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Effect of the Type of Water Used in Irrigation of Olive Trees on the Storability of Olive Oil at Room Temperature

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Abstract: This study covers the effect of irrigation of olive trees with water of different types (treated wastewater, well water and rain-fed) on the storability of the produced olive oil at room temperature (10-30°C). The results of the fatty acid profile revealed that the fresh olive oil samples contain about 16-18% palmatic, 2.3-2.4% stearic, 61-65% oleic, 14-17% linoleic and 0.7-0.9% linolenic acid. It was observed that water type had no significant effect on the quantity of both palmitic and stearic acids. On the contrary, water type affected significantly the quantity of oleic, linoleic and linolenic acids. Higher quantities of linoleic and linolenic and lower one of oleic acids were present in olive oils taken from rain-fed olive trees. It was evident that the type of water used in irrigation had a significant effect on the storability of olive oil where rain-fed olive trees produced olive oil that had the best storability i.e lower acidity, lower peroxide values, higher total phenol content, higher sensory scores for the positive sensory attributes with the absence of negative ones. Taking into consideration the type of package used in storage of olive oil at room temperature (10-30°C), the data obtained revealed that metal cans were the worst in preserving the olive oil quality parameters followed by plastic containers whereas glass containers gave the best results. Regarding the storage time (0, 3, 6 and 9 months), the results showed that more deterioration for the quality of olive oil was achieved after 6 months storage.

Key words: Irrigation water quality, storability of olive oil, sensory properties, chemical properties, packaging materials

INTRODUCTION

Olive is considered one of the most important crops in Jordan with an annual production of 250,000 tons of olive fruits and 35 000 tons of olive oil (Ministry of Agriculture, 2009). Jordan ranks the tenth on the list of the world's nations in olive oil production (IOOC, 2005). One of the strategies to be adopted to alleviate the water shortage problem in Jordan is to use The Treated Wastewater (TWW) in irrigation purposes. As a result, 19 TWW treatment plants generating 80 million cubic meter of treated wastewater per year were established in the last few years (Al-Shdiefat *et al*., 2009).

Bedbabis *et al*. (2010) studied the effect of wastewater irrigation on the extra virgin olive oil quality from the Tunisian cultivar Chemlali. They observed a significant decrease in the phenols content of the oils obtained from olive trees irrigated with treated wastewater.

Light exposure, temperature and oxygen concentration influence virgin olive oil quality and freshness during transportation, storage and consumption (Curtis *et al*., 2006). Polyphenols are highly sensitive compounds in oil and they are not stable to heat and light in bad storage conditions. Therefore, optimization of best conditions of heat, light and packaging materials is very important to preserve polyphenols and their antioxidant activity (Tsimidou *et al*., 1992). Curtis *et al*. (2006) studied the effect of light and dark storage of virgin olive oil for 12 months at ambient and low temperature. They found that virgin olive oil stored in the dark at low temperature (1°C) had characteristics closest to fresh oil while oil stored with light exposure showed the largest departure from freshness. Naz *et al*. (2005) reported that exposure of olive oil to heat, oxygen and light caused alteration to its composition especially fatty acid and antioxidant contents, resulting in lowering its health benefits.

The main objectives of this study are to study the effect of irrigation of olive trees with different types of water (rainfed, well and reclaimed water) on the storability of the produced olive oil at room temperature.

MATERIALS AND METHODS

Experimental design, olive orchard and irrigation treatments: The experiment was carried out during 2009 growing seasons (from March to November), using 15-year old 'Nabali Muhasan' olive trees planted at 3 x 6 m distance (density of 550 trees/ha). The orchard is located in Alhashemia area in the north-east of Jordan. Soil texture is silty clay; the summer temperature in this area often exceeds 30°C and the average winter rainfall is about 100-200 mm annually.

The experiment was designed to include three treatments, each consisted of 20 trees in two rows. All 20 olive trees in each treatment were irrigated with the

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same amount of water (300 L) twice monthly except the 20 trees on the rain water treatment which was considered as the control where only 75 L water was given to each olive tree for sustainability purposes. Irrigation treatments began on middle of July and continued until middle of November resulting in 8 irrigations. The selected trees were irrigated With Treated Wastewater (TWW) which was taken from a neighboring treating plant, fresh Well Water (WW) and Rain Water (RW).

Analytical determinations in irrigation water: Three samples of each types of water (WW), (RW) and (TWW) were collected and analyzed according to standard methods (Eaton *et al*., 1995).

Olive fruits harvesting and pressing: The 20 olive trees for each treatment were harvested by hand during the last week of November 2009. Olive fruits were sent to the mill in a 25 kg ventilated plastic boxes. Olives were stored at ambient temperature (15-20°C) for a maximum duration of 48 hrs. The olive fruits were milled at low temperature (28-32°C) using centrifugal experimental press of the type Olimio Mini 50 of the capacity 50 kg/hr.

Olive oil filling and storage: Three representative samples of olive oil extracted from olive fruits harvested from olive trees irrigated with (TWW), (WW) and (RW) were collected; the olive oil was mixed and filled in 3 types of containers i.e. metallic, glass and plastic of 1.5, 1 and 1 L capacity respectively. Olive oil samples filled in the different containers were stored in the dark at room temperature (15-30°C) for a duration of 9 months.

Olive oil analysis: Free acidity and peroxide value were determined according to the EC regulation no. 2568/91 (EC, 1991). Total phenols content were measured in the polar fraction extracted from 15 g olive oil using methanol-water mixture (60:40 v/v); the determination based on Folin-Ciocalteu method (Eaton *et al*., 1995); results were expressed as mg gallic acid/kg oil. Fatty acid composition was determined following the EC Regulation no. 2568/91 (EC, 1991).

Sensory evaluation of olive oil samples: Sensory evaluation was carried out on the fresh as well as stored olive oil samples by 12 trained olive oil tasters using the official International Olive Oil Council (IOOC) testing methodologies (IOOC, 2007). The panel of assessors were recognized by IOOC.

Statistical analysis: Data were analyzed using one-way analysis of variance (SAS, 2004). Means were compared using Duncan's multiple range tests. Significance was set at ($p \leq 0.05$). The means for each sensory olive oil attribute was also calculated using the IOOC statistical computer program (IOOC, 2007) and accordingly the classification of the oil was determined.

Table 1: Effect of package type on some of the chemical properties of stored olive oil

Package type	Free acidity % Oleic acid/100 g	Peroxide value meq O_2/kg	Total poly-phenols mg/kg
Metal	0.65a	21.30a	158.60b
Plastic	0.61a	13.66b	181.30a
Glass	0.56b	12.00c	180.30a

RESULTS AND DISCUSSION

Characteristics of irrigation water: Chemical and physical characteristics of Well Water (WW), Rain Water (RW) and Treated Wastewater (TWW) were determined (data are not included). It is clear from the obtained results that the levels of many quality parameters (EC, TDS, Ca, Mg, Na, Cl and SO_4) of WW did not achieve the Jordanian Standards for ground water (Andre, 2003). The high levels of these parameters indicate the high salinity of this type of water (WW). Such nonconformity may have some negative effect on the sensory quality of the olive oil (Wiesman *et al*., 2004).

Effect of package type on some of the chemical properties of stored olive oil: It is obvious from data presented in Table 1, that glass containers achieved the best results in preserving the chemical properties of the olive oil stored at room temperature followed by plastic containers, whereas metal containers were the worst with this regard. These results agree with those reported by Al-Ismail *et al*. (2010) who found that storing of olive oil in metallic cans at room temperature for 7 months affected negatively its quality.

Effect of type of water used in irrigation of olive trees on some fatty acid composition of fresh and stored olive oil: Results in Table 2 show that irrigation water type had no effect on the three fatty acids i.e palmatic, stearic and oleic. On the other hand, rain-fed treatment gave olive oil containing higher amounts of both linoleic and linolenic fatty acids compared to the other two treatments. Higher values for oleic acid and lower one for lenolic acid was reported by other researchers (Gomez-Alonso *et al*., 2007). Regarding the effect of storage at room temperature on the fatty acid composition of olive oil, it was apparent that storage for 9 months at room temperature (15-30°C) had no effect on the studied fatty acids with an exception for the stored olive oil of the rain-fed treatment which showed a slight although significant ($p \geq 0.05$) increase in palmatic, stearic and oleic acids. However, the level of the five studied fatty acids in the different olive oil samples are within the permitted level as mentioned by the International Olive Oil Council (IOOC, 2006).

Table 2: Effect of type of water used in irrigation of olive trees on some fatty acid composition of fresh and stored olive oil

Irrigation water type	Palmatic	Stearic	Oleic	Linoleic	Linolenic
	---------- Fresh olive oil ----------				
Rain	17.00b	2.30b	61.06b	16.52a	0.90a
Well	15.89b	2.38b	65.30b	13.70b	0.73b
Treated wastewater	16.20b	2.40b	63.21b	15.00b	0.85a
	---------- 12 months stored olive oil ----------				
Rain	22.90a	2.90a	68.60a	19.20a	1.00a
Well	17.00b	2.35b	64.55b	13.40b	0.74b
Treated wastewater	-----	2.30b	63.87b	14.15b	0.81a

Table 3: Effect of type of water used in irrigation of olive trees on some of the chemical properties of stored olive oil

Irrigation water type	Free acidity % Oleic acid/100 g	Peroxide value meq O_2/kg	Total polyphenols mg/kg
Rain	0.44a	19.30a	159.60b
Well	0.23b	10.80c	181.00a
Treated wastewater	0.37a,b	17.50b	124.65c

Table 4: Effect of storage duration at room temperature (15-30°C) on some of the chemical properties of olive oil

Storage duration (month)	Free acidity % Oleic acid/100 g	Peroxide value meq O_2/kg	Total polyphenols (TPC) mg/kg
0	0.06d	0.66c	235.00a
3	0.33c	0.97c	204.73c
6	0.40b	22.66b	218.00b
9	0.58a	32.87a	125.05d

Effect of type of water used in irrigation of olive trees on some of the chemical properties of stored olive oil: Table 3 lists some of the stored olive oil chemical properties as affected by the different types of irrigation water. It is obvious from data in Table 1 that there were slight changes in the free acidity of the 9 months stored olive oils made from trees received the 3 types of irrigation water (WW, RW and TWW). The free acidity values ranged between 0.23 and 0.44% (%oleic acid/100 g olive oil), however, those values were still less than the permitted upper limit of 0.8% oleic acid/100 g for free acidity as mentioned by the local standard for extra virgin olive oil (JS, 2004). It is clear from data in Table 3 that the nine months stored olive oil samples had peroxide values ranging from 10.8-19.30 meq O_2/kg olive oil; those peroxide figures are still considered acceptable since they are less than the maximum permitted limit of 20 meq O_2/kg according to the national standard for olive oil. On the other hand, marked loss could be observed in the Total Phenol Content (TPC) of the 9 months stored olive oil; the highest loss (47%) was in the olive oil obtained from trees irrigated with treated wastewater, while the lowest (24%) was for olive oil obtained from well water treatment. Such results agree with those reported by other researchers (Al-Ismail *et al*., 2010; Psomiadou and Tsimidou, 2002) who found a remarkable decrease in TPC of olive oil samples during storage. However, it can be concluded from data in Table 3 that the well water treatment gave olive oil having the best storability at room temperature with regard to chemical properties followed by rain-fed treatment.

Effect of storage duration at room temperature (15-30°C) on some of the chemical properties of olive oil: Acidity and peroxide values (Table 4) showed a progressive and significant ($p \geq 0.05$) increase throughout the storage period indicating a deteriorative process in the olive oil quality. However, the acidity values remained less than 0.8% oleic acid/100 g after 9 months storage at room temperature (15-30°C) meaning that the stored olive oil still conforms to the local standard with regard to acidity. On the other hand, peroxide values exceeded the permitted levels (20 meq O_2/kg) after 6 months storage at room temperature. Additionally, marked and significant changes ($p \geq 0.05$) could be observed in the TPC after 9 months storage at room temperature; these results agree with those reported by other researchers (Al-Ismail *et al*., 2010; Psomiadou and Tsimidou, 2002) who found a sharp decrease in TPC of olive oil samples during storage.

Effect of irrigation water type, package type and storage duration at room temperature (15-30°C) on the sensory attributes of olive oil: Data (not included) relating to the effect of irrigation water type (WW, RW and TWW), storage duration at room temperature (15-30°C) and effect of package on the sensory properties of the studied olive oil samples show that the median for the positive sensory properties i.e. fruity, bitter and pungency of the fresh olive oil samples was 4.00, 3.25 and 4.00 respectively with the absence of any negative attribute. Such scores for the fresh olive oil classify it as extra virgin (IOOC, 2007; JS, 2004). It is clear from the obtained sensory data that the RW treatment gave olive oil characteristic with higher positive attributes compared with the other two treatments (WW, TWW). Such variations might be attributed to the differences in the irrigation water composition (Alsaed *et al*., 2011). Considering the effect of storage duration, it was noticed that increasing of storage time caused a decrease in the positive sensory attributes as well as the appearance of

negative sensory attributes particularly after 6 months of storage. These results agree with those reported by Naz *et al*. (2005) and Kalua *et al*. (2006).

Regarding the effect of package type on the sensory properties of olive oil, it was apparent that olive oil filled in glass bottles retained the highest positive sensory properties for 6 months with no presence for the defects. Plastic containers were scored second and metallic containers the 3rd or the worst since the negative attributes started to appear after 3 months of storage.

Conclusion: According to the obtained results, it is advised to use RW or WW in irrigation of olive trees and to store olive oil in glass or plastic containers taking into consideration that storage duration at room temperature will not extend more than 9 months. It is also recommended to have further studies on the effect of using TWW in the irrigation of olive trees.

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REFERENCES

Al-Ismail, K.M., A.K. Alsaed, R. Ahmad and S. Ayoub, 2010. Influence of irrigation water quality on the chemical properties of olive oil. La Rivista Italiana Delle Sostanze Grasse, 87: 82-88.

Alsaed, A., S. Ayoub, K. Al-Ismail, R. Ahmad and S. Abdel-Qader, 2011. Influence of water quality used in irrigation on the sensory properties of olive oil, Accepted for publication in La Rivista Italiana Delle Sostanze Grasse.

Al-Shdiefat, S., S. Ayoub and K. Jamjoum, 2009. Effect of irrigation with reclaimed waste water on soil properties and olive oil quality. Jordan J. Agric. Sci., 5: 128-141.

Andre, P.M., 2003. Wastewater reuse in localized irrigation, EAU and Irrigation: Water and Irrigation News, October Issue.

Bedbabis, S., B. Ben Rouina and M. Boukhris, 2010. The effect of waste water irrigation on the extra virgin olive oil quality from the tunisian cultivar chemlali, Scientia Horiculturae, in press.

Curtis, M.K., D.R. Bedgood, A.G. Bishop and P.D. Prenzler, 2006. Discrimination of storage conditions and freshness in virgin olive oil. J. Agric. Food Chem., 54: 7144-7151.

Eaton, A.D., L.S. Clesceri and A.E. Greenberg, 1995. Standard Methods for the Examination of Water and Wastewater. APHA, AWWA, WEF, 19th Edn., Washington, DC.

EC Regulation, 2568/91, 1991. On the characteristics of olive oil and olive residue oil and relevant methods of analysis. Official J. L, 248, p: 1.

Gomez-Alonso, S., V. Mancebo-Campos, M. Alvador and G. Fregapane, 2007. Evolution of major and minor components and oxidative indices of virgin olive oil during 21 months storage at room temperature. Food Chem., 100: 36-42.

IOOC, 2005. International Olive Oil Council, world olive oil figures, from http://www.internationaloliveoil.org/economics2.asp.

IOOC, 2006. International Olive Oil Council, Trade standard applying to olive oils and olive-pomace oils. COI\T.15/NC no.3/Rev.2, Madrid, Spain.

IOOC, 2007. International Olive Oil Council. Sensory analysis of olive oil method for the organoleptic assessment of virgin olive oil. COI\T.20\Doc. no. 15\Rev.

JS, 2004. Jordan Institution for Standards and Metrology. Olive oil and olive-pomace. Standard JS3, (Arabic).

Kalua, C., D.R. Bedgood, A.G. Bishop and P.D. Prenzler, 2006. Discrimination of storage conditions and freshness in virgin olive oil. J. Agric. Food Chem., 54: 7144-7151.

Ministry of Agriculture, 2009. Olive oil mills distribution in the country. Olive Office, Ministry of Agriculture, Amman, Jordan.

Naz, S., R. Siddiqi, H. Sheikh and S.A. Sayeed, 2005. Deterioration of olive and soybean oils due to air, light, heat and deep frying. Food Res. Int., 38: 127-134.

Psomiadou, E. and M. Tsimidou, 2002. Stability of virgin olive oil. 1. Autoxidation studies. J. Agric. Food Chem., 50: 716-721.

SAS Institute, 2004. SAS User's Guide in Statistics, SAS Institute Inc. Cary, NC., USA.

Tsimidou, M., G. Papadopoulos and D. Boskou, 1992. Phenolic compounds and stability of virgin olive oil. Food Chem., 45: 141-144.

Wiesman, Z., D. Itzhak and N. Ben Dom, 2004. Optimization of saline water level for sustainable Barnea olive and oil production in Palestine desert conditions. Scientia Horticulturae, 100: 257-266.