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JOURNAL OF PLANT PROTECTION RESEARCH Vol. 50, No. 1 (2010)

DOI: 10.2478/v10045-010-0008-2

STUDY ON THE POTENTIAL USE OF ESSENTIAL OILS FOR DECAY CONTROL AND QUALITY PRESERVATION OF TABARZEH TABLE GRAPE

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Received: March 19, 2009
Accepted: November 12, 2009

Abstract: *Borytis cinerea* is responsible for the most postharvest losses of table grape. In the current research, the effect of essential oils extracted from sweet basil, fennel, summer savory and thyme plants were investigated both on mycelial growth of *B. cinerea* under *in vitro* condition and on fungal decay and quality sensors of table grape [*Vitis vinifera* (L.) cv. Tabarzeh] under *in vivo* conditions. Results showed that essential oils especially thyme, fennel and summer savory oils had a high inhibitory effect on mycelial growth of *B. cinerea*. Under *in vivo* assays, thyme and summer savory oils were able to reduce fungal decay sensory on table grape after 60 days of storage. In addition, essential oils had significant efficacy on quality parameters of fruit reducing a weight loss, berry shrinkage and berry and rachis browning. Also essential oil treatment increased the maturity index levels in treated fruits in comparison with controls. GC/MS analysis showed that linalool (65.25%), trans-anethole (64.72%), carvacrol (54.14%) and β-ocimene (12.62%) were the main compounds identified in sweet basil, fennel, summer savory and thyme oils, respectively. Results obtained from presented study showed that essential oils especially these one containing more phenolic compounds had a great antifungal activity and could be used as a benefit and safe tool for preservation of table grape.

Key words: essential oil, table grape [*Vitis vinifera* (L.) cv. Tabarzeh], antifungal, fungal decay, quality parameters

INTRODUCTION

Grapes have been cultivated for thousands of years and many adaptations have been made to improve the quality and appearance of this product. In addition, with growing new markets of table grapes around the world, handling, storage and marketing of table grapes requires growth of new commercial technologies which are focused on maintaining the fresh appearance of the table grapes without damaging fruit taste (Droby and Lichter 2007). Postharvest fungal decay and stem browning of table grapes are the major problems for arrival of this goal. Several fungal species such as *Botrytis cinerea* Pers.: Fr., *Aspergillus niger* Tiegh, *Rhizopus stolonifer* (Ehrenb. Fr.) Vuill., *Penicillium* spp. and *Mucor* sp. are prevalent postharvest pathogens of table grapes, which within *B. cinerea*, the casual agent of gray mold disease is the most economically important postharvest fungus of table grape in most countries (Nelson 1985; Snowdon 1990).

Storage in low temperature and use of sulfur dioxide (SO_2), either by frequent fumigation in storage rooms, or by packaging the grapes in polyethylene-lined boxes with SO_2 generator pads are the standard practices in world wide scale for decrease of postharvest fungal decay and expanding storage term of table grapes (Luvisi *et al.* 1992; Crisosto *et al.* 1994). Despite the fact that SO_2 had a considerable effect in controlling fungal decay in table grapes, it is distinguished that SO_2 causes phytotoxicity symptoms, such as bleaching, discoloration, hairline on the berries, sulfurous taste and browning of the rachis of grape. Also sulfite residues may cause hypersensitivity reactions in some people (Smilanick *et al.* 1990; Zoffoli *et al.* 2008).

This negative perceptions and consumer demands for less/eliminate use of synthetic preservatives have promoted the search to explore alternative strategies which can control the postharvest rotting of grapes without any human, environment and plant toxicity. In the few years, there has been target interest in biologically active compounds isolated from plant species for elimination of different fungi on the plants and food products, because they are safe substances for human and environment (Romanazzi *et al.* 2007; Kumar *et al.* 2008). Essential oils are complex multicomponent mixtures of fragrant volatile substances, monoterpenes, sesquiterpenes, aromatic

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compounds and their derivatives that plants usually synthesize in response to stress conditions and produce antibacterial, antiviral and antifungal effects (Lovkova *et al.* 2001). The antifungal activity of essential oils against a large number of phytopathogenic fungi under *in vitro* conditions is well documented (Bouchra *et al.* 2003; Boyraz and Özcan 2006; Viuda-Martos *et al.* 2007). But, a few studies in the case of the efficacy of essential oils and constituents to control of postharvest pathogens and maintain quality of some fruit and vegetables such as strawberry, apple, cherry tomato, table grape were investigated (Reddy *et al.* 1998; Martinez-Romero *et al.* 2004; Valero *et al.* 2006; Guillén *et al.* 2007; Lee *et al.* 2007; Tripathi *et al.* 2008).

The aim of this work was to determine whether the essential oils extracted from sweet basil, fennel, summer savory and thyme had any activity against *B. cinerea*, the casual agent of postharvest fruit decay and whether they could maintain postharvest quality sensors of table grape and, if so, to increase the storage-life of table grapes without use of SO_2. As far as, according to the best our knowledge, there has not been a relevant study investigating the effectiveness of mentioned above essential oils against postharvest fungal decay of table grapes.

MATERIALS AND METHODS

Collection of plant material and extraction

The ripe seeds of fennel (*Foeniculum vulgare* Mill.) and aerial parts of thyme (*Thymus vulgaris* L.), summer savory (*Satureja hortensis* L.) and sweet basil (*Ocimum basilicum* L.) at flowering stage were harvested, air-dried and stored at room temperature in darkness until distillation. The air-dried materials were subjected to hydrodistillation for 3 h using a Clevenger-type apparatus. The essential oils were collected, dried over anhydrous sodium sulfate and stored at 4°C until use and analysis.

Gas chromatography-mass spectrometry and identification of the components

The GC analyses were carried out on a Shimutzu 17A gas chromatograph and a DB-5 (non-polar and 95% dimethyl polysiloxane) capillary column (30 m × 0.25 mm; 0.25 μm film thickness). The oven temperature was held at 30°C for 3 min then programmed at 2.1 ml/min to 280°C. Other operating conditions were as follows: carrier gas He, with a flow rate of 2.1 ml/min; injector temperature 230°C; detector temperature 250°C; split ratio, 50 HC/MS analyses were performed on a Shimutzu 17A GC coupled with a Shimutzu QGD5050 Mass system. The operating conditions were the same as described above but the carrier gas was He. Mass spectra were taken at 70 e V. Mass range was from m/s 50–450 amu.

The constituents of the oils were identified by calculation of their retention indices under temperature-programmed conditions for identification of individual n-alkanes (C_6–C_{24}) and the oil on Db-5 capillary column. Compounds were identified by comparison of their mass spectra with those of the internal reference mass spectra library (NIST 98 and Wiley 5.0) or with authentic compounds or with those of reported in the literature (Davies 1990; Adams 1995). Quantitative data were obtained from FID area percentages without use of the correction factors.

Test fungus

The test fungus *B. cinerea* were isolated from the infected table grape fruits and identified in the Agriculture Faculty, Plant Pathology Department, Urmia University. The isolated fungus was maintained on Potato Dextrose Agar (PDA) medium at 4°C for further studies. A 7 days old culture of the fungus was used for bioactivity tests.

***In vitro* antifungal activity test**

For the test of antifungal activity of essential oils against *B. cinerea* the method of poison food medium was used. In this assay, different concentrations of essential oils (0, 100, 200, 300, 400 and 500 μl/l) of essential oils were add aseptically to sterile molten PDA medium (≈ 45°C) containing Tween 80 (0.5%, v/v). The resulting growth media was poured (≈ 20 ml/plate) into sterilized Petri dishes (9 cm). Petri dishes were then inoculated with a mycelial disc of 5 mm diameter that was taken form growing edges of 4 days old cultures. All inoculated Petri dishes were incubated for 7 days, at 25°C in the darkness. In controls, sterilized distilled water and Tween 80 were used instead of essential oil. Observations were recorded on 7th day, the time by which the growth of the control would have reached the edge of the dish. Each test was replicated four times and fungitoxicity was measured in terms of per cent of mycelial growth inhibition [MGI (%)] calculated by the following formula:

$$MGI\ (\%) = [(dc–dt)/dc] \times 100$$

where: dc and dt represent mycelial growth diameter in control and treated Petri dishes, respectively.

Spraying of table grape clusters with essential oils

The effectiveness of essential oils on fungal decay and postharvest quality attributes of table grape (*V. vinifera* cv. Tabarzeh), a white, seedless cultivar, was evaluated. The grapes were harvested from a commercial vineyards located in the Balow area of Urmia, Iran and immediately transported to the laboratory. Ripe clusters were selected on the basis of uniform color, size, shape, absence of injuries and healthy green rachises. Clusters (200–250 g) were randomly distributed into batches with four replicates of six clusters per treatment. The different concentrations (0, 200, 400 and 600 μl/l) of essential oil solutions were sprayed on grape clusters by using a hand-sprayer until clusters were enough wet to runoff. Treated clusters were placed on absorbent pad in the polypropylene bags, and then were immediately sealed to minimize vaporization. Bags were placed in the plastic boxes and all plastic boxes were stored in a cold room at 0°C and 90% RH.

Evaluation of fruit decay

After 20, 40 and 60 days of storage, fruit decay was scored by using the following scoring system: (0) bunch without rots; (1) 1–5% of rotted berries; (2) 6–10% of rotted berries; (3) 11–25% of rotted berries; (4) 26–50% of

rotted berries; (5) 51–75% of rotted berries; (6) more than 75% of rotted berries (Artés-Hernández *et al.* 2004).

Evaluation of quality sensors

Weight loss was calculated by weighting the fruit at harvest and reweighting at the end of the storage period (60th day). Weight loss percentage was calculated as percentage loss of initial weight.

After 60 days of cold storage, treated bags were removed from cold storage, and overall visual appearance and berry and rachis color were evaluated. The overall visual appearance of the grapes was evaluated for intensity on a 9-point scale: 1 – extremely poor or soft in case of texture; 3 – poor or soft; 5 – moderate; 7 – good; 9 – excellent (Artés-Hernández *et al.* 2004). Berry and rachis browning development were evaluated on a 5-point intensity scale of damage by using the following scoring system: 1 – none; 2 – slight; 3 – moderate; 4 – severe; 5 – extreme (Artés-Hernández *et al.* 2004). Also berry shrinkage of fruits was evaluated on a 5-point scale: 1 – very shrinkage; 2 – low shrinkage; 3 – medium; 4 – smooth; 5 – very smooth (Bourne 1980). At the end of storage period (60th day) plus 2 days at 20°C, taste analyses to compare the quality of treated and control table grapes were carried out by 10 trained panelists. A questionnaire was used to record the data; each judge evaluated five berries for each treatment for the following characteristics: visual aspect (general aspect), firmness, sweetness, juiciness, sourness and crunchiness, on a 5-point scale: 1 – very low; 2 – low; 3 – medium; 4 – high and 5 – very high (Valero *et al.* 2006).

A random sample of berries (10 berries) was sampled per replicate, juiced, and filtered to get a clear sample. Total soluble solids content (TSS) was determined by means of digital refractometer (Atago, Tokyo, Co. Ltd, Japan) and results were expressed in °Brix. Titrable acidity (TA) content was titrated with phenolphthalein as indicator using 0.1 mol/l NaOH and expressed as mmol H^+ per 100 g of fresh weight. Maturity index was expressed as the ratio of TSS to TA.

Statistical analyses

Data were analyzed using completely randomized design (CRD) with 4 replicates representing 6 clusters per treatment. Data were subjected to ANOVA analysis. Mean differences were separated by Duncan's multiple range test ($p < 0.05$). Statistical analysis of the data was performed with SAS 8. statistical data analytical software.

RESULTS

GC-MS analysis

The chemical composition of the essential oils was analyzed using a GC-MS technique. Qualitative and quantitative analytical results are shown in table 1. The major compounds found in essential oils of sweet basil, fennel, summer savory and thyme were linalool (65.25%), trans-anethole (64.42%), carvacrol (54.14%) and thymol (10.56%), respectively (Table 1).

***In vitro* antifungal efficacy of essential oils**

Evaluation of *in vitro* assay showed that thyme, summer savory and fennel oils had strong antifungal activities followed by sweet basil oil. The percentage of MGI depended on the type and concentration of essential oils used for treatments. In all concentrations, sweet basil oil showed lowest antifungal activity, but mycelial growth of the fungus was totally inhibited by fennel oil at concentration of 500 µl/l (Table 2).

Table 1. Chemical composition of essential oils

Percentage [%]	Component	Essential oil
65.25	linalool	sweet basil
4.08	l-βEudesmo	
3.86	trans-α-bergamotene	
3.62	1,8-Cineol	
64.72	trans-Anethole	fennel
14.59	fenchone	
3.37	limonene	
54.14	carvacrol	summer savory
20.59	terpinolene	
5.31	α-Phellandrene	
3.56	ϱ-Cymene	
12.62	β-Ocimene	thyme
10.56	thymol	
8.5	α-Phellandrene	
6.85	carvacrol	

Quantification of each constituent was determined by retention indices

Table 2. Effect of essential oils from sweet basil, fennel, summer savory and thyme on mycelial growth of *B. cinerea*

Essential oil concentration [µl/l]	Mycelial growth inhibition percent MGI (%)			
	sweet basil	fennel	summer savory	thyme
100	3.6 j	6.1 j	26.39 h	25.55 h
200	15.27 i	38.05 g	61.94 f	57.22 f
300	15 i	68.33 e	68.6 e	72.5 de
400	24.72 h	86.11 b	83.61 b	79.72 bc
500	42.5 g	100 a	77.78 cd	79.99 bc

Values followed by a common letter in columns are not significantly different at $p < 0.01$

Table 3. Means squares for the variance of the effects of essential oils on quality param eters of treated fruits

MI	TA	TSS	Taste	Berry shrinkage	Rachis browning	Berry browning	Cluster appearance	Weight loss	Disease severity	Significance
**	**	ns	**	*	ns	ns	**	**	**	EO
**	**	**	ns	ns	**	**	**	**	**	Con
ns	ns	ns	ns	ns	ns	ns	**	**	ns	EO * Con

EO – essential oil; Con – essential oil concentration;
*, ** and ns – Significant at $p < 0.05$, $p < 0.01$ and not significant, respectively
TSS – Total Soluble Solids; TA – Titrable Acidity; MI – Maturity Index

Table 4. Effect of different concentrations of essential oils on disease severity, berry shrinkage, berry browning, rachis browning. TSS, TA and MI

MI	TA	TSS	Berry shrinkage	Rachis browning	Berry browning	Disease severity	Concentration [µl/l]
73.6 a	0.3 b	21.94 a	4.12 a	4.24 a	2.35 b	4.97 a	Control [0]
65.14 b	0.32 b	20.16 c	3.82 ab	4.1 a	2.33 b	4.66 b	200
65.21 b	0.31 b	20.38 bc	3.62 b	3.8 b	2.77 a	4.25 c	400
58.22 c	0.36 a	20.88 b	3.51 b	3.68 b	2.92 a	4.1 c	600

Values followed by a common letter in columns are not significantly different at $p < 0.05$
TSS – Total Soluble solids; TA – Titrable Acidity; MI – Maturity Index.

Efficacy of essential oils on fungal disease severity

Results showed that essential oil treatment and different concentrations of essential oils had a good antifungal effect on treated clusters, but counter-effects (reciprocal effects) of different type and concentrations of essential oils were not significant (Table 3). According to the results, with increasing of essential oil concentrations, the antifungal activity of essential oils were increased (Table 4). Thyme and summer savory oils showed strong inhibitory effect on disease severity in treated fruits in comparison with other essential oils used (Table 5).

Efficacy of essential oils on quality sensors

The weight loss of clusters was affected by essential oil treatment and the percentage of weight loss in clusters treated with sweet basil, thyme and fennel oils was followed by summer savory oil (Table 5), although there were not any noticeable effects among different concentrations of essential oils (Table 3).

The evaluation of cluster appearance showed that the essential oil treatment had a significant effect on cluster appearance (Table 3). Along with the increase of the concentration of essential oils, the cluster's appearance was developed and summer savory oil at 600 µl/l concentration had greatest effect, while sweet basil oil in all concentrations used had not any effect on cluster appearance when compared with controls. Also, thyme and fennel oils showed great effect on cluster appearance although there were not significant differences between 400 and 600 µl/l concentrations (Fig. 2).

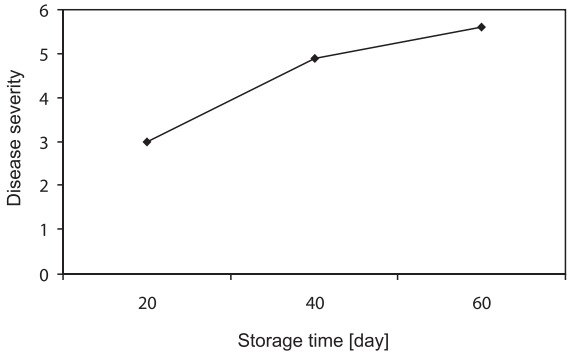
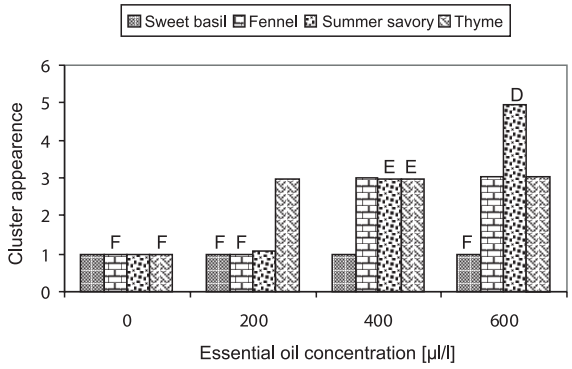


Fig. 1. Effect of storage time on disease severity

The results depicted in table 3 indicated that although spraying at different concentrations of essential oils on clusters had significant ($p < 0.01$) effect on berry and



Values followed by a common letter in columns are not significantly different at $p < 0.01$

Fig. 2. The effect of essential oil treatments on cluster appearance of fruits

rachis browning but had not noticeable differences among essential oils. Essential oil treatment caused decrease in berry and rachis browning and along with increase in essential oil concentrations used for treatment, the berry and rachis browning decreased but there were not any significant differences between 400 and 600 µl/l concentration (Table 4).

Berry shrinkage analyses showed that treatment of essential oils had no adverse effect on berry shrinkage and with increase of essential oil concentration the level of berry shrinkage decreased. The effectiveness of sweet basil oil in reduction of berry shrinkage was higher than the other essential oils (Tables 4, 5).

The sensory analyses showed that different essential oils affected the taste of treated fruits (Table 3). Sweet basil oil had better effect on taste of treated fruits as compared with other oils.

Table 5. The effect of essential oils on disease severity, berry shrinkage, taste, weight loss, TA and MI

MI	TA	Taste	Berry shrinkage	Weight loss	Disease severity	Essential oil
56.82 b	0.37 a	0.3 b	3.15 a	2.37 b	4.87 a	sweet basil
61.06 b	0.34 b	0.48 ab	2.8 b	2.39 b	4.83 a	fennel
69.28 a	0.3 c	0.6 a	2.8 b	2.82 a	4.2 b	summer savory
75 a	0.28 c	0.4 ab	2.86 b	2.78 a	4.08 b	thyme

Values followed by a common letter in columns are not significantly different at $p < 0.05$
TSS: Total Soluble Solids, TA: Titrable Acidity; MI: Maturity Index

The TSS evaluation showed that different concentrations of essential oils had significant effect on TSS of treated fruits (Table 3). TSS was lower in treated fruits than the control. Along with increases of essential oil concentration, TSS increased (Table 4). The TA was affected by the type and concentration of essential oils (Table 3) and increased in treated clusters compared to the control (Table 4). The values of maturity index in treated fruits were lower than the control and along with increase of essential oil concentration, the maturity index decreased (Table 4). In addition, fruits treated with thyme and sweet basil oils showed highest and lowest maturity index values, respectively (Table 5).

DISCUSSION

The antifungal property of several essential oils on postharvest pathogens of fruits and vegetables under *in vitro* and in vivo conditions have been investigated previously (Zambonelli *et al.* 1996; Feng and Zheng 2007). Although there are a few reports on the control of postharvest fungal decay in table grapes under *in vivo* conditions by using of essential oils. In the present study, the essential oils from sweet basil, fennel, summer savory and thyme screened for their antifungal activity under *in vitro* and *in vivo* conditions. In addition, this study provides further information on the effect of these essential oils on quality parameters of table grape during treatment with essential oils and then preservation in cold storage.

Results showed that antifungal activities of essential oils were different under *in vitro* and *in vivo* conditions and these activities were higher under *in vitro* conditions. Dikbas *et al.* (2008) noticed that these differences could be attributed to the alternation of site action of essential oils or alternation in membranes of fungi under *in vivo* condition. Thyme and summer savory oils showed a strong antifungal activity in comparison with fennel and sweet basil oils. The antifungal capacity of thyme oil also has been demonstrated by Reddy *et al.* (1998) and Feng and Zheng (2007) in relation to the reduction of postharvest fungal decays induced by *B. cinerea, R. stolonifer* and *A. alternata* on strawberry and tomato. Also Bouchra *et al.* (2003) and Viuda-Martos *et al.* (2007) reported that thyme and oregano oils showed great inhibitory effect on mycelial growth of *B. cinerea* and *Aspergillus flavus*. Dubey *et al.* (2007) described that essential oil from *Eupatorium cannabinum* had an antifungal activity against *Botryodiplodia theobromae* and *Colletotrichum gloeosporioides* causing stem end rot and anthracnose diseases in mango, respectively. In addition, they found that this essential oil had an inhibitory effect on pectinase and cellulase, two important enzymes produced by phytopathogenic fungi in disease development. Also, Tripathi *et al.* (2008) described that essential oils from *Prunus persica*, *Ocimum sanctum* and *Zingiber officinalis* showed antifungal activity and enhanced the storage life of grape up to 4, 5 and 6 days respectively.

The effectiveness of pure (alone) constituents of thymol and carvacrol as the major constituents of thyme and summer savory oils, respectively in reduction of postharvest fungal decay in table grapes have been documented previously (Martínez-Romero *et al.* 2004; Valverde *et al.*

2005; Valero *et al.* 2006; Guillén *et al.* 2007). Also Liu *et al.* (2005) reported that fumigation of plums with thymol reduced brown rot incidence in treated fruits in comparison with control.

As mentioned above thyme, summer savory and fennel oils have shown significant inhibitory activity, while less potent activity was shown by sweet basil oil. Expression of antifungal activity of essential oils is often very clear, but the mechanism of antifungal action is not completely understood. Reddy *et al.* (1998) reported that in case of thyme oil, the reduction in the growth of *B. cinerea* and *R. stolonifer* on strawberry fruits treated with it could be attributed to the reduction of spore germination of these fungi. Zambonelli *et al.* (1996) noticed that the antifungal activity of thyme oil related to its activity to degeneration of fungal hyphae. It was evident that essential oils increased membrane permeability and that compounds actually dissolved in the membranes causing swelling and reduced membrane function (Holley and Patel 2005). A lipophilic property of essential oils affect their antifungal activity via their ability to penetrate to cell wall and affects the enzymes responsible in wall synthesis reactions, therefore they altered the morphological characters of fungi (Cox *et al.* 2000; Rasooli *et al.* 2006). Many of previous studies demonstrated that the antimicrobial property of essential oils could be related to their major components and with in phenolic compounds such as thymol and carvacrol showed higher antimicrobial activity (Conner 1993). Lopez-Malo *et al.* (2006) distinguished that antimicrobial activities of phenolic compounds was related to their concentration so, at lower concentration these compounds affected enzymes associated with energy production, whereas at higher concentrations they caused protein denaturizing. Also phenolic compounds could affect the enzymes responsible for spore germination and interfere with amino acids that were necessary in germination processes (Nychas 1995). On the other hand, some authors reported that existing antagonistic and/or synergistic relationship between total components available in essential oil could affect the antimicrobial activity of essential oils and even minor components or precursors of major components might affect essential oil properties (Daferera *et al.* 2000; Ultee *et al.* 2002). From results of this study, it becomes evident that a relationship exists between the high antifungal activity of thyme and summer savory oils and the presence of phenolic compounds such as thymol (10.56%) and carvacrol (54.14%) in thyme and summer savory oils, respectively. Therefore, this observation supports the hypothesis that the essential oils that have a higher percentage of phenolic compounds are more active than the essential oils contain the alcoholic compounds (Farag *et al.* 1989).

In spite of the fact that quality parameters of table grape are important factors in evaluating the treatment effect but data on the effect of plant essential oils on postharvest quality of table grape are scarce. Weight loss is one of the most important quality parameters of table grapes which affect fruit susceptibility to fungal decay (Valverde *et al.* 2005). The percentage of weight loss in treated fruits was lower than controls. These data confirm previous reports about constituents of essential oils such as carvacrol, thymol and eugenol effects in reduction of weight loss in table grape and sweet cherry (Serrano *et al.* 2005; Valverde *et al.* 2005; Valero *et al.* 2006; Guillén *et al.* 2007). However, the mechanism by which these essential oils reduced the percentage of weight loss still unknown.

Berry and rachis browning are important factors of table grape from the consumer point of view that affect cluster appearance (Crisosto and Crisosto 2002). In this study thyme oil at 600 µl/l concentration showed greatest effect on cluster appearance in comparison with control. On the other hand berry and rachis browning in treated fruit were lower than control. Hence, great cluster appearance could be related to berry and rachis browning. Nelson (1985) described that berry and rachis browning has been linked to fruit dehydration. Being of low browning could be related to the lower weight loss in treated fruits. Moreover, browning process caused by polyphenol oxidase (PPO) enzyme (Vial *et al.* 2005) and could be speculated that essential oils might reduce the PPO activity. On the other hand the berry shrinkage score in treated berries were higher than control berries, that this could be related to slight percentage of treated fruits.

In the case of taste, essential oil treatment had not adverse effect on fruits taste. Guillén *et al.* (2007) also reported that treatment of grape berries with thymol, carvacrol and eugenol had not negative effect on grape berries taste, because essential oils were evaporated and did not have any residue on fruits. At the end of storage period, the level of TSS increased and in treated fruits TSS was lower than controls and this may be related to low weight loss in treated fruits in comparison with controls. Inhibition of fruit respiration may be caused by essential oil coating. On the other hand, TA level at the end of storage period decreased. In this experiment we found that essential oil treatment especially in high concentration decreased maturity index of the grape fruits in comparison with controls. The above agreed with previous works (Valverde *et al.* 2005; Guillén *et al.* 2007). This may be related to the inhibition of fruit respiration by essential oil coating but the reason of differences among several essential oils indeterminate. In spite of the face that results obtained in present study showed that essential oil treatments had noticeable effect on quality parameters of table grape but this results did not agree with previous reports that described essential oil treatment had not significant effect on quality factors of banana and strawberry fruits (Ranasinghe *et al.* 2005; Tzortzakis 2007).

CONCLUSION

This study demonstrates *in vitro* and *in vivo* antifungal properties of essential oils against phytopathogenic fungi and potential use of essential oils as a preservative agent for table grape preservation. However, further studies are needed to mark the optimal type of essential oil, concentration and method of use of these natural and safe products for protecting and increasing shelf life of fruits and vegetables.

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POLISH SUMMARY

BADANIA NAD POTENCJALNYM ZASTOSOWANIEM OLEJKÓW ETERYCZNYCH W ZWALCZANIU PLEŚNI I KONSERWACJI WINOGRON ODMIANY TABARZEH

Pleśń *Borytis cinerea* jest czynnikiem sprawczym większości strat pozbiorowych winogron. W badaniach testowano wpływ olejków eterycznych z roślin bazylii, kopru włoskiego, cząbru ogrodowego i tymianku zarówno na wzrost *B. cinerea* w warunkach *in vitro* jak i zgnilizny grzybowej oraz jakości winogron [*Vitis vinifera* (L.) cv. Tabarzeh], w warunkach *in vivo*. Wykazano, że olejki eteryczne, zwłaszcza z tymianku, kopru włoskiego i cząbru ogrodowego, posiadały silny wpływ na wzrost grzybni *B. cinerea*. W badaniach *in vivo* olejki z tymianku i cząbru ogrodowego redukowały podatność na gnicie winogron po 60 dniach przechowywania. Dodatkowo, olejki eteryczne posiadały znaczną wydajność pod względem parametrów jakościowych owoców, redukując straty masy, kurczenie się jagód czy ich brązowanie. Poza tym, traktowanie olejkami eterycznymi powodowało wzrost poziomów wskaźnika dojrzałości w roślinach w porównaniu z roślinami kontrolnymi. Analiza GC/MS wykazała, że głównymi składnikami zidentyfikowanymi w olejkach z bazylii, kopru włoskiego, cząbru ogrodowego i tymianku były odpowiednio: linalol (65,25%), trans-anetol (64,72%), karwakrol (54,14%) oraz β-ocymen (12,62%). Stwierdzono, że olejki eteryczne, szczególnie te zawierające więcej związków fenolowych, posiadają dużą aktywność przeciwgrzybową i mogłyby być używane jako bezpieczne konserwanty podczas przechowywania winogron.