Analytical evaluation of virgin olive oils produced from three varieties *Koroneiki* , *Arbequina* and *Arbosana* grown in east of Morocco

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Introduction The intensification of olive production, extension of olive grove surface areas and improvement of olive oil quality are the essential objectives for olive growing sector development through the "Green Morocco Plan". This program, aims also to improve productivity by introduction of new varieties of olive trees. The application of a high density planting (HDP) according to a Spanish super intensive planting system of olive trees, allows reduction of production cost and provides an olive oil of quite good quality or even with a superior quality. Like in Spain, in the area of Haouz (West of Morocco), the profitability of HDP system for olive production has been well demonstrated. In the area of Chark (East of Morocco), olive production with irrigated HDP system has been introduced just since few years ago.
This study consists in an analytical evaluation of monovarietal olive oils, produced from HDP olive groves in East of Morocco. The characterization of olive oils from three cultivars *Arbequina*, *Arbosana* and *Koroneiki* was carried out. The analytical parameters evaluated were : quality indexes, determination of Triacylglycerol profile , fatty acids composition, chlorophylls, carotenes , total phenols , and the oxidative stability of those olive oils .

Classical methods of analysis were used for a preliminary characterisation: analysies were performed according to commercial standards, applicable to the olive oil (IOC 2001).

Quality parameters

As shown in Table 1, all the analysed oils showed very low values for the regulated physicochemical parameters. Those quality parameters did not exceed the limits established for the best commercial quality olive oil, designated as "extra virgin olive oil category", by International Olive Oil Council (IOOC, 2011).

Table 1 Physicochemical quality indices of monovarietal virgin olive oil produced in eastern area of Morocco.

Physicochemical parameters	varieties		
	Arbequina	*Arbosana*	*Koroneiki*
Free fatty acids (%C18:1)	0.46 ± 0.03a	0.53 ± 0.11a	0.58 ± 0.04a
Peroxide value ($meq\ O_2\ kg^{-1}$)	12.55 ± 1.16b	17.54 ± 0.69c	17.08 ± 1.13c
K270	0.08 ± 0.02a	0.11 ± 0.01ab	0.14 ± 0.01b
K232	1.43 ± 0.22a	1.56 ± 0.01a	1.63 ± 0.13a
ΔK	0.002± 0.0003b	0.001±0.0003b	0.004±0.0004c

Significant differences in the same row are shown by different letters (a–d) varieties (P<0.05).

Stability parameters

Stability parameters such as total phenols, chlorophylls and carotenes are shown in Table 2. Among the olive oils, the highest oxidative susceptibility was observed in *Koroneiki* oil (93.16 h). This result was confirmed by fatty acids and total phenols levels since OS depends on their values.

Table 2 Minor component contents and oxidative stability of monovarietal virgin olive oil samples.

	Varieties		
	Arbequina	*Arbosana*	*Koroneiki*
Total phenols ($mg\ kg^{-1}$)[a]	209.1 ± 6,25a	260.85 ± 8.27a	459.48 ± 11.6d
Chlorophylls ($mg\ kg^{-1}$)	1.86 ± 0.05b	1.94 ± 0.04c	3.94 ± 0.01d
Carotenes ($mg\ kg^{-1}$)	1.66 ± 0.11b	1.65 ± 0.01b	2.17 ± 0.02c
Oxidative stability (h)	49.69 ± 1.06b	60.17 ± 1.16c	93.16 ± 1.67d

Significant differences in the same row are shown by different letters (a-d) ($p < 0.05$).
[a] Concentration of polyphenols expressed as milligram of caffeic acid per kilogram of oil (colorimetric method).

Fatty acid composition

The tree VOOs analysed showed a fatty acid composition (Table 3) in compliance with established limits (IOOC, 2011) and with ranges depending to the varieties.
The level of palmitic acid showed a maximum value of 17.95% observed in *Arbequina*. Oleic acid, the major monounsaturated fatty acid, showed also a wide variability depending to the varieties. It is especially high in *Koroneiki* virgin olive oil (76.24%).

Table 3 Fatty acid compositions and iodine index of monovarietal virgin olive oils produced in eastern area of Morocco.

Fatty acid	Varieties		
	Arbequina	*Arbosana*	*Koroneiki*
C16:0 (%)	17.65 ± 3.64a	13.71 ± 0.43a	15.7 ± 0.37a
C16:1 (%)	1.89 ± 0.37b	1.27 ± 0.04a	1.23 ± 0.06a
C17:0 (%)	0.11 ± 0.02a	0.14 ± 0.01b	ND
C17:1 (%)	0.27 ± 0.04a	0.34 ± 0.01b	ND
C18:0 (%)	1.86 ± 0.56b	1.91 ± 0.44b	0.51 ± 0.13a
C18:1 (%)	69.05 ± 4.14a	75.68 ± 0.7b	76.24 ± 0.52b
C18:2 (%)	8.13 ± 0.1c	5.66 ± 0.07b	5.26 ± 0.07a
C18:3n3 (%)	0.54 ± 0.02a	0.64 ± 0.02b	0.64 ± 0.01b
C20:0 (%)	0.26 ± 0.1a	0.37 ± 0.01b	0.24 ± 0.01a
C20:1 (%)	0.21 ± 0.07ab	0.26 ± 0.01b	0.18 ± 0.01a
ΣSFAs	19.88 ± 3.86a	16.13 ± 0.79a	16.45 ± 0.45a
ΣMUFAs	71.42 ± 3.8a	77.55 ± 0.72b	77.65 ± 0.51b
ΣPUFAs	8.67 ± 0.12c	6.3 ± 0.08b	5.9 ± 0.08a
O/L ratio	8.49 ± 0.46b	13.37 ± 0.06c	14.5 ± 0.25d
Iodine Index	80.19 ± 3.5a	81.33 ± 081a	81.07 ± 0.36a

Significant differences in the same row are shown by different letters (a–d) varieties (P<0.05). SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; O/L, oleic/linoleic ratio;. C16:0, palmitic acid; C16:1, palmitoleic acid; C17:0, margaric acid; C17:1, margaroleic acid; C18:0, stearic acid; C18:1, oleic acid; C18:2, linoleic acid; C18:3, linolenic acid; C20:0, arachidic acid and C20:1, gadoleic acid.

Triacylglycerol composition

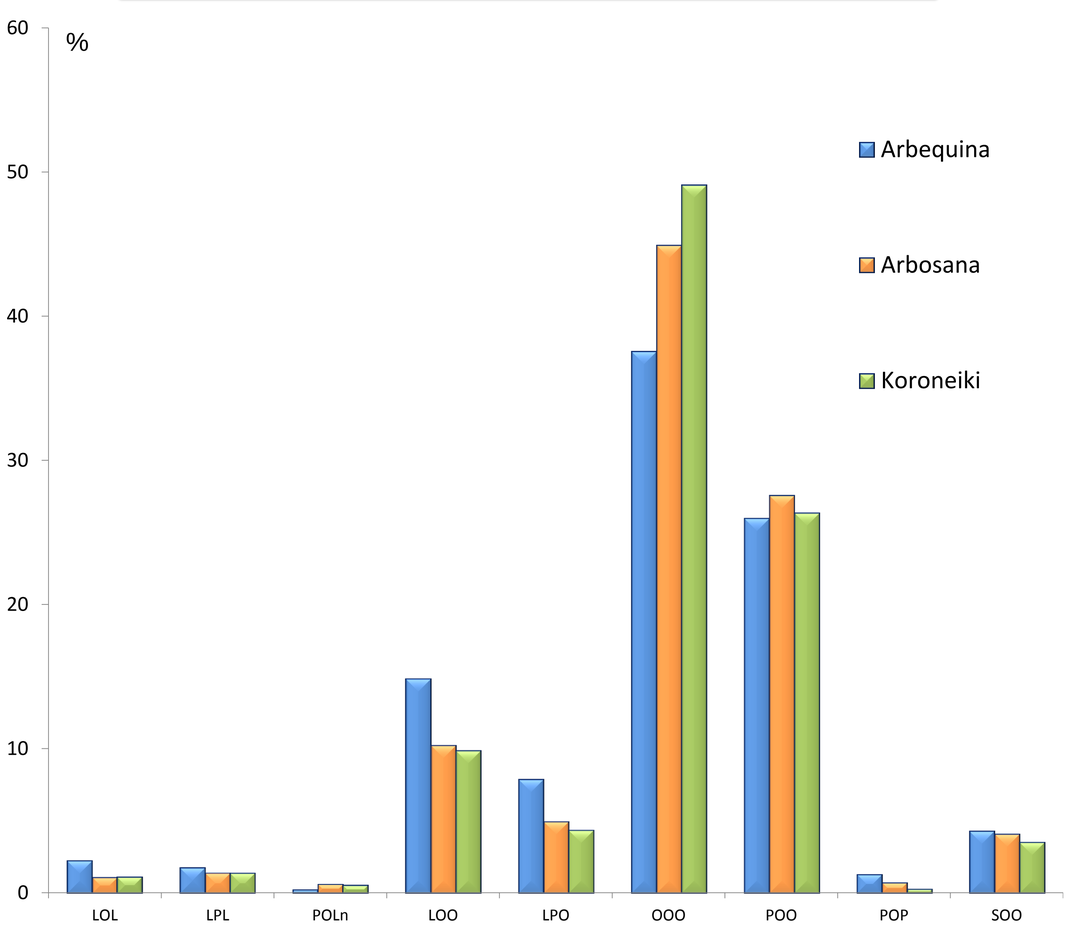

Figure 1: Triacylglycerol molecular species of monovarietal olive oils analysed by HPLC (Ln=C18:3; L= C18:2; O=C18:1; S=C18:0; P= C16:0)

Table 4 Comparison of major fatty acids in olive oils of cultivars planted in eastern of Morocco or in their original sites in Spain or Greek.

	Varieties					
	Arbequina		*Arbosana*		*Koroneiki*	
	In Morocco	In Spain	In Morocco	In Spain	In Morocco	In Greek
C16:0 (%)	17.65 ± 3.64	13.3[a]	13.71± 0.43	13.4[a]	15.7 ± 0.37	10.36[b]
C18:1 (%)	69.05 ± 4.14	70.5[a]	75.68 ± 0.7	74.3[a]	76.24 ± 0.52	76.22[b]
C18:2 (%)	8.13 ± 0.1	11.7[a]	5.66 ± 0.07	7.6[a]	5.26 ± 0.07	8.34[b]
Phenols ($mg\ kg^{-1}$)	209.1 ± 6,25	128[a]	260.85 ± 8.27	278[a]	459.48 ± 11.6	583[b]

Data are expressed by mean values ± S.D. of three independent experiments.
[a] Irrigated high-density system. [b] Rain fed cultural system.

Olive oil samples and Olive plantation in HDP system, Oujda Angad, East of Morocco

Conclusion The majority of the analysed parameters were greatly influenced by the cultivar–environment interaction. *Arbequina and Arbosana* as Spanish cultivars, when grown in Morocco under irrigated HDP system, produced olive oils with some differences from those obtained in their traditional growing area. However *Koroneiki*, a Greek variety cultivated in the same conditions as the previous varieties, produced an olive oil with nearly the same composition as in Greek.