The Production Potential of the Olive Oil from Native Cultivars in Albania

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Abstract— *Albania has an annual production capacity of ca. 50 000 tons of olive fruits and 6000 tons of olive oil. The corresponding cultivation area covers 41000 ha, distributed over 90 000 small farms. In total, olive trees area covers 6.3% of the total arable land. This paper, presents the characterizes the fatty acid profile and total phenolic content of 6 olive varieties, namely, Kalinjot, Ulli i bardhe Tirana (Bianco di Tirana), Karren, Nisiot, Kotruvs, and Kokerrmadh Berati, all from the same harvesting period.*

Results on fatty acid (FA) profiles exhibit a variation in concentration of oleic acid, 71.53 ± 0.02% (Kotruvs) to 80.07 ± 0.04% (Nisiot). The content of linoleic acid varies from 4.10 ± 0.00% (Nisiot) to 9.31 ± 0.01% (Kotruvs), whereas the content of linolenic acid varies from 0.45 ± 0.01% (Karren) to 0.72 ± 0.02% (Kalinjot). Analysed OO from six olive varieties revealed moderate levels of palmitic acid, between 9.94 ± 0.01% (Nisiot) to 12.21 ± 0.01% (Kotruvs). From a nutritional point of view, it is worth noticing that the Nisiot variety has an n-6/n-3 ratio of 8.11, while the Karren 18.72.

The total phenolic content for the studied olive cultivars varied from 89.74 ± 5.47 (Karren) to 445.03 ± 16.83 mg/kg olive oil (Ulli i bardhe Tirana); such variation may reflects different antioxidant capacity among olive cultivars.

Keywords— Native Olive Cultivars; Kalinjot; Ulli i Bardhe Tirana, Kokerrmadh Berati, Nisiot, Fatty acid, Polyphenol content.

I. INTRODUCTION

The origin of olive trees in Albania is not different from the road of the distribution of this tree in the Mediterranean area. Archaeological evidences on the agriculture activities such as wheat cobs, truss grapes, olive lop are stamped in stones and coins of the Illyrian tribes. Olive tree cultivation is mainly concentrated in the Western Plain of the country, by penetrating the mainland through the river valleys (*[1]; [2]*). Its distribution is diversified according to climate and geography. It is mainly cultivated in the Mediterranean Climatic Zone, which covers 36.2 % of the Albanian territory.

Albania is a country with an actual annual producing capacity of 50 000 tons of olive fruits and 6000 tons of Olive oil. The olive plantations cover an area of 41000 ha, corresponding to 6.3% of the total arable land, where the characteristic is its distribution over 90 000 small farms. The incomes from the olive sector are 16 million Euros (*[3]*).

Recent genetic studies concluded that Albania owns 22 native olive cultivars. All 22 native cultivars are clustered in 7 different groups and the main factor influencing such clustering is the dimension of the olive fruit (*[4]*). In what concerns the region from which the native cultivars in this study have been selected, and based on RAPD methods, cultivars are grouped in three main groups, where the main group belongs to the *Ulli i bardhe Tirana* (UbT) with a coefficient of similarity that varies from 45% to 84%. Hence, scientific studies on the native cultivars are very important, due to their impact in the future of the olive oil industry. Based on their distribution, native olive cultivars are grouped in principal cultivars and secondary cultivars (*[4]*).

Olive oil is the only vegetable oil that can be consumed without prior refining treatment (*[5]; [6]*). Its major components are triglycerides, which represent more than 98% of the total weight. The remaining part belongs to non-saponifiable chemical compounds such as sterols, polyphenols, alcohols, waxes, hydrocarbons etc (*[7];* Servilli, Montedoro, 2003; *[9]*). Virgin olive oil composition depends on numerous factors such as the interaction between the cultivar and the environment, cultivation techniques, fruit ripeness and the oil extraction system (*[6]*). The characterisation of fatty acid profiles of olive oils from different olive cultivars is usually proposed as a methodology to differentiate these products according to their cultivar and geographical origin (*[6]; [10]*).

In this study, are presented the fatty acid composition and total polyphenol content of six olive cultivars. Studied cultivars were *Kalinjot, Ulli i bardhe Tirana (UbT), Karren, Nisiot, Kotruvs, Kokerrmadh Berati*, which belong to different regions of Albania, with different pedoclimatic conditions. The olives from these cultivars are mainly used in the production of oil except to Kokerrmadh Berati used as Table Olive.

Nowadays, an attempt to modify the national fund of olive tree is an ongoing process. The scope of the study presented herein is linked with chemical evaluation of the Monovarietal Virgin Olive Oils. Assessment of quality parameters and nutritional value of olive oils from studied cultivars is presented in this paper. Such pioneering study will allow for the identification of native cultivars that produce good quality olive oil and that are very well adapted to the pedoclimatic conditions in Albania.

II. MATERIALS AND METHODS

2.1 Sample collection and oil extraction

A total of 6 native olive cultivars, namely, *Kalinjot, Ulli i bardhe Tirana (UbT), Karren*, *Nisiot*, *Kotruvs* and *Kokerrmadh Berati*, were harvested in their main area of Tirana and Kruja Regions, between October and November 2014, and prepared as described in Table 1. The climatic characteristics of the production areas, in terms of temperature, are reported in Figs. 1.

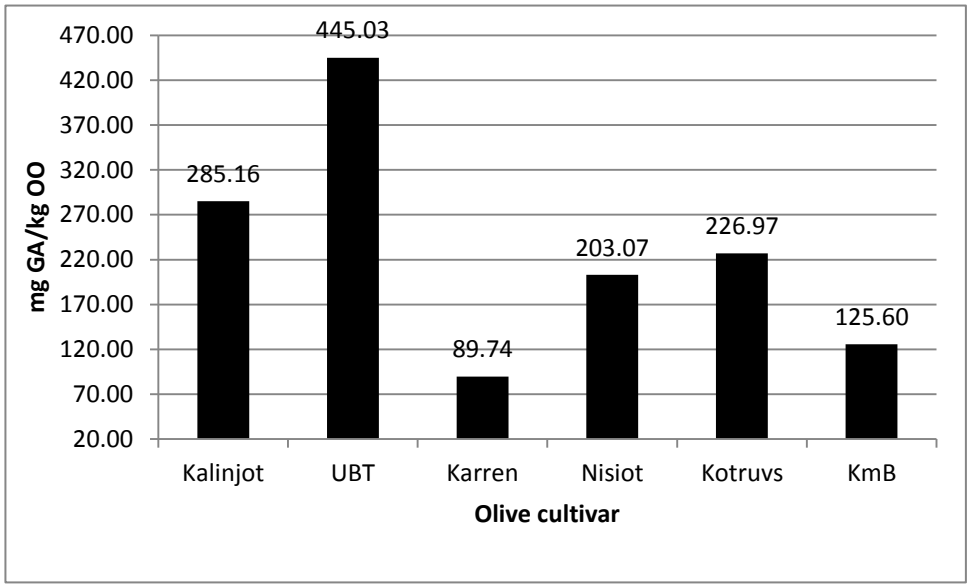

FIGURE 1: TPC OF SIX MONOVARIETAL VIRGIN OLIVE OILS OF NATIVE CULTIVAR. (UBT-ULLI I BARDHE TIRANA; KMB-KOKERMADH BERATI)

TABLE 1
OLIVE VARIETIES, HARVESTING AND EXTRACTION DAY

Code sample	Cultivar name	Harvesting day	Extraction day
Nr. 1	Kalinjot	8/11/2014	8/11
Nr. 2	Ulli Bardhe Tirana	10/10/2014	10/10
Nr. 3	Karren	12/11/2014	13/11
Nr. 4	Nisiot	12/11/2014	13/11
Nr. 5	Kotruvs	13/11/2014	13/11
Nr. 6	Kokerrmadh Berati	13/11/2014	14/11

Oil extraction was performed with a Laboratory press, under cold extraction conditions and mechanical pressing. Once the olives had been properly cleaned and washed, they were poured into the receiving hopper, where a screw activated by hand through a handle fed the crusher that was equipped with a fixed grate and a hollow knife impeller. The paste produced fell into the lower mixer, where a helicoidally shaped stirrer prepared it. A speed change gear sends the paste to the decanter

where separation took place: oil from the front and waste mixed with water from the back of the machine. The oil samples were stored in the dark at 4^{o}C until analysis.

2.2 Chemicals

The chemical reagents were analytical grade, from Sigma-Aldrich Chemie (Steinheim, Germany). Internal standard C15:0 was purchased from Sigma-Aldrich. Gallic acid and Folin-Ciocalteau reagent were supplied by Fluka Chemie GmbH (Buchi, Switzerland).

2.3 Analytical methods

2.3.1 Determination of fatty acid profiles

Fatty acid methyl esters (FAME) were prepared through direct basic transesterification, according to IOOC, using pentadecanoic acid (C 15:0) as Internal Standard. The assay of FAME was carried out with a HP-6890 Gas chromatograph, equipped with a Flame Ionization Detector (GC-FID). Separation was achieved in a SP-2380 capillary column (60 m x 0.25 mm x 0.20 μm) from Supelco. Hydrogen was used as carrier gas at a flow rate of 1.0 ml min^{-1}. Calculations were performed according to Official Method Ce 1b-89 ([*11]*). Identification of FA was undertaken with pure standards (Sigma-Aldrich, Supelco), based on the comparison of retention times. Fatty acids were named by using the code *i:j(n-k)*, where *i*-indicates the total number of carbons, *j*-the number of double bonds, and *k*-the position of the last double bound counted from the terminal methyl group.

2.3.2 Determination of Total Polyphenol Content

- **Fractionation of olive oils**

The method used to perform the fractionation of oils was proposed by *[12]*). Briefly, samples were dissolved in n-hexane (Sigma, Germany) and extracted with a methanol/water mixture (60:40, vol/vol). The insoluble fraction (non-polar) in methanol/water fraction was removed, whereas the polar fraction was used, as it was, for further analysis.

- **Colorimetric determination of total polyphenol content**

The Folin-Ciocalteau method was used to determine the total polyphenol content (TPC) of samples, according to method proposed by (*[12]*). The absorbance of mixture was measured after 1 h of reaction with a UV-VIS Mini-1240 Spectrophotometer (Shimadzu) at 725 nm. Results were expressed as Gallic acid equivalent (mg/kg olive oil), calculated from the following calibration curve, determined by linear regression:

$$A_{725}= 3.015\ [GA] + 0.005\ (r^2=0.999) \quad (1)$$

where [GA] was concentration of gallic acid, expressed as mg/kg oil.

2.4 Statistical analysis

The complete data were evaluated by randomized block design, with three replicates from fatty acid analysis and duplicates for TPC values. Results were displayed as mean values and standard error (n=3). Significance of the differences among the values was determined by analysis of variance using One-way ANOVA test. The level of significance was determined at $P<0.05$. The employed statistical program was SPSS 17.0 Statistics 2008 (SPSS Inc., Chicago, IL, USA).

III. RESULTS AND DISCUSSION

Fatty acid profiles of the olive cultivars studied are described in Table 2. One-way ANOVA analysis showed that fatty acid profiles of the seven olive cultivars were statistically significantly different. Results revealed that, in what concerns palmitic acid (PA), the cultivars can be grouped in two groups: (i) those with lower PA content, such as Nisiot (9.94 ± 0.01%), UBT (10.88 ± 0.01%), Kokerrmadh Berati (10.41 ± 0.01%), and Kalinjoti 10.92 ± 0.17%), cultivars, and those with higher PA content, such as Kotruvs (12.21 ± 0.01%) cultivar.

The oleic acid (OA) content was as follows: 71.53 ± 0.02 % (Kotruvs), 74.61 ± 0.06 % (UbT), 73.94 ± 0.02% (Karren), 75.1 ± 1.21% (Kalinjot), 80.07 ± 0.04% (Nisiot). Linoleic acid (LA) content showed high variation among the studied cultivars; olive cultivars such as Kalinjot (7.56 ± 0.13%), UbT (8.00 ± 0.07%), Karren (8.35 ± 0.01%), Kotruvs (9.31± 0.01%) and Nisiot (4.10 ± 0.00%), presented low content of LA.

The alpha-Linolenic acid (ALA) was found below 1%, submitting the quality criteria of the Extra Virgin Olive Oils (EVOO). The ALA content varied according to the following ascending order: 0.45 ± 0.01% (Karren), 0.51 ± 0.01% (Nisiot and Kotruvs), 0.58 ± 0.01% (UbT), 0.72±0.02% (Kalinjot), 0.67 ± 0.01% (Kokerrmadh Berati).

TABLE 2
TPC OF SIX MONOVARIETAL VIRGIN OLIVE OILS OF NATIVE ORIGIN (MG GALLIC ACID/KG OLIVE OIL)

Variety	Mean±SD
Kalinjot	285.16±3.29
Ulli i Bardhe Tirana	445.03±16.83
Karren	89.74±0.47
Nisiot	203.07±7.51
Kotruvs	226.97±1.40
Kokerrmadh Berati	125.60±6.09

A high content of ALA contributes to the n-6/n-3 ratio, a very important value for the nutritional evaluation of lipids of different origin. Regarding such ratio, the Nisiot cultivar shows a n-6/n-3 ratio of 8.11, followed by 10.31 (Kokrremadh Berati), 10.47 (Kalinjot), and 13.75 (UbT), while the remaining cultivars show higher values, Karren (18.72) and Kotruvs (18.25).

Comparison of the FA profiles of the Albanian native cultivars with those in neighbouring countries (*[7]; [13]; [14]*) and Northern Africa ([15]) gives indication that they are comparable with Italian olive cultivars, but also with other Mediterranean countries (*[7]; [13]*). For example, the level of palmitic acid in the studied native cultivars is comparable with Italian cultivars Leccino (14.3%) and Moraiolo (10.5%); Spanish cultivars Arbequina (14.3%); Lechin (10.5%) and Redondilla (12.5%), and Greek cultivar (13.3%). The level of oleic acid in Albanian cultivars is comparable with Frantoio (78.2%), Arbequina, 75.3% and Koreiniki, 71.9% (*[13]*). Related to the linoleic acid trends is not as even since the Albanian olive cultivars present content differences. The UbT content is comparable with Arbequina, Frantoio, Leccino and Koreiniki. On the other hand, the Boçi cultivar presents high content of linoleic acid comparable to the Spanish cultivars Redondilla and Lechin (*[7], [14]*).

TABLE 3
FATTY ACID PROFILE, TOTAL POLYPHENOL CONTENT (TPC), N-6/N-3 AND 18:1/18:2 RATIOS OF THE SEVEN NATIVE OLIVE CULTIVARS

Formula	Kalinjot	Ulli i Bardhe Tirane	Karre	Nisiot	Kotruvs	Kokerrmadh Berati
14:0	ND	ND	ND	ND	ND	ND
16:0	10.92±0.17	10.88±0.01	11.17±0.02	9.94±0.01	12.21±0.01	10.41±0.00
16:1(n-9)	0.09±0.00	0.07±0.00	ND	0.12±0.00	0.09±0.00	0.13±0.00
16:1(n-7)	0.48±0.01	0.35±0.01	0.36±0.00	0.41±0.00	0.82±0.00	0.61±0.00
17:0	0.04±0.05	0.13±0.00	0.14±0.00	ND	ND	ND
17:1 (n-7)	0.14±0.01	0.19±0.00	0.18±0.00	ND	ND	ND
18:0	2.31±0.03	2.83±0.01	3.22±0.01	2.56±0.01	1.96±0.01	2.10±0.01
18:1(n-9)trans	ND	ND	ND	ND	ND	ND
18:1(n-9)cis	75.11±1.21	74.61±0.06	73.94±0.02	80.07±0.04	71.53±0.02	76.26±0.07
18:1(n-7)	1.88±0.02	1.53±0.00	1.45±0.01	1.55±0.00	2.87±0.00	2.20±0.01
18:2 (n-6)cis	7.56±0.13	8.00±0.07	8.35±0.01	4.10±0.00	9.31±0.01	6.92±0.00
20:0	0.36±0.01	0.43±0.01	0.50±0.01	0.45±0.02	0.37±0.01	0.40±0.01
18:3 (n-3)	0.72±0.02	0.58±0.01	0.45±0.01	0.51±0.00	0.51±0.01	0.67±0.01
20:1 (n-9)	0.31±0.01	0.28±0.01	0.24±0.02	0.31±0.01	0.34±0.01	0.33±0.01
22:0	0.08±0.04	0.07±0.00	ND	ND	ND	ND
n-6/n-3	10.47	13.75	18.72	8.11	18.25	10.31
□□SFA	13.36	14.34	15.04	12.95	14.54	12.92
□□MUFA	78.01	77.05	75.94	82.46	75.65	79.53
□□PUFA	8.29	8.59	9.03	4.60	9.82	7.59
18:1/18:2	9.93	9.33	8.86	19.54	7.68	11.02
MUFAs/SFAs	5.84	5.37	5.05	6.37	5.20	6.16
MUFAs/PUFAs	9.42	8.97	8.41	17.92	7.71	10.48

The ratio between monounsaturated and saturated fatty acids of the studied cultivars had an average value of 5.05 - 6.37, whereas the ratio between monounsaturated and polyunsaturated fatty acids presented an average value of 7.71-17.92 (Table 3), which are relatively low; however, the high phenol content could indicate that oil quality was maintained without lipid deterioration.

Analysis of the ratio 18:1/18:2 is another indication that refers to the oil oxidation stability. The limit value proposed is 18:1/18:2 ≥ 7.00 (*[17]*). The results show that the Monovarietal olive oils from 7.68 (Kotruvs) to 9.33 (UbT) and 19.54 (Nisiot) have acceptable oxidation stability. In conclusion all the OO from studied cultivars are above the limit value of 7.00.

Quantitative determination of phenolic compounds in olive oil was performed according to the colorimetric method Folin-Ciocalteau (*[12]*). The amount of phenolic compounds in olive oil varies from 50 to 1000 mg/kg and depends on several factors such as: climate, and extraction technology (*[6]*), cultivar (*[19]*) and degree of maturation (*[18]*).

The results for the six olive cultivars (Table 3) reveal that the highest value belongs to UbT, 445.03 ± 11.90 mg GA/kg olive oil, and the lowest value belongs to Karren, 63.02 ± 3.9 mg GA/kg olive oil. The results show that the polyphenol content of the studied olive oils had significant differences (p<0.05) among the cultivars. According to the classification for the olive oils proposed by Montedoro et al (*[19]*) regarding to the Total Polyphenol Content, the Karren and Kokermadh Berati cultivars can be classified in group of "low" content (50-200 mg/kg); while the next four cultivars, Kalinjoti, UBT, Nisioti and Kotruvs can be classified in the group of "medium" content (200-500 mg/kg). The obtained results from the studied cultivars can be related mainly to the cultivar differences. The geographical and pedo-climatical conditions are relatively comparable among regions were collected the olive fruits. The TPC results for UBT are comparable with Koreiniki (Greece), Picual (Spain) and Frantoio (Italy) cultivars (*[7], [13]*).

IV. CONCLUSION

The results on the chemical composition of the studied cultivars give for the first time a comprehensive analysis of the Albanian olive cultivars. The variations, observed in fatty acid composition and phenolic compounds, are probably due to both genetic factors and environmental conditions. By comparison with results from literature, it can be concluded that the levels of fatty acids in the oils of the studied cultivars are similar to those found in the group of olive cultivars typical from Northern Mediterranean regions. In general referred to the 18:1/18:2 ratio an index of the oxidative state to the monovarietal olive oils give good consistency. The nutritional profile of *Nisioti* cultivar is highly interesting, as well as the *Kokerrmadh Berati* cultivar. The total phenolic content of the UBT is particularly of interest, with potential to be expanded beyond its territory.

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