Oil Characteristics of Four Palestinian Olive Varieties

Enrico Maria Lodolini^{1*}, Serena Polverigiani¹, Saed Ali², Mohammed Mutawea², Mayyada Qutub³, Taysir Arabasi³, Fabio Pierini³, Mohammed Abed⁴ and Davide Neri⁵

¹ Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università Politecnica delle Marche, Ancona, ITALY

² Union of Agricultural Work Committees (UAWC), Ramallah, THE STATE OF PALESTINE

³ Gruppo di Volontariato Civile (GVC), Bologna, ITALY

⁴ National Agricultural Research Center (NARC), Qabaty, THE STATE OF PALESTINE

⁵ Fruit Tree Research Center - Council for Agricultural Research and Economics, Rome, ITALY

Abstract: Olive oil represents an important source of income for Palestinian farmers in local, national and international markets. Sometimes, olive oil produced in local climatic conditions, does not achieve the International Olive Council (IOC) trade standards so that international markets are precluded. The oil chemical composition and sensory profile of four Palestinian olive varieties (Nabali Baladi, Nabali Mohassan, Sourì and K18) were characterized in 2010 throughout an *in situ* evaluation. Most of the physico-chemical characteristics and the fatty acid composition of the varieties met the International Olive Council trade standards (IOC-TS) for extra virgin olive oils. Values of K_{270} for Nabali Baladi and linolenic acid for Sourì slightly exceeded the limit. Eicosanoic acid exceeded the IOC-TS limits in the oils of all considered varieties. Among the sterols, the Δ -7-stigmastenol resulted too high for Nabali Baladi and Sourì. Sensory profile for the tested varieties showed a reminiscence of tomato or artichoke and light to medium bitter and pungent sensations. Results represent an important baseline reference for further studies about oil composition and quality of the main Palestinian olive germplasm and provide indication of potential critical points to be controlled in order to ensure the full achievement of IOC-TS and access international markets.

Key words: IOC-TS, fatty acid composition, sterol content, total polyphenols, sensory analysis

1 Introduction

Palestinian areas cultivated with olive trees account for more than 80% of the agricultural land surface, meaning about 76,000 hectares¹⁾. Olive cultivation represents a pivotal contribution to the social and economical wellbeing of Palestinians. Olive harvest account for about the 12% of the total national agricultural output, reaching the 20% in the West Bank, and represents about 4.6% of the Palestinian gross domestic product²⁾. The main olive productive areas are located in the western and northern West Bank. The areas of largest groves are Jenin with a total olive cultivated surface of 17,974 ha, Nablus (18,373 ha), Tulkarem (11,863 ha) and Ramallah (14,832 ha)³⁾.

Due to the ancient origin of olive cultivation in the region^{4,5)}, the Palestinian olive germplasm is characterized by a high level of diversity. Nevertheless, no successful experiences exist nowadays in establishing a complete database of the Palestinian olive germplasm based on molecular markers⁶⁾ nor on physico-chemical oil features. A description of the oil quality, phenols and sterols composition and of sensory profile is still lacking even for the most economi-

cally relevant cultivars.

Nabali (Baladi and Mohassan) and Sourì represent the most diffused cultivars in Palestine⁶⁾ and together with K18 are used for both oil and table olives production.

A full characterization of the main Palestinian olive germplasm would be essential in order to identify the different cultivars (or clones) present in each area, thus setting the necessary background for future breeding and olive germplasm valorization. Furthermore a germplasm characterization would be of service to scientific purposes allowing to univocally link all future projects conducted on the same cultivars. The detailed definition of oil characteristics would be beneficial, at farm level, during new olive orchard installation or in adult groves in order to improve the precision of field management practices and to monitor potential quality weakness.

The objective of this study was to achieve a systematic description of oil physico-chemical and sensorial character-

Abbreviations: IOC-TS, International Olive Council - Trade Standards; EVOO, Extra Virgin Olive Oil; PCA, Principal Component Analysis

* Correspondence to: Enrico Maria Lodolini, Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università Politecnica delle Marche, Ancona, ITALY

E-mail: emlodolini@libero.it

Accepted December 21, 2016 (received for review September 16, 2016)

Journal of Oleo Science ISSN 1345-8957 print / ISSN 1347-3352 online

<http://www.jstage.jst.go.jp/browse/jos/> <http://mc.manuscriptcentral.com/jjocs>

istics of the main Palestinian cultivars throughout *in situ* evaluation, in order to state if, in local growth conditions, International Olive Council (IOC) trade standards can be achieved by the tested cultivars and highlight potential critical points.

2 EXPERIMENTAL PROCEDURES

2.1 Plant material, fruit collection and oil extraction

The study was carried out in 2010 and covered four districts of the north-western West Bank: Tulkarem, Qalqilya, Nablus and Jenin (Table 1). Meteorological data for each location were recorded from the nearest weather stations of the General Department of Meteorology (Ministry of Transport) and the comparison with 5-year mean (2008-2012) showed lower precipitations for each district in 2010. Lower average temperatures in the same period were also recorded with differences from the 5-year mean ranging from -3.5 to -0.6°C depending on the location. The average temperatures from September to November 2010 were lower than the 5-year mean for all locations except for Nablus where similar values were recorded. The daily average minimum and maximum temperatures of the year in the study area were 4.0 and 29.0°C , respectively and total rainfall was 412.3 mm (Table 1).

The main four varieties of the region were included in the study: Nabali Baladi, Nabali Mohassan, Sourì and K18 (synonym of cv. Barnea). One to three trees per variety were selected from private farms or experimental germ-plasm collections on each of the 5 different villages included in the study and located one in the Qalqilya, Nablus and Jenin and two in the Tulkarem districts (Table 1). 10 Kg of

hand-picked and healthy fruits from each tree were collected before reaching the pigmentation index 4 according to Beltran *et al.*⁷⁾. One oil sample per tree, meaning at least 5 oil samples for each variety, was extracted using a laboratory scale hammer mill (Oliomio, Toscana Enologica Mori, Tavernelle Val di Pesa, Italy). After 30 minutes of malaxation at room temperature the oil was separated by centrifugation in the same operative conditions. Then the oil was filtered and stored using dark green glass bottles without head space, in the dark at 8°C until analysis (maximum two months).

2.2 Free fatty acids, peroxide values and spectrophotometric parameters

The physic-chemical analyses were carried out on the oil samples according to the European Union standard methods, the ECC 2568/91⁸⁾ and the subsequent amendments 1989/2003⁹⁾. Free acidity and peroxide value were expressed as % of oleic acid and milli-equivalents of active oxygen per kilogram of oil ($\text{meq O}_2 \text{ kg}^{-1}$), respectively. The K_{232} and K_{270} extinction coefficients were measured from absorption at 232 and 270 nm wavelengths.

2.3 Total polyphenol content

The total polyphenol content of the oils was determined according to the Folin-Ciocalteu method. Briefly, total polyphenols were extracted from 5 g of olive oil by mixing with 5 mL of a methanol/water solution (70/30; v/v) and vortex shaking for 5 min. Extracts were separated by centrifugation for 10 min. The supernatant was collected in another tube and the second extraction was performed with a methanol/water solution. For each extract, an aliquot of 200 μL was added to 1 mL distilled water in

Table 1 Geographical coordinates, total rainfalls, temperatures in 2010 and detail of September-November 2010 temperatures for the considered Palestinian districts.

	Tulkarem	Qalqilya	Nablus	Jenin
N. of villages	2	1	1	1
Latitude °N	32.29	32.19	32.22	32.40
Longitude °E	35.12	34.98	35.26	35.28
Elevation (m a.s.l.)	180	79	550	312
Rainfall (mm/year)	391	412	508	336
	<i>554</i>	<i>565</i>	<i>614</i>	<i>459</i>
Temp of the year ($^{\circ}\text{C}$)*	18.9 (16-22)	17.9 (14-23)	17.8 (13-22)	20.3 (14-27)
	<i>22.4 (17-26)</i>	<i>20.5 (16-25)</i>	<i>18.5 (14-24)</i>	<i>20.9 (16-26)</i>
Temp September-November ($^{\circ}\text{C}$)*	21.7 (18-25)	21.5 (16-26)	20.2 (16-25)	22.7 (16-30)
	<i>24.5 (19-28)</i>	<i>22.5 (18-27)</i>	<i>20.5 (16-26)</i>	<i>23.5 (18-29)</i>

In *grey and Italic* the average values for 5-years climatic data (2008-2012).

* Average temperature. Average minimum and maximum temperatures are reported between brackets.

spectrophotometric cuvettes, and then 200 μL of Folin-Ciocalteu reagent was added. The solution was mixed and allowed to equilibrate. After 2 min, 1 mL of a 10% (w/v) sodium carbonate solution was added. The mixture was shaken at 25°C for 15 min. Then, the absorbance was measured at 740 nm using a UV-Visible spectrophotometer (Helios Alpha, UNICAM UV-Visible Spectrometry, Cambridge, UK). The total polyphenols content was expressed as mg of gallic acid kg^{-1} of oil¹⁰⁾.

2.4 Fatty acid composition

The fatty acid composition was expressed as percentage and the determination was performed in accordance with the European Official Methods⁹⁾. A gas chromatograph (Thermo Scientific-TRACE GC Ultra) equipped with a capillary column (Supelco SPTM-2340; 30 m $\times$ 0.25 mm i.d. $\times$ 0.20 μm film thickness) and a flame ionization detector (FID) was used. Column flow rate was 0.8 mL min^{-1} . Injector and detector temperatures were held at 230 and 290°C, respectively. The following oven temperature program was employed: initial temperature 140°C held for 1 min; ramped at 5°C min^{-1} up to 230°C, held for 5 min. The injection volume was 1 μL and a split injection mode (1/100 ratio) was used.

2.5 Sterol content and composition

The determination of sterols was performed according to the ECC 2568/9⁸⁾ and the subsequent amendments⁹⁾ using a gas chromatograph (Thermo Scientific-TRACE GC Ultra) equipped with a capillary column (Supelco-SPB[®]-5; 30 m $\times$ 0.25 mm i.d. $\times$ 0.25 μm film thickness), a split injector (1/75 ratio) and FID detector. Column flow rate was 1 mL min^{-1} . Injector and detector temperatures were held at 300°C. The oven temperature program was isothermal at 265°C. The injection volume was 1 μL . Sterol content and composition was expressed as mg kg^{-1} of oil and as percentage, respectively.

2.6 Sensory profile

Sensory analysis of the oil samples was performed by the official ASSAM (Agenzia Servizi Settore Agroalimentare delle Marche, Ancona, Italy) panel accredited by the International Olive Council (COI/T.28/Doc no 3/Rev. 7 11/2003). One sample of 15 mL derived from one to three different trees on each location was tasted in a normalized cup at 28 $\pm$ 2°C for a total of at least 5 replicates for cultivar. The descriptive analysis used a six-point intensity ordinal rating scale from 0 (no perception) to 5 (extreme) to quantify the intensity of different olfactory (olive fruit, green fruity, apple, green tomato, artichoke, almond, aromatic herbs) sensory (bitterness, pungency and sweetness) and negative (rancid, fusty/muddy, winey, metallic, wet wood and musty-humid) attributes.

Results were expressed as the median intensity of the

sensory perceptions of the tasters and the organoleptic profile of each cultivar was created and expressed by showing the intensity of the main positive attributes according to the official procedure^{8, 11)}.

2.7 Data analysis

All data referring to oil characteristics were tested for normality using the Shapiro-Wilk test and subjected to one-way ANOVA to highlight differences among cultivars. Significant values of the ANOVA were followed by a Tukey LSD test ($\alpha = 0.05$) for cultivars means separation. Statistical analysis was performed using JMP.9 (SAS Institute Inc., Cary, NC).

Oil characteristics of the studied Palestinian olive cultivars were discussed according to Muzzalupo¹²⁾ and Uceda *et al.*^{13, 14)} classifications and physic-chemical and sensory parameters were evaluated comparing them with the International Olive Council trade standards (IOC-TS) for extra virgin olive oils¹⁵⁾.

3 Results and Discussion

3.1 Free fatty acids, peroxide values and spectrophotometric parameters

The physic-chemical parameters of the oils of the five studied cultivars (Table 2) met the standards defined by the IOC for Extra Virgin Olive Oil (EVOO) quality and showed values generally within the limits established for this commercial classification (acidity $\leq$ 0.8%; peroxide value $\leq$ 20 meq O_2 kg^{-1} ; $K_{232} \leq 2.5$; $K_{270} \leq 0.22$ and $\Delta K \leq 0.01$) except for Nabali Baladi K_{270} value slightly exceeding the limit. The percentage of the free acidity and the peroxide value of the oils for all the studied varieties ranged from 0.22 to 0.32% and from 5.0 to 8.97 meq O_2 kg^{-1} , respectively. The spectrophotometric absorbance values in the ultra-violet for the oils of the studied varieties ranged from 1.75 to 1.87 for K_{232} and from 0.14 to 0.25 for K_{270} .

3.2 Total polyphenol content

Total polyphenol content of the oils of the tested varieties (Table 2) ranged from 265 to 801 mg kg^{-1} oil. In particular, K18 showed the highest level of polyphenols (801 mg kg^{-1} oil) with significant differences compared to Souri (the lowest registered value: 265 mg kg^{-1} oil). No significant differences between Souri, Nabali Baladi and Nabali Mohassan were registered.

The oils of the tested varieties showed a variable polyphenol content confirming that genotype plays a strong role in influencing this parameter^{16, 17)}. For Nabali Baladi, the polyphenol content coincided with values reported by Abu-Reidah *et al.*¹⁸⁾. When compared to the results presented by Rotondi *et al.*¹⁹⁾, K18 can be assimilated to the group of Italian cultivars Coratina, Bianchera, Moraiolo and

Mignola for their high total polyphenol content ($> 500 \text{ mg kg}^{-1}$ oil), while Nabali Baladi and Nabali Mohassan to the group of Frantoio, Ravece, Bosana, Raggia, Leccino and Casaliva for their medium total polyphenol content (included between 400 and 500 mg kg^{-1} oil) and Sourì to the group of Piantone di Mogliano, Ascolana Tenera, Peranzana, Nocellara del Belice, Biancolilla and Itrana for their total low polyphenol content ($< 400 \text{ mg kg}^{-1}$ oil).

3.3 Fatty acid composition

All varieties produced oil with high content of palmitic and relatively low oleic acid (Table 3) compared to Coratina, Koroneiki and Picual: some among the main commercial olive cultivars¹⁶. Palmitoleic, heptadecanoic, heptadecenoic, stearic, linoleic and linolenic acid contents in the oils of the studied varieties resulted within the IOC-TS limits for the EVOO commercial classification except for Sourì that showed linolenic acid values which fluctuated around the maximum allowed by IOC-TS. Eicosanoic acid exceeded the IOC-TS limits in the oils of all the considered varieties.

The fatty acid composition was never significantly differ-

ent among the tested cultivars and the only exception was represented by higher concentration of palmitic acid in Nabali Mohassan. Low oleic acid content was found for all cultivars. Palmitic acid content in the oil of the studied varieties resulted slightly higher than those reported by Rotondi *et al.*¹⁹ for 16 main Italian cultivars, while linoleic and linolenic acid content resulted in the range registered for the olive cultivars of the southern Italy¹².

As reported in several studies^{20–22} high temperatures during oil accumulation period, and especially from stone hardening until the beginning of turning colour, reduce oleic acid and increase linoleic and palmitic acid content. The average temperatures recorded from September to November in this study ranged from 20.2 to 22.7 and exceeded the average values of most locations suitable for olive cultivation²³.

Registered values for oleic, palmitic, linoleic and linolenic acids for the cultivar Nabali Baladi confirm the results reported by Abu-Reidah *et al.*¹⁸.

Table 2 Quality indices of the oils of the considered Palestinian olive varieties.

	Nabali B.	Nabali M.	Sourì	K18	IOC-TS
Free acidity (%)	$0.31^a \pm 0.15$	$0.22^a \pm 0.07$	$0.32^a \pm 0.07$	$0.24^a \pm 0.05$	≤ 0.8
Peroxide value ($\text{meq O}_2 \text{ kg}^{-1}$)	$7.63^a \pm 1.60$	$7.65^a \pm 1.1$	$8.97^a \pm 3.1$	$5.00^a \pm 1.1$	≤ 20
K_{232} (nm)	$1.76^a \pm 0.11$	$1.87^a \pm 0.15$	$1.83^a \pm 0.20$	$1.75^a \pm 0.13$	≤ 2.50
K_{270} (nm)	$0.25^a \pm 0.22$	$0.14^a \pm 0.02$	$0.14^a \pm 0.03$	$0.17^a \pm 0.05$	≤ 0.22
ΔK	$-0.004^a \pm 0.001$	$-0.005^a \pm 0.003$	$-0.005^a \pm 0.003$	$-0.004^a \pm 0.001$	≤ 0.01
Tot polyphenol (mg kg^{-1})	$407.67^b \pm 159.3$	$423.25^{ab} \pm 235.6$	$264.67^b \pm 38.58$	$801.0^a \pm 267.5$	

Values are mean of at least 5 oil samples $\pm$ Standard Deviation (SD).

Values followed by the same letters within the same line are not significantly different according to Tukey HSD test ($p > 0.05$).

The IOC trade standard (TS) values for extra virgin olive oils are reported in the last column.

Table 3 Fatty acid composition of the oils of the considered Palestinian olive varieties.

Fatty acids (%)	Nabali B.	Nabali M.	Sourì	K18	IOC-TS
Palmitic	$14.5^b \pm 2.5$	$17.9^a \pm 1.9$	$14.3^b \pm 1.1$	$14.7^{ab} \pm 1.3$	7.5-20
Palmitoleic	$0.58^a \pm 0.4$	$1.12^a \pm 0.4$	$0.82^a \pm 0.3$	$0.99^a \pm 0.3$	0.3-3.5
Heptadecanoic	$0.16^a \pm 0.09$	$0.17^a \pm 0.07$	$0.15^a \pm 0.15$	$0.06^a \pm 0.03$	≤ 0.30
Heptadecenoic	$0.17^a \pm 0.08$	$0.21^a \pm 0.08$	$0.24^a \pm 0.13$	$0.09^a \pm 0.03$	≤ 0.30
Stearic	$3.67^a \pm 0.30$	$3.11^a \pm 0.39$	$3.75^a \pm 1.01$	$2.44^a \pm 0.62$	0.5-5
Oleic	$66.25^a \pm 5.48$	$61.90^a \pm 4.38$	$65.01^a \pm 5.61$	$67.87^a \pm 4.21$	55-83
Linoleic	$12.84^a \pm 12.79$	$13.91^a \pm 2.44$	$13.78^a \pm 5.06$	$12.1^a \pm 3.93$	3.5-21
Linolenic	$0.80^a \pm 0.17$	$0.90^a \pm 0.21$	$1.03^a \pm 0.37$	$0.87^a \pm 0.21$	≤ 1.0
Eicosanoic	$0.44^a \pm 0.04$	$0.50^a \pm 0.09$	$0.50^a \pm 0.16$	$0.54^a \pm 0.11$	≤ 0.4

Values are mean of at least 5 oil samples $\pm$ SD.

Values within the same line followed by the same letters are not significantly different according to Tukey HSD test ($p > 0.05$).

The IOC trade standard (TS) values for extra virgin olive oils are reported in the last column.

3.4 Sterol content and composition

The total sterol content in the oils of all the varieties was higher than the 1,000, minimum limit for the EVOO, and ranged from 1,291 to 1,942 mg kg⁻¹ oil (Table 4). In the oils of all varieties the registered values of cholesterol, brassicasterol, campesterol, stigmasterol, apparent β -sitosterol (i.e. β -sitosterol + Δ -5-avenasterol + Δ -5-23-stigmastadienol + clerosterol + sitostanol + Δ -5-24-stigmastadienol) and erythrodiol + uvaol were included in the range allowed by the IOC standards for EVOO classification. The main critical point was represented by Δ -7-stigmastenol values that were generally high for all tested varieties and exceeded the EVOO limit of 0.5% as indicated by the IOC-TS in Nabali Baladi and Sourì. The limit for Δ -7-stigmastenol parameter has been fixed to detect adulterations (mixture with other vegetable oils), but some varieties, in specific climatic conditions, can naturally show relatively high amounts. Abu-Reidah *et al.*¹⁸⁾ also reported values higher than 0.5% for this parameter in Nabali virgin olive oils from Nablus, Salfit, Qalqilya and Jenin provinces of the northern West Bank in the 2007 harvest. As well, Chehade *et al.*²⁴⁾ informed about values slightly exceeding 0.5% for Sourì cultivar and exceeding 1.0% for Baladi cultivar in Lebanon. Arbequina exceeded the limit allowed by the IOC TS for several sterols included Δ -7-stigmastenol in a study on the adaptability to Argentinian climate²⁵⁾. Values higher than 0.5% of Δ -7-stigmastenol have been reported for the cultivars Colombaia²⁶⁾ in Central Liguria (Italy) and Empeltre²⁷⁾ in Bajo Aragon (Spain) in experimental studies carried out for three consecutive years, 2001-2003 and 1996-1998, respectively. Among the Syrian varieties, Doeblì and Khoderi in the Tartous and Lattakia areas (Syria), respectively, registered values of Δ -7-stigmastenol higher than the limit allowed by the IOC-TS in a three-year study period 2004-2006²⁸⁾. As well, Manai-Djebali *et al.*²⁹⁾ reported values strongly higher than 0.5% for this parameter in five

olive cultivars grown in the arid climate of Central Tunisia.

The sterol composition did not show a wide range of variation among the oils due to the cultivar except for the higher campesterol concentration in K18. These results are in accordance with Abu-Alruz *et al.*³⁰⁾, Abu-Reidah *et al.*¹⁸⁾, Ebiad and Abu-Qaoud³¹⁾ and Ayoub *et al.*³²⁾ that reported similar characteristics for the cultivars in the area.

3.5 Sensory profile

No negative sensory attributes were found on any of the tested samples (data not shown). All tested oils resulted extra virgin for the sensory analysis with a median of defects = 0 and of positive attributes > 0 (COI/T.15/NC no 3/Rev. 8/2015). According to Uceda *et al.*¹⁴⁾ and Muzzalupo¹²⁾ the sensory profile of the oils of the five tested Palestinian cultivars showed a low green fruity olfactory profile and a medium-intense olive fruit sensation (Table 5). Light tomato perception was recorded in Nabali Mohassan and K18 and artichoke perception mainly in Nabali Baladi. Bitter intensity ranged from 1.7 to 3.7 and pungent from 2.1 to 3.3. Considering the EC Reg. n. 182/2009, Nabali Baladi and Sourì were classified as light bitter and pungent oils (median of the two attributes < 3), whereas Nabali Mohassan as light bitter and medium pungent oil (median of the two attributes < 3 and included between 3 and 6, respectively) and K18 as medium bitter and light pungent oil (median of the two attributes included between 3 and 6 and < 3, respectively).

Such results are consistent with polyphenols content registered for the tested cultivars and confirm the strict relationship between bitter sensations and phenols content³³⁾.

Table 4 Sterolic composition and content and erythrodiol + uvaol content of the oils of the considered Palestinian olive varieties.

Sterols (%)	Nabali B.	Nabali M.	Sourì	K18	IOC-TS
Cholesterol	0.33 ^a ± 0.21	0.22 ^a ± 0.16	0.23 ^a ± 0.18	0.20 ^a ± 0.15	≤ 0.5
Brassicasterol	<0.1	<0.1	<0.1	<0.1	≤ 0.1
Campesterol	2.63 ^b ± 0.40	2.67 ^b ± 0.21	2.77 ^b ± 0.51	4.40 ^a ± 0.32	≤ 4.0
Stigmasterol	0.80 ^a ± 0.31	0.97 ^a ± 0.23	0.82 ^a ± 0.54	0.60 ^a ± 0.37	<Campesterol
Apparent β -sitosterol*	100.77 ^a ± 1.23	99.52 ^a ± 1.18	99.175 ^a ± 2.35	100.00 ^a ± 2.24	≥ 93.0
Δ -7-stigmastenol	1.00 ^a ± 0.41	0.47 ^a ± 0.05	0.95 ^a ± 0.50	0.40 ^a ± 0.15	≤ 0.5
Total sterol (mg kg ⁻¹ oil)	1420.83 ^{ab} ± 564.5	1291.78 ^b ± 216.6	1942.05 ^a ± 397.0	1591.60 ^{ab} ± 254.4	≥ 1000
Erythrodiol+Uvaol (% total sterols)	2.70 ^a ± 1.09	2.10 ^a ± 0.48	2.52 ^a ± 1.12	1.70 ^a ± 0.35	≤ 4.5

Values are mean of at least 5 oil samples ± SD.

Values within the same line followed by the same letters are not significantly different according to Tukey HSD test ($p > 0.05$).

The IOC trade standard (TS) values for extra virgin olive oils are reported in the last column.

*Apparent β -sitosterol = β -sitosterol + Δ -5-avenasterol + Δ -5-23-stigmastadienol + clerosterol + sitostanol + Δ -5-24-stigmastadienol.

Table 5 Sensory profile of the oils of the considered Palestinian olive varieties.

	Nabali B.	Nabali M.	Souri	K18
Olfactory profile				
Green	1.3 ^a ± 0.23	1.3 ^a ± 0.0	0.8 ^b ± 0.17	1.3 ^a ± 0.0
Olive fruit	2.7 ^a ± 0.17	2.9 ^a ± 0.06	2.0 ^b ± 0.40	2.8 ^a ± 0.00
Tomato	1.6 ^b ± 0.29	1.3 ^a ± 0.06	0.6 ^b ± 0.69	1.1 ^a ± 0.17
Artichoke	1.0 ^a ± 0.17	0.0 ^c ± 0.00	0.3 ^{bc} ± 0.35	0.6 ^{ab} ± 0.18
Almond	0.0 ^b ± 0.00	0.8 ^a ± 0.17	0.8 ^a ± 0.11	0.0 ^b ± 0.00
Sensory profile				
Bitter	2.3 ^b ± 0.12	2.4 ^b ± 0.52	1.4 ^c ± 0.35	3.7 ^a ± 0.00
Pungent	2.8 ^a ± 0.12	2.8 ^a ± 0.58	1.7 ^b ± 0.46	2.6 ^a ± 0.34
Sweet	1.6 ^{ab} ± 0.29	1.9 ^{ab} ± 0.58	2.2 ^a ± 0.23	1.3 ^b ± 0.30

Values are mean of at least 5 oil samples ± SD.

Values within the same line followed by the same letters are not significantly different according to Tukey HSD test ($p > 0.05$).

4 CONCLUSION

The results presented in this study contribute to the characterization of the oil composition and quality of the main Palestinian olive germplasm.

A general good quality for both physic-chemical and organoleptic characteristics was registered for the oil of these varieties making them highly appreciable on the local and international market.

These results represent a baseline reference for the Palestinian territories (northern West Bank) and can be used for further characterization of the local varieties. Moreover, the establishment of a national olive germplasm collection is advisable in order to deepen the knowledge about the Palestinian olive cultivars and to set a mother trees field for the propagation of certified plants for the design of new orchards.

ACKNOWLEDGEMENTS

This research has been conducted in the frame of the projects “Increasing income of impoverished small olive oil producers in 10 villages of the North West Bank (occupied Palestinian territory)” funded by European Union cod. n. FOOD/2007/143-961 and jointly implemented by GVC and UAWC and “Olive Oil Export Promotion Project” funded by AFD-Agence Française de Développement and implemented by Paltrade.

References

- 1) PCBS-Palestinian Central Bureau of Statistics. First agricultural census in the Palestinian Territory 2010. Ramallah, State of Palestine, pp.1-4 (2011).
- 2) PCBS-Palestinian Central Bureau of Statistics. Agricultural Statistics 2006/2007 (2008).
- 3) Ministry of Agriculture (MOA) General Directorate of Extension & Rural Development. Olive Oil Fact Sheet, pp.1-3 (2010).
- 4) Liphshitz, N.; Gophna, R.; Hartman, M.; Biger, G. The beginning of olive (*Olea europaea*) cultivation in the old world: A reassessment. *J. Archaeol. Sci.* **18**, 441-453 (1991).
- 5) Zohary, D.; Hopf, M. Olive: *Olea europaea*. in *Domestication of plants in the Old World*. 2nd ed., Clarendon Press, Oxford, pp 137-143 (1994).
- 6) Basheer-Salimia, R.A.; Awad, M.K.; Kalaitzis, P.K. Genetic fingerprinting of Palestinian olive (*Olea europaea* L.) cultivars using SNP markers. *Jordan J. Agric. Sci.* **5**, 282-294 (2009).
- 7) Beltran, G.; Uceda, M.; Hemoso, M.; Frias, L. Maduracion. in *El cultivo del olivo* (Barranco, D.; Fernandez-Escobar, R.; Rallo, L. eds.), Junta de Andalucia, Mundi-Prensa, Madrid, pp. 159-183 (2004).
- 8) EUC, European Union Commission Regulation 2568/91. Characteristics of olive and olive pomace oils and their analytical methods. *Official Journal of European Community* L248, 1-82 (1991).
- 9) EUC, European Union Commission Regulation 1989/2003. Characteristics of olive and olive pomace oils and their analytical methods. *Official Journal of European Community* L295, 57-77 (2003).
- 10) Montedoro, G.F.; Servili, M.; Baldioli, M.; Miniati, E. Simple and hydrolyzable phenolic compounds in virgin olive oil. 1. Their extraction, separation and quantification and semiquantitative evaluation by HPLC. *J. Agric. Food Chem.* **40**, 1571-1577 (1992).
- 11) EUC, European Union Commission Regulation 640/2008. Amending Regulation No 2568/91/EEC. *Of-*

- 11) *Official Journal of the European Communities* L178: 11-16 (2008).
- 12) Muzzalupo, I. Olive germplasm – Italian catalogue of olive varieties. Rijeka, Croatia: InTech. <http://dx.doi.org/10.5772/3577> (2012).
- 13) Uceda, M.; Hermoso, M.; Aguilera, M.P. La calidad del aceite de oliva. in *El cultivo del olivo* (Barranco, D.; Fernandez-Escobar, R.; Rallo, L. eds.), Junta de Andalucía, Mundi-Prensa, Madrid, pp. 699-727 (2008).
- 14) Uceda, M.; Aguilera, M.; Jimenez, A.; Beltran, G. Variedades de olivo y aceituna. Tipos de aceites. in *El aceite de oliva virgen: tesoro de Andalucía* (Gutierrez, F.; Carretero, S. eds.), Servicio de Publicaciones de la Fundación Unicaja, Malaga, pp. 107-138 (2009).
- 15) International Olive Council, Trade standard applying to olive oils and olive-pomace oils. COI/T.15/NC no 3/ Rev. 8/2015 (2015).
- 16) Aparicio, R.; Luna, G. Characterisation of monovarietal virgin olive oils. *Eur. J. Lipid Sci. Tech.* **104**, 614-627 (2002).
- 17) Servili, M.; Selvaggini, R.; Esposto, S.; Taticchi, A.; Montedoro, G.F.; Morozzi, G. Health and sensory properties of virgin olive oil hydrophilic phenols: Agronomic and technological aspects of production that affect their occurrence in the oil. *J. Chromatogr. A.* **1054**, 113-127 (2004).
- 18) Abu-Reidah, I.; Yasin, M.; Urbani, S.; Servili, M.; Montedoro, G. Study and characterization of Palestinian monovarietal Nabali virgin olive oils from northern West Bank of Palestine. *Food Res. Int.* **54**, 1959-1964 (2013).
- 19) Rotondi, A.; Magli, M.; Morrone, L.; Alfei, B.; Pannelli, G. Italian national database of monovarietal olive oils. in *The Mediterranean genetic code – grapevine and olive* (Poljuha, D.; Sladonja, B. eds.), Rijeka, Croatia: InTech – Open Access Company <http://dx.doi.org/10.5772/51772> pp. 179-200 (2013).
- 20) Ripa, V.; De Rose, F.; Caravita, M.L.; Parise, M.R.; Perri, E.; Rosati, A.; Pandolfi, S.; Paoletti, A.; Pannelli, G.; Padula, G.; Giordani, E.; Bellini, E.; Buccoliero, A.; Mennone, C. Qualitative evaluation of olive oils from new olive selections and effects of genotype and environment on oil quality. *Adv. Hortic. Sci.* **22**, 95-103 (2008).
- 21) Inglese, P.; Famiani, F.; Servili, M.; Esposto, S.; Urbani, S. Factors affecting extra-virgin olive oil composition. *Hort. Rev.* **38**, 83-147 (2011).
- 22) Rondanini, D.P.; Castro, D.N.; Searles, P.S.; Rousseaux, M.C. Fatty acid profiles of varietal virgin olive oils (*Olea europaea* L.) from mature orchards in warm arid valleys of Northwestern Argentina (La Rioja). *Grasas Aceites* **62**, 399-409 (2011).
- 23) Lombardo, N.; Marone, E.; Alessandrino, M.; Godino, G.; Madeo, A.; Fiorino, P. Influence of growing season temperatures in the fatty acids (FAs) of triacylglycerols (TAGs) composition in Italian cultivars of *Olea europaea*. *Adv. Hortic. Sci.* **22**, 49-53 (2008).
- 24) Chehade, A.; El Bittar, A.; Kadri, A.; Choueiri, E.; Nababout, R.; Youssef, H.; Smeha, M.; Awada, A.; Al Chami, Z.; Dubla, E.; Trani, A.; Mondelli, D.; Famiani, F. *In situ* evaluation of the fruit and oil characteristics of the main Lebanese olive germplasm. *J. Sci. Food Agr.* <http://dx.doi.org/10.1002/jsfa.7373> (2015).
- 25) Ceci, L.N.; Carelli, A.A. Characterization of monovarietal Argentinian olive oils from new productive zones. *J. Am. Oil Chem. Soc.* **84**, 1125-1136 (2007).
- 26) Boggia, R.; Evangelisti, F.; Rossi, N.; Salvadeo, P.; Zunin, P. Chemical composition of olive oils of the cultivar Colombaia. *Grasas Aceites* **56**, 276-283 (2005).
- 27) Gómez, M.S.G. Composición química de distintas alidade de aceites de oliva virgen de la variedad “Empeltre” en el bajo Aragón. *Grasas Aceites* **52**, 52-58 (2001).
- 28) Jbara, C.; Jawhar, A.; Bido, Z.; Cardone, G.; Dragotta, A.; Famiani, F. Fruit and oil characteristics of the main Syrian olive cultivars. *Ital. J. Food Sci.* **4**, 395-400 (2010).
- 29) Manai-Djebali, H.; Krichene, D.; Ouni, Y.; Gallardo, L.; Sanchez, J.; Osorio, E.; Daoud, D.; Flamini, G.; Zarrouk, M. Chemical profiles of five minor olive varieties grown in central Tunisia. *J. Food Comp. Anal.* **27**, 109-119 (2012).
- 30) Abu-Alruz, K.; Afaneh, I.A.; Quasem, J.M.; Hmidat, M.A.; Abbady, J.; Mazahreh, A.S. Factors affecting Δ -7-stigmastenol in Palestinian olive oil. *J. Appl. Sci.* **11**, 797-805 (2011).
- 31) Ebiad, R.; Abu-Qaoud, H. Morphological and biochemical characterization of three olive “*Olea europaea* L.” cultivars in Palestine. *Jordan J. Agric. Sci.* **10**, 130-143 (2014).
- 32) Ayoub, S.; Shdiefat, S.; Ahmad, R.; Al-Hewian, M. Morphological and pomological characteristics of Jordanian olive cultivars. *Proceedings of the Third International OliveBiotech, Sfax, Tunis* (2009).
- 33) Siliani, S.; Mattei, A.; Benevieri, L.B.; Innocenti, B.; Zannoni, B. Bitter taste and phenolic compounds in extra virgin olive oil: an empirical relationship. *J. Food Qual.* **29**, 431-441 (2006).