteristics of 'Shahroudi' table grape after storage for 90 days at 0-2°C (RH > 90%)

Chitosan (%)	Decay (%)	TSS (° Brix)	TA (%)	L^*	Hue	Chroma
0	$1.76^{a} \pm 0.09$†	$14.74^{b} \pm 0.15$	$0.29^{c} \pm 0.01$	$39.66^{b} \pm 0.26$	$179.97^{a} \pm 0.002$	$9.21^{b} \pm 0.30$
0.5	$0.90^{b} \pm 0.02$	$14.60^{b} \pm 0.12$	$0.34^{b} \pm 0.01$	$40.57^{ab} \pm 0.36$	$179.96^{b} \pm 0.002$	$9.01^{b} \pm 0.29$
1	$0.95^{b} \pm 0.02$	$15.41^{a} \pm 0.13$	$0.37^{a} \pm 0.01$	$41.82^{a} \pm 0.94$	$179.96^{b} \pm 0.002$	$9.76^{a} \pm 0.24$

Chitosan (%)	Flesh firmness (1-5)	Berry appearance (1-5)	Weight loss (%)	Rachis appearance (1-5)	Shatter	Cracking	Flavour (1-5)
0	$3.69^{b} \pm 0.15$	$2.69^{a} \pm 0.15$	$o.7^{a} \pm 16.21$	$4.15^{a} \pm 0.09$	$1.28^{a} \pm 0.05$	$1.01^{a} \pm 0.04$	$5.16^{b} \pm 0.19$
0.5	$3.79^{b} \pm 0.10$	$2.20^{b} \pm 0.09$	$0.55^{b} \pm 12.45$	$3.79^{b} \pm 0.07$	$0.99^{b} \pm 0.03$	$0.95^{b} \pm 0.02$	$5.55^{a} \pm 0.13$
1	$4.29^{a} \pm 0.09$	$1.99^{c} \pm 0.10$	$0.55^{b} \pm 13.92$	$3.53^{c} \pm 0.08$	$0.99^{b} \pm 0.02$	$0.85^{c} \pm 0.01$	$5.64^{a} \pm 0.12$

† Values in columns followed by unlike letters differ significantly according to Duncan's multiple range test at $P < 0.05$.

Table 3. Effect of TEO on some postharvest qualitative and quantitative characteristics of 'Shahroudi' table grape after storage for 90 days at 0-2°C (RH > 90%)

TEO (µL L^{-1})	Decay (%)	TSS (°Brix)	TA (%)	*L**	Hue	Chroma
0	$1.36^{a} \pm 0.09$†	$14.61^{b} \pm 0.14$	$0.34^{a} \pm 0.01$	$40.97^{a} \pm 0.32$	$179.96^{a} \pm 0.002$	$8.80^{b} \pm 0.29$
150	$1.17^{b} \pm 0.06$	$15.00^{a} \pm 0.14$	$0.33^{ab} \pm 0.01$	$40.11^{a} \pm 0.33$	$179.96^{a} \pm 0.002$	$9.16^{b} \pm 0.25$
300	$1.08^{c} \pm 0.05$	$15.16^{a} \pm 0.14$	$0.32^{b} \pm 0.01$	$40.97^{a} \pm 0.95$	$179.96^{a} \pm 0.002$	$10.01^{a} \pm 0.28$

TEO (µL L^{-1})	Flesh firmness (1-5)	Berry appearance (1-5)	Weight loss (%)	Rachis appearance (1-5)	Shatter	Cracking	Flavour (1-5)
0	$3.60^{b} \pm 0.14$	$2.49^{a} \pm 0.14$	$0.62^{a} \pm 15.97$	$3.79^{a} \pm 0.09$	$1.18^{a} \pm 0.05$	$1.05^{a} \pm 0.04$	$5.25^{b} \pm 0.19$
150	$3.81^{b} \pm 0.11$	$2.35^{a} \pm 0.12$	$0.58^{a} \pm 13.68$	$3.80^{a} \pm 0.08$	$1.07^{b} \pm 0.03$	$0.87^{b} \pm 0.01$	$5.65^{a} \pm 0.12$
300	$4.35^{a} \pm 0.08$	$2.03^{b} \pm 0.10$	$0.59^{a} \pm 14.04$	$3.89^{a} \pm 0.07$	$1.00^{b} \pm 0.02$	$0.89^{b} \pm 0.01$	$5.44^{ab} \pm 0.14$

† Values in columns followed by unlike letters differ significantly according to Duncan's multiple range test at $P < 0.05$.

Quality

The loss in weight during storage after treatments with 0.5 and 1% chitosan and both levels of TEO was significantly less than that of the controls (Table 2). Chitosan-coated fruit showed about 21% less weight loss compared to the control (Table 2). However, weight loss of grape berries for all treatments increased continuously with storage time. In general, this positive effect of edible coatings is based on their hygroscopic properties, which enables the formation of a water barrier between the fruit and the environment, thus reducing weight loss (Xu et al., 2007).

Xu et al. (2007) reported that grapefruit seed extract with chitosan treatment significantly reduced fruit firmness loss, with losses of >50% detected in control grapes after four weeks of cold storage period. According to our results, control fruit had less firmness than treated fruit (Table 4). The reduction in β-galactosidase, polygalacturonase, and pectinmethylesterase activities will cause table grape ripening. Also in the main cell wall degrading enzymes are responsible for table grape softening (Nunan et al., 1998). Actually, chitosan film on fruit can act as a barrier for O_2 uptake, thereby slowing the metabolic activity, and consequently the ripening process (Reddy et al., 2000).

Table 4. Effect of *Thymus* essential oil and chitosan and their interaction effect on some quantitative and qualitative traits of grape cv. 'Shahroudi'

Chitosan (%)	Thymus essential oil (µl l^{-1})	Decay (%)	Berry abscission (1-5)	value	Flesh Firmness (1-5)	TSS (°Brix)	Berry appearance (1-5)	Rachis appearance (1-5)
0	0	46.53^{a}†	1.67^{a}	7.89^{e}	2.87^{e}	14.22^{d}	3.36^{a}	4.37^{a}
0	150	17.4^{b}	1.37^{b}	9.37^{bc}	3.77^{cd}	14.76^{bcd}	2.56^{b}	4.02^{b}
0	300	11.23^{c}	1.20^{c}	10.36^{a}	4.43^{a}	15.25^{ab}	2.13^{cd}	4.05^{b}
0.5	0	0.60^{d}	1.00^{d}	9.71^{ab}	3.67^{d}	15.17^{abc}	2.13^{cd}	3.90^{c}
0.5	150	0.33^{d}	1.00^{d}	9.61^{b}	3.60^{d}	15.47^{a}	1.96^{d}	3.92^{c}
0.5	300	0.13^{d}	1.00^{d}	9.95^{ab}	4.10^{b}	15.62^{a}	1.86^{d}	3.93^{c}
1	0	1.07^{d}	1.03^{d}	8.80^{cd}	4.27^{ab}	14.44^{d}	2.36^{bc}	3.91^{c}
1	150	0.70^{d}	1.03^{d}	8.49^{cd}	4.06^{bc}	14.77^{bcd}	2.13^{cd}	3.78^{d}
1	300	0.27^{d}	1.03^{d}	9.71^{ab}	4.53^{a}	14.60^{cd}	2.10^{cd}	3.41^{e}

† Values in columns followed by unlike letters differ significantly according to Duncan's multiple range test at $P < 0.05$.

The appearance of control grape clusters deteriorated more quickly than other treatments with the extension of storage time. At the end of cold storage, control fruit had a darker color than treated fruit, showing characteristics of the over-ripe fruit, considered to be detrimental to color quality it was according Dehestani Ardakani and Mostofi (2018). Fruit treated with 0.5% chitosan plus 150 and 300 µL L^{-1} TEO had the best appearance (Table 4).

The beneficial effect of TEO or TEO with chitosan coating to delay rachis dehydration and browning which is associated with rotted berries was clearly determined. These symptoms first appeared on pedicels followed by lateral branches and finally on the central axis, as has been reported for 'Flame Seedless' table grapes, due to increased polyphenol oxidase activity (Xu et al., 2007). Fruit treated with 1% chitosan plus 300 µL L^{-1} TEO had the best rachis appearance (Table 4).

This study also demonstrated that the occurrences of shattering and cracking in control fruits were higher than treated fruit (Fig. 2 a, b). These results were agreement with weight loss and dehydration of table grape berries in this experiment it.

According to panelist idea, all treated fruit showed better flavor than control and among them, treated fruits with 1% chitosan plus 150 µL L^{-1} TEO showed the best flavor (Fig. 2 c). Coating films could act as barriers to moisture and oxygen during processing, handling, and storage, and not only solely retard food deterioration, but also improve safety by inhibition or delay of the growth of microorganisms, due to their natural biocide activity or to the incorporation of antimicrobial compounds, allowing edible coatings to be widely used (Cha & Chinnan, 2004).

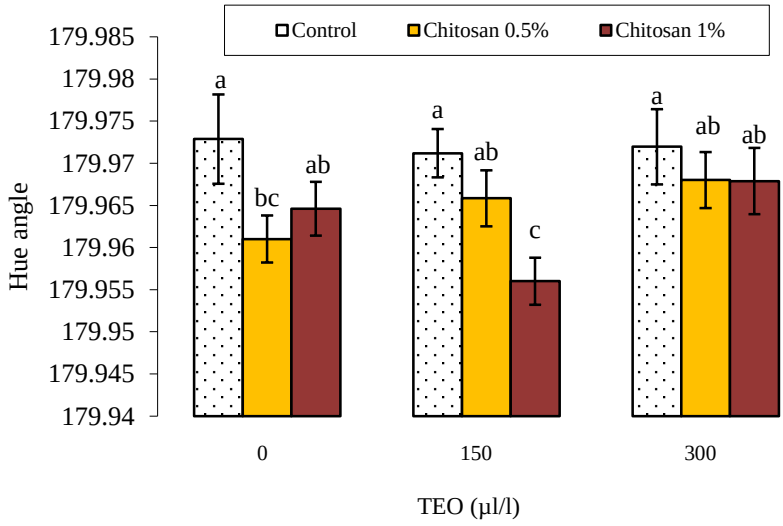

Fig. 1. Effect of chitosan and TEO on hue angle of 'Shahroudi' table grape after storage for 90 days at 0-2°C (RH > 90%). The vertical bars indicate standard deviations and columns with unlike letters differ significantly according to Duncan's multiple range test at $P < 0.05$.

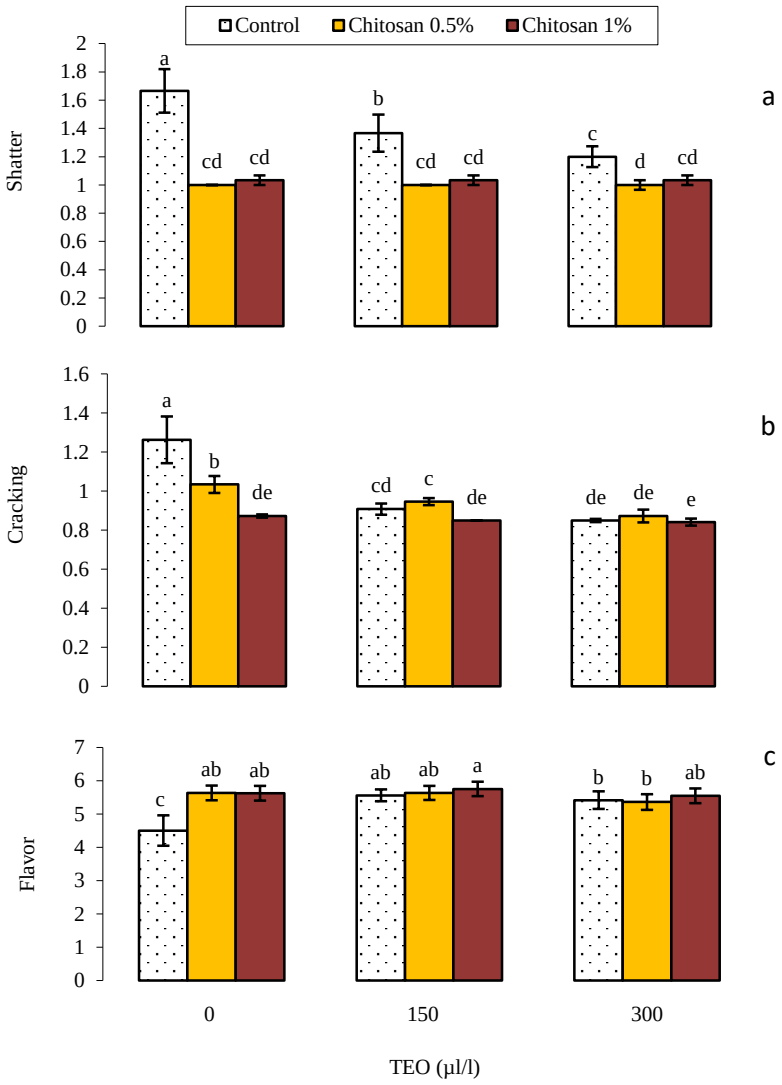

Fig. 2. Effect of chitosan and TEO on the postharvest shatter (a) cracking (b) and flavor (c) of 'Shahroudi' table grape after storage for 90 days at 0-2°C (RH > 90%). The vertical bars indicate standard deviations and columns with unlike letters differ significantly according to Duncan's multiple range test at $P < 0.05$.

CONCLUSION

According to this research, the rate of respiration and weight loss decreased with Chitosan and TEO coating and firmness maintained. Also, results showed that chitosan and TEO had reduced the effect of fungus and decreased decay. As it's known, SSC increased gradually with the maturity of the grape fruit so, the fruit treated with chitosan and TEO indicated an increase in SSC compared with non-treated controls. The TA content of the grape fruit decreased through enhancing storage days. Furthermore, in treated fruit with chitosan, higher TA levels than control were indicated. Totally, chitosan-coated and uncoated samples showed a significant decrease in chroma and increase in hue angle. Also, fruit treated with 1% chitosan plus 300 µL L^{-1} TEO had the best rachis appearance. According to panelist idea,

treated fruits resulted in better flavor than control. To our findings, chitosan and TEO extended the postharvest life of grapes and quality of berries was generally acceptable.

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کاربرد پس از برداشت کیتوزان و اسانس آویشن جهت افزایش کیفیت انگور رقم "شاهرودی"

مریم دهستانی اردکانی و یونس مستوفی

چکیده:
کیتوزان یک بیوپلیمر طبیعی با خواص ضدقارچی و تحریک کنندگی بوده که قادر به کاهش فساد پس از برداشت انگور می‌باشد. خواص ضد قارچی و ضد میکروبی اسانس‌ها در نتیجه ترکیباتی است که با یکدیگر هم‌افزایی دارند. در پژوهش حاضر تاثیر اسانس آویشن (TEO) و کیتوزان در کنترل پوسیدگی پس از برداشت و حفظ کیفیت انگور رقم "شاهرودی" بررسی شد. انگورها با ۰/۵٪ و ۱٪ (w/v) محلول کیتوزان، ۱۵۰ و ۳۰۰ مایکرولیتر در لیتر اسانس آویشن و ترکیب آنها تیمار شدند (میوه‌های تیمار نشده به‌عنوان شاهد در نظر گرفته شدند). در تیمار ترکیبی، ابتدا محلول کیتوزان آماده شد، سپس اسانس آویشن اضافه شد. انگورها پس از برداشت در بسته‌های ۲۰۰ گرمی بسته‌بندی شدند و در انبار در دمای ۰±۲ °C و رطوبت نسبی ۹۰٪ به‌مدت ۹۰ روز نگهداری شدند. آزمایشات در قالب طرح کاملا تصادفی انجام شد. تفاوت در کاهش وزن، تغییر رنگ، رسیدن، آنالیز کیفی و فساد میان انگورهای تیمار شده با کیتوزان و TEO و شاهد نشان داد که TEO و کیتوزان هر دو پوشش‌های خوراکی مناسبی بودند. به‌علاوه نتایج آنالیز حسی نشان داد که اثرات مفید در رابطه با تاخیر در قهوه‌ای شدن و دهیدراسیون دم خوشه‌ها و حفظ خصوصیات ظاهری آنها بدون اثرات مخرب بر مزه و عطر و طعم می‌باشد. TEO و کیتوزان اثر خوبی در کاهش پوسیدگی قارچی پس از برداشت و حفظ کیفیت انگور "شاهرودی" نشان دادند اما کیتوزان بهتر از TEO عمل کرد.

کلمات کلیدی: *Vitis vinifera* L.، کیتوزان، اسانس آویشن، عمر پس از برداشت