Effects of olive scale (*Parlatoria oleae* (Colvée)) attack on yield, quality and fatty acid profile of virgin olive oil

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Summary

Olive scale (*Parlatoria oleae* (Colvée)) is a common pest in Mediterranean olive orchards which primarily causes damage on olive fruits. The quality of virgin olive oil is strongly related to the health status of the olive fruits from which is extracted. In this paper the effects of olive scale (*Parlatoria oleae* (Colvée)) attack on the oil yield, chemical and sensorial quality, as well as on the fatty acid profile of virgin olive oil were studied. Olive fruits (*Olea europea* L.) from Bova cultivar (Istria, Croatia) were collected and divided into different groups according to the presence or absence of infestation by the olive scale. Olive scale attack did not induce ripening process nor stimulate oil synthesis in the infested fruits. Healthy and infested fruit groups were processed separately to produce corresponding olive oils. As regards the oil acidity, the oil samples obtained from infested fruits had similar values as samples obtained from healthy fruits. However, olive scale attack led to slight oxidative deterioration of oil, but had no effect on sensory characteristics of obtained olive oils. Fatty acid profile was slightly affected by olive scale attack: an increase of linoleic (about 13 %) and palmitoleic acid (about 8 %), but a decrease of oleic (about 3 %) and stearic acid (about 4 %) in oils obtained from infested fruits was detected. Oleic to linoleic ratio was lower in oils obtained from infested fruits indicating its lower oxidative stability.

Keywords: Olive scale (*Parlatoria oleae* (Colvée)), virgin olive oil, quality, sensory characteristics, fatty acids

Introduction

Virgin olive oil (VOO) is extracted from olive fruits (*Olea europea* L.) by mechanical and physical methods and it is widely appreciated for its unique and delicate flavor. Moreover, virgin olive oil has been associated with health benefits linked to a Mediterranean diet (Harwood and Yaqoob, 2002). The quality of virgin olive oil depends on many agronomical and technological factors such as olive cultivar, olive tree cultivation, fruit harvesting and storage as well as olive processing step conditions (Di Giovacchino et al., 2002; Kalua et al., 2007; Kalua et al., 2013). Furthermore, the quality of VOO is strongly related to the health status of the olive fruits from which is extracted, which is confirmed in the case of olive fruit damage caused by olive fruit fly infestation (Mraicha et al., 2010; Koprivnjak et al., 2010).

Olive scale (*Parlatoria oleae* (Colvée)) is a common pest in Croatian olive orchards (Bjeliš, 2005), as well as in other Mediterranean countries (Zalom et al., 2013) and in California (USA) and Argentina (Alvarado et al., 2008) which primarily causes damage on olive fruits. Dark purple spots occur on otherwise green to yellowish fruit where the scale has settled. Heavy olive scale infestations will also occur on branches, twigs, and leaves and such infestations could reduce the productivity of a tree (Zalom et al., 2013). Olive scale has usually two generations per year, first generation is present from mid-April till the end of May while the second is present from July till September (Bjeliš, 2005; Alvarado et al., 2008), but life cycle depends closely on the local climatic conditions (Biche and Sellami, 2011).

To our knowledge, there is a lack of information about influence of olive scale attack on olive oil yield and quality. Thus, the aim of this work is evaluate for the first time the effect of olive scale attack on the olive oil yield, chemical and sensorial quality, as well as on the fatty acid profile of Bova cultivar virgin olive oil.

Materials and methods

Preparation of virgin olive oil samples

Olive fruits of Bova cultivar tree, grown in the west part of Istria region (Croatia), were handpicked on the beginning of November 2011. Fruits were immediately divided in two groups of 1.5 kg each, one containing healthy fruits and one containing infested fruits (Fig. 1), and the experiment was done in duplicate. Olive scale was determinated according to morphological characteristics described by Alvarado et al. (2008) and olive fruits with more than three purple spots on olive fruit skin were

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considered as infested fruits. The ripening index (RI) of each group of fruits was determined applying the method described by Garcia and Yousfi (2005) which is based on the evaluation of the olive skin and pulp color, ranging from 0 (bright green skin) to 7 (black skin and purple flesh). Different groups of olive fruits were processed separately using an Abencor system (MC2 Ingenieria y Sistemas, Spain) within 6 hours after harvesting. Fruits were crushed with a hammer crusher and olive paste samples were malaxed with a thermo-mixer for 45 min at 25 ± 1 °C. After centrifugation at 3500 rpm for 60 seconds, extracted olive oil samples were decanted after 4 hours and stored at room temperature in taped dark bottles filled with nitrogen until analyses.

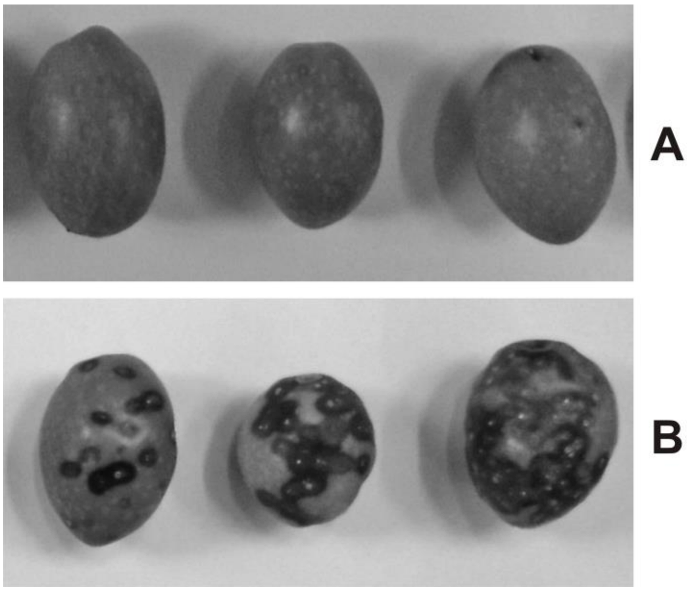

Fig. 1. Healthy fruits (A) of Bova olive cultivar and fruits infested by olive scale (B)

Preparation of olive paste samples and determination of water and olive oil content

Olive paste samples were collected during the process of preparation of virgin olive oil samples, immediately after olive fruits crushing. Obtained olive pastes were dried at 80 °C until constant weight, in order to determine the water content. Analyses were done in duplicates. Dried olive pastes were then stored at – 18 °C until analyses of olive oil content. Frozen olive pastes were gently grinded with a mortar and pestle, and then redried before extraction.
Olive oil content in dry olive paste was determined according to Brkić et al. (2006) using the semi-automated Soxtec apparatus (Soxtec Avanti 2055, Foss Tecator, Sweden). Approximately 3 g of dried paste was weighed in cellulose thimbles and inserted into the extraction unit. Weighed aluminum vessels were filled with 50 ml of solvent (petrolether, b.p. 40-70 °C p.a., purchased from Kemika, Croatia) and inserted into the extraction unit as well. The temperature was set at 135 °C, which is the temperature setting recommended by the manufacturer for the solvent used. The program was: 30 minutes of boiling, 60 minutes of rinsing, 15 minutes of evaporation and recuperation of the solvent, and finally 20 minutes of drying the aluminum vessels containing the extracted oil. Drying of the sample was continued in an oven at 80 °C for one hour, weighing was done every 30 minutes until constant weight was reached. Analyses were done in duplicates. The percentage of olive oil in dried olive paste was determined gravimetrically.

Trade quality parameters and fatty acid composition of VOO

Free fatty acids (FFA), peroxide value (PV), spectrophotometric indices (K_{232} and K_{270}) and fatty acid composition were determined in olive oil samples according to the analytical methods described in the European Commission Regulation EEC 2568/91 (EEC, 1991).

Sensory analysis of VOO

Quantitative descriptive analysis and quality grading of olive oil samples was performed by a panel of eight assessors trained for VOO sensory analysis. Different pleasant odor and taste attributes as well as unpleasant attributes were quantified using a six-point intensity ordinal rating scale from 0 (no perception), 1 (scarce), 2 (light), 3 (middle), 4 (strong) to 5 (extreme). For quality grading, a nine-point overall rating scale from 1 (the lowest quality) to 9 (the highest quality) was applied.

Statistical analysis

Differences among samples were tested by the one-way analysis of variance at 5 % significance level. The homogeneity of variance was tested by the Levene test. The mean values were compared by the Tukey's honest significant difference test ($p \leq 0.05$). Statistical analyses were performed using the software package Statistica version 9 (Stat-Soft, Tulsa, OK, USA).

Results and discussion

Effect on RI, oil yield and water content

The ripening index (RI) of the fruits is usually used as a tool for harvesting date determination and it is based on evaluation of on skin and pulp color of the fruits. Bova cultivar fruits were harvested on the beginning of November when fruit's skin became green-yellowish, since early harvesting period is common practice for autochthonous olive cultivars in Istria region (Croatia). According to the results of RI shown in Table 1, it could be concluded that olive scale attack did not induce ripening process of Bova cultivar fruits. Beltran et al. (2004) reported that the oil content depends on olive fruit ripening stage of some Spanish and Italian cultivars (Picual, Hojiblanca and Frantoio). Probably because the ripening process was not induced by olive scale infestation, stimulation of oil accumulation or water content reduction in the infested fruits was not detected (Table 1).

Table 1. Ripening index (RI), water content in samples of fresh olive paste and oil content in dry olive paste of Bova cultivar obtained from healthy fruits and fruits infested by olive scale

	Healthy	Infested
RI	1.10 ± 0.15^a	1.25 ± 0.10^a
Water content (%)	53.37 ± 0.29^a	54.43 ± 0.40^a
Oil content in dry paste (%)	31.33 ± 1.01^a	32.33 ± 0.74^a

Results are mean values of four measurements (2 independent replications x duplicate analysis). The means within each row, labelled by different letters, are significantly different (Tukey's test, $p < 0.05$).

Effect on VOO quality parameters

Influence of infestation of the fruits by olive scale on quality parameters of obtained olive oil were shown in Table 2. FFA value is the quality parameter that is correlated to the extent of pulp cellular structure injury because of disruption of oil-containing vacuole and consequently oil exposure to endogenous lipase (Koprivnjak et al., 2010). Obtained results show that there was no significant increase of the FFA value in oils obtained from infected fruits, which indicates absence of lipolytic breakdown progress caused by olive scale attack (Table 2). In this case olive scale infestation does not cause extensive damage and breakdown in the olive pulp, probably due to early harvest of Bova fruits when the pulp were still firm and therefore less sensitive to mechanical damage. These conditions do not favor the entrance and development of fungi and bacteria responsible for the activity of hydrolytic enzymes and lipolytic activity that can cause increase of FFA.
On the other hand, PV, an indicator of olive oil oxidative degradation, increased (about 30 %) in oils obtained from infested fruits (Table 2). Nevertheless, the PV value remained much lower than maximum limit for extra virgin olive oil (EVOO) category that is 20 milliequivalents of oxygen per kg of oil according to the current EU legislation (EEC, 1991). Attack of olive scale also influenced a slight increase of values of two others oxidative degradation indicators, spectrophotometric indices K_{232} and K_{270} (Table 2). The main reason of oil oxidation was probably the exposure to the oxygen because of damage at fruits skin caused by olive scale attack (Fig. 1B). Since the olive skin was damaged, it became more susceptible to the effects of atmospheric conditions and therefore to oxidation. Considering those quality parameters, even oils obtained from infested fruits were slightly deteriorated, they still remained within EVOO category (EEC, 1991).

Effect on VOO sensory quality

Although slight oxidative degradation was detected by chemical analysis in oils obtained from infested fruits, the olive scale attack did not influence the occurrence of any sensory defect of the obtained oils (Fig. 2). Moreover, the results of sensory analyses showed that olive scale attack had no effect on intensities of positive sensory characteristics of obtained olive oils (Fig. 2). Consequently, significant difference between the sensory score of oils obtained from healthy fruits and oils obtained from infested fruits was not found (Table 2). Since ripening degree of olive fruits is strongly related to intensities of positive sensory characteristics of obtained olive oil (Brkić Bubola et al., 2012), the occurred stability of sensory profile could be due to the absence of induced ripening caused by olive scale attack.

Table 2. Quality parameters (free fatty acids, peroxide value, spectrophotometric indices K_{232} and K_{270}, and sensory score) of Bova cultivar virgin olive oil samples obtained from healthy fruits and fruits infested by olive scale

	Healthy	Infested	EVOO*
Free fatty acids (% oleic acid)	0.15 ± 0.01^a	0.16 ± 0.01^a	≤ 0.8
Peroxide value (meq O_2/kg)	9.55 ± 0.08^b	12.69 ± 0.09^a	≤ 20
K_{232}	1.94 ± 0.04^b	2.21 ± 0.01^a	≤ 2.50
K_{270}	0.13 ± 0.00^b	0.15 ± 0.00^a	≤ 0.22
Sensory score	8.09 ± 0.27^a	7.75 ± 0.71^a	≥ 6.50

Results are mean values of four measurements (2 independent replications x duplicate analysis). The means within each row, labelled by different letters, are significantly different (Tukey's test, $p < 0.05$). *Actual limits for extra virgin olive oil category (EEC, 1991), except for sensory score

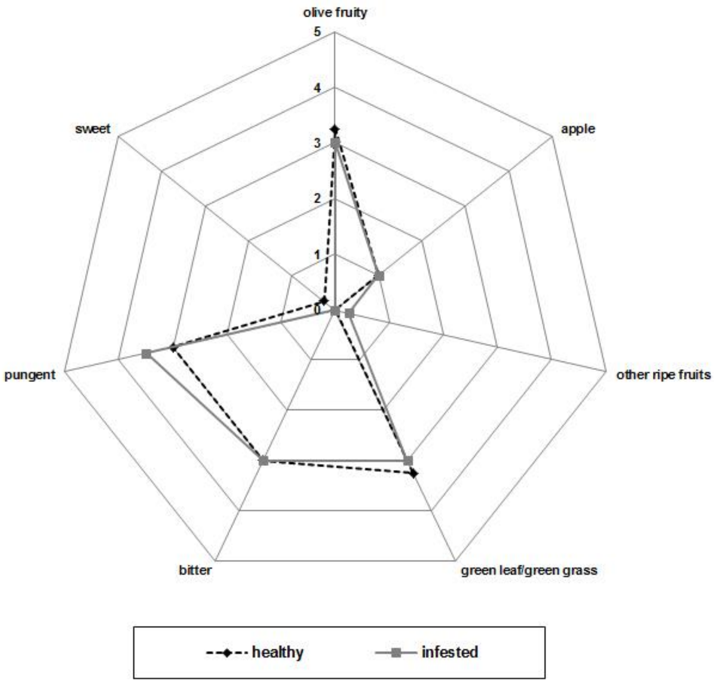

Fig. 2. Sensory profile of Bova cultivar virgin olive oils obtained from healthy fruits and infested by olive scale. Results for each group are means of 2 independent replication values (median of eight assessments for each descriptor). Numbers 0-5 represent perception intensity of sensory characteristics: 0 (no perception), 1 (scarce), 2 (light), 3 (middle), 4 (strong), 5 (extreme)

Effect on fatty acids

In the Table 3 fatty acid composition of Bova cultivar virgin olive oils obtained from healthy fruits and fruits infested by olive scale are presented. A significant increase of linoleic acid (about 13 %) and decrease of oleic acids (about 3 %) in oils obtained from infested fruits were detected. Oleic to linoleic acid ratio is frequently used as an oxidative stability parameter of virgin olive oil and high ratio (>7) favorably influences oil oxidative stability (Velasco and Dobarganes, 2002; Matos et al., 2007). Due to above mentioned decrease of oleic and increase of linoleic acid, the oleic to linoleic ratio was lower in oils obtained from infested fruits indicating their lower oxidative stability (Table 3). Moreover, oils obtained from infested fruits had oleic to linoleic acid ratio lower than 7 indicating low resistance to oxidation, which is in accordance to their oxidative degradation determined by quality parameters (Table 2). Furthermore, significant increase of palmitoleic acid (about 8 %) and decrease of stearic acid (about 4 %) in oils obtained from infested fruits were detected. Since palmitoleic and stearic acid are fatty acids usually presented in virgin olive oils in low levels, slight changes occurred in their levels probably did not significantly affect the oxidative stability of the olive oil obtained from infested fruits.

Table 3. Fatty acid composition (%) of Bova cultivar virgin olive oil samples obtained from healthy fruits and fruits infested by olive scale

	Healthy	**Infested**
Myristic (C14:0)	0.01 ± 0.00^a	0.01 ± 0.00^a
Palmitic (C16:0)	15.52 ± 0.40^a	16.13 ± 0.18^a
Palmitoleic (C16:1)	1.97 ± 0.03^b	2.13 ± 0.02^a
Margaric (C17:0)	0.05 ± 0.01^a	0.05 ± 0.00^a
Heptadecenoic (C17:1)	0.10 ± 0.01^a	0.11 ± 0.00^a
Stearic (C18:0)	2.18 ± 0.02^a	2.09 ± 0.01^b
Oleic (C18:1)	68.39 ± 0.30^a	66.34 ± 0.09^b
Linoleic (C18:2)	9.65 ± 0.04^b	10.93 ± 0.03^a
Arachidic (C20:0)	0.45 ± 0.01^a	0.43 ± 0.00^a
Linolenic (C18:3)	1.15 ± 0.00^a	1.22 ± 0.00^a
Eicosenoic (C20:1)	0.32 ± 0.01^a	0.31 ± 0.01^a
Behenic (C22:0)	0.15 ± 0.00^a	0.16 ± 0.00^a
Erucic (C22:1)	0.00 ± 0.00^a	0.00 ± 0.00^a
Lignoceric (C24:0)	0.10 ± 0.00^a	0.10 ± 0.00^a
Oleic/linoleic ratio (C18:1/C18:2)	7.09 ± 0.00^a	6.07 ± 0.01^b

Results are mean values of four measurements (2 independent replications x duplicate analysis). The means within each row, labelled by different letters, are significantly different (Tukey's test, $p < 0.05$).

Conclusions

The results obtained in this work suggested that olive scale attack have no influence on ripening process of the fruits, as well as on oil synthesis or water content reduction in infected fruits of Bova cultivar. Since olive scale does not cause extensive damage and breakedown in the olive pulp, oils obtained from infested fruits have similar acidity and sensory profile related to oils obtained from healthy fruits. However, damage on the olive skin caused by olive scale attack influences slight oxidative deterioration of obtained oil and reduces its oxidative stability.

It is well known that different varieties could be distinctly susceptible to certain pests attack and that virgin olive oil can have quite idiosyncratic varietals behavior. In order to understand better the effect of olive scale attack on quantity and quality of compositionally different VOOs, further investigation involving a wide number of olive cultivars are desirable.

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References

Alvarado M., Civitanos M., Durán J.M. (2008): Plagas. In: El Cultivo del Olivo 6.[a] edición, Barranco D. et al. (*eds*.), Madrid, Spain: Ediciones Mundi Prensa y Junta de Andalucia, pp.534-537.

Beltran, G., Del Rio, C., Sanchez, S., Martinez, L. (2004): Seasonal changes in olive fruit characteristics and oil accumulation during ripening process, J. *Sci. Food Agric.* 84, 1783-1790.

Biche M., Sellami M. (2011): Biology of Parlatoria oleae C (Homoptera, Dispididae) in the area of Cap-Djenet (Algeria), *Agr. Biol. J. N. Am.* 2, 52-55.

Bjeliš, M. (2005): Olive Protection in Ecological Production, Split, Croatia: Graf form, pp. 70 (*in Croatian*).

Brkić Bubola, K., Koprivnjak, O., Sladonja, B., Škevin, D., Belobrajić, I. (2012): Chemical and sensorial changes of Croatian monovarietal olive oils during ripening, *Eur. J. Lipid Sci. Technol.* 114, 1400-1408.

Brkić, K., Radulović, M., Sladonja, B., Lukić, I., Šetić, E. (2006): Application of Soxtec apparatus for oil content determination in olive fruit, *Riv. Ital. Sostanze Gr***.** 83, 115-119.

Di Giovacchino, L., Sestili, S., Di Vincenzo, D. (2002): Influence of olive processing on virgin olive oil quality, *Eur. J. Lipid Sci. Technol.* 104, 587-601.

EEC: Characteristics of olive oil and olive-residue oil and the relevant methods of analysis. Regulation EEC/2568/91 and latter modifications, *Off. J. Eur. Commun*. 1991, L24, 1-83.

Garcia, J.M., Yousfi, K. (2005): Non-destructive and objective methods for the evaluation of the maturation level of olive fruit, *Eur. Food Res. Technol.* 221, 538-541.

Harwood, J.L., Yaqoob, P. (2002): Nutritional and health aspects of olive oil, *Eur. J. Lipid Sci. Technol.* 104, 685-697.

Kalua, C.M., Bedgood Jr., D.R., Bishop, A.G., Prenzler, P.D. (2013): Flavour quality critical production steps from fruit to extra-virgin olive oil at consumption, *Food Res. Int.* 54, 2095-2103.

Kalua, C.M., Allen, M.S., Bedgood Jr., D.R., Bishop, A. G., Prenzler, P.D., Robards, K. (2007): Olive oil volatile compounds, flavour development and quality: A critical review, *Food Chem.* 100, 273-286.

Koprivnjak, O., Dminić, I., Kosić, U., Majetić, V., Godena, S., Valenčič, V. (2010): Dynamics of oil quality parameters changes related to olive fruit fly attack, *Eur. J. Lipid Sci. Technol.* 112, 1033-1040.

Matos, L.C., Cunha, S.C., Amaral, J.S., Pereira, J.A., Andrade, P. B., Seabra, R. M.,. Oliveira, B. P. P. (2007): Chemometric characterization of three varietal olive oils (Cvs. Cobrançosa, Madural and Verdeal Transmontana) extracted from olives with different maturation indices, *Food Chem.* 102, 406-414.

Mraicha, F., Ksantini, M., Zouch, O., Ayadi, M., Sayadi, S., Bouaziz, M. (2010): Effect of olive fruit fly infestation on the quality of olive oil from Chemlali cultivar during ripening, *Food Chem. Toxicol.* 48, 3235-3241.

Velasco, J., Dobarganes, C. (2002): Oxidative stability of virgin olive oil, *Eur. J. Lipid Sci. Tech.* 104, 661-676.

Zalom, F.G., Vossen, P.M., Van Steenwyk, R.A., Sibbet, G.S., Ferguson L.: UC IPM Pest Management Guidelines: Olive. http://www.ipm.ucdavis.edu/PMG/r583300311.html#REFERENCE. Accessed on 12th of August, 2013.

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