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Evaluation of oil richness or technological characteristics of introduced varieties and local types of olive trees (*Olea europaea* L.) grown in Ouazzane areas (Northern Morocco)

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ABSTRACT

For the majority of local and foreign varieties, Moroccan Picholine and oleasters types, the obtained oil content relating to the fruit fresh weight varied between 14.3% to 23%; excepted, the Picual variety, type oleastre BM2, Manzanille and Cucco varieties and Moroccan Picholine M1 type, which gave oil contents higher than 23%, respectively 23.23%; 23.76%; 23.83%; 25.14% and 25.83% compared to other cultivars. Gordal, Ascolana Dura, and Bouchouk Rkike Varieties, have given average oil content relative to the fresh matter lower than 17% for the local variety Bouchouk Rkike, 16% for Gordal variety and 16.9% for Ascolana Dura variety. Also, in studied oleaster types, noticeable oil contents were obtained especially for the types BM2 (23.76%), BM3 (20.95%), BMR (21.36%), BMM (18.09%). The Gordal and Bouchouk Rkike varieties presented the highest humidy percentage. Ascolana Dura, Cucco and Manzanille, Moroccan Picholine type M1 and oleaster type BM3, BMK, BMR, have the lowest one. By cons, varieties of Bouchouk Laghlide, Bouchouika, Bakhboukh Beldi, Dahbia, Picholine du Languedoc, Picual, Ascolana Tenera, types Moroccan Picholine, G9, G10, S1, S2, M6, type oleasters BM2, BM4, have presented an intermediate percentage of fruit humidity.

Keywords: Olive (*Olea europaea* L.), genetic resources, oil richness, fruit humidity.

INTRODUCTION

In Morocco, the olive trees has a greater socio-economic importance and is cultivated for oil production and canned fruit (production: 1500000 T of olives; 150000 T of oil, 15 millions of work days assured in year) (*Ouazzani, 2013 and 2014*). The obtained oil by fruit cold pressing has excellent nutritional and dietary value characteristics and potential medical virtues due to its beneficial effect in Mediterranean diet for human health (*Mercedes, 2004*).

Moroccan olive patrimony (indigenous varieties) contains an important genetic resources, rich, diverse, include a wide range of cultivars widely extended for their economic value and are not yet exploited, because their productivity and quality potentials remains still largely unknown and ignored. However, there are urgent threats on both the heritage and biodiversity (modernization, migration to towns, and social relations evolution) (*Boulouha, 2006 and 2010*; *Ouazzani, 2007 and 2008*).

The inventorization, collection and characterization of genetic resources in olive is able to play a key role to improve the national olive growing for the business

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requirements demanded by a free competitive market (quality, labeling, local products, AOC, AOP, DOP, IGP) and to deep cultural significance as a symbol of the society and ties to traditional land.

Moreover, genetic characteristics of a variety, have a more intense incidence on lipogenesis than that exerted by environmental conditions (soil, climate), the oil content of olives and its qualitative or organoleptic characteristics are related to biological and nutritional virtues of the oil (*Montedoro, 1988; Cimato, 1990 and 1996; Michelakis, 1992; Alessandri, 1997; Salas et al. 1997; Ismail et al. 1999; Fourati et al. 2003; Gucci et al. 2004; Pastor et al. 2005; Berenguer et al. 2006;* Tangkam *et al. 2008).* Thus, the varietal olive assortment includes varieties of table olives with low oil content, oil rich varieties and suitable binary use varieties (oil and table olives).

For all three groups of varieties, oil content, determined to the fresh and dry matter basis of healthy olives, varied between 5% and 36% and between 20% and 70% (*Ouazzani et al.1997).*

The aim of the present study was to characterize and to evaluate the most important Moroccan and foreign cultivars (genetic resource) cultivated in the same pedoclimatic conditions in Ouazzane region concerning the potential richness of oil or technological characteristics of varieties, which causes a huge problem of management in the collections of genotypes as an olive gene bank or germoplasm and traceability and authenticity of virgin olive oils production.

MATERIALS AND METHODS

Plant materials:

Four local varieties (Bouchouk Laghlide, Bouchouk Rkike, Bouchouika, Bakhboukh Beldi), six types of oleaster (BM2, BM3, BMK, BMM, BMR, BM4), six types of Moroccan Picholine (M1, M6,G9,G10,S1,S2), traditional Moroccan variety Dahbia and seven exotic or foreign olive cultivars, the most present and widely dispeared in Ouazzane areas suitable for oil and table use (Picual, Gordal, Manzanille, Picholine du Languedoc, Ascolana Tenera, Ascolana Dura, Cucco) were analyzed.

Oil content and fruit humidity:

The oil content on the basis of fresh and dry fruit weight, was determined using the Soxhlet method (apparatus, hexane solvent) and adjusted by nuclear magnetic resonance spectrometry (NMR Type Oxford 4000)(*COI, 1997*). All samples of ripe fruit were tacked up at harvest at optimal ripening stage (ripening or maturity index: 4) (*COI, 1997*).

RESULTS AND DISCUSSION

The olive oil richness of the studied local types and foreign varieties was evaluated by determination of their oil content in relation to fresh and dry weight (Table-1). It's showed that there is a high significant difference between studied varieties regarding the oil yield.

For the majority of local and foreign varieties, Moroccan Picholine and oleasters, the obtained oil content in relation to the fruit fresh weight varied from 14.3% to 23%; excepted, the Picual variety, type oleastre BM2, Manzanille and Cucco varieties and Moroccan Picholine type M1, which gave oil contents higher than that in other cultivars, above 23%, respectively 23.23%; 23.76%; 23.83%; 25.14% and 25.83% (Table-1, Figure-1).

For table variety Cucco, previous studies reported average oil content in function of the fresh matter of 13% (*Moundi and Bouzroude, 1981 and 1990; Krimi Bencheqroune, 1996; Chahbar, 1984; Barranco et al. 2000*) and very high oil yield in its original environment (Italy)(*Guerriero et al. 1988*).

The oil Picual variety has given in the conditions of south Spain (Jaen) oil contents in function of the fresh matter varied from 23% to 27% and in function of the dry matter of 47.95% (*Loussert and Brousse, 1978; Tous and Romero, 1991 and 1994; Barranco et al. 2000; Barranco et al. 2001*). This variety has given in the agro-climatic conditions of Meknes, oil content compared to fresh weight varying from 21.84% to 23.6% (*Ouazzani et al.* 2007 and 2008).

The dual purpose of Manzanille variety gave in agro-climatic conditions of Meknes and Marrakech, oil contents in function of the fresh matter from 14.6% to 26.6% (Cheveau, 1938; Moundi, 1974; Loussert and Brousse, 1978; Moundi and Bouzroud, 1981 and 1990; Chahbar, 1984). This variety has given in soil and climatic conditions of south of Spain, the lowest oil yield compared to fresh matter from 16.7% to 21% and 44.93% relative to the dry matter (*Loussert and Brousse,1978;Tous and Romero, 1991 and 1994; Barranco et al. 2001).*

Varieties Gordal, Ascolana Dura, and Bouchouk Rkike, have given average oil yield in function of fresh matter under 17% for the local variety Bouchouk Rkike, 16% for Gordal variety and 16.9% for Ascolana Dura variety.

For table varieties Gordal and Ascolana Dura, similar oil contents in function of the fresh matter were obtained in the agro-climatic conditions of Meknes, Marrakech and south Spain (Gordal from 8% to 18%, Ascolana Dura from 10% to 19.75%)

(*Moundi, 1974; Loussert and Brousse, 1978; Moundi and Bouzroud, 1981 and 1990; Barranco et al. 2001).* The oil contents obtained in function of fresh matter for Moroccan traditional varieties Dahbia, Bouchouika, Bakhboukh Beldi, Bouchouk Laghlide, types Moroccan Picholine respectively, S1, S2, G9, G10, M6, and foreign varieties Picholine du Languedoc, and Ascolana Tenera varied from 20% to 22%. It was noticed that the Dahbia variety has also given in agro-climatic conditions in Meknes the lowest oil yield (17% to 18%) (*Lakhdar, 1981; El Mekkaoui, 1984).*

Also, it's noticed that oil contents in function of the fresh matter varied from 17% to 27.48% and from 9% to 24.5% respectively for varieties Picholine Languedoc and Ascolana Tenera in the agro-climatic conditions of Meknes and Marrakech (*Cheveau, 1938; Moundi 1974; Loussert and Brousse, 1978; Moundi and Bouzroud, 1981 and 1990; Senhaji, 1984 and 1986*).

The Moroccan Picholine local types characterized by oil contents varying from 18% to 25% (*Cheveau 1938; Moundi 1974; Loussert and Brousse, 1978; Moundi and Bouzroud, 198*1; *Senhaji, 1984 and 1986*), presented the same oil contents, from 21.73% to 25.83%, identical oil contents and highly appreciated by consumers, in comparison with those obtained in oil the Picual variety (23.23%) and dual purpose of Dahbia varieties (21.74%), Picholine du Languedoc (21,9%), Ascolana Tenera (22.6%) and Manzanille (23.88%).

The variety Manzanille has presented oil contents from 16.7% to 20.1% in the south of Spain (*Barranco et al. 2001*). Fruit load of the trees in low or high yield year and agro-climatical conditions (cultural practices, water deficit, and temperature) influenced directly the fruit oil yield (*Cimato, 1990 and 1996; Barone et al. 1994; Raina, 1995; Zarrouk et al. 1996; Al Maaitah et al. 2009).* In fact, trees fruit in low yielding (off) or producing year (on) have a large caliber and ripened early before those of the top charged fruit trees and accumulated oil rapidly and final oil yield is higher (*Barone et al. 1994*).

In Italy and Jordan, the fruit harvested from mid-November to mid-December, presented very high oil content (*Rotundo, 1988; Presiosi and Tini, 1990; Al Maaitah et al. 2009).* The oil yield of harvested fruit at night and full day was similar in the Italian variety Ogliarola (*Di Serio et al. 2014).*

Table-1. Oil contents of studied foreign varieties and local types of olive tree.

Varieties and local types	Fruit Humidity (%)	Oil content (%)	
		Fresh matter	Dry matter
Bouchouk Laghlide	55.93	21.19	47.85
Bouchouk Rkike	63.36	17.08	40.62
Bakhboukh Beldi	54.83	22.78	50.09
Bouchouika	55.83	20.07	44.19
Type Oléastre BM2	52.22	23.76	46.7
Type Oléastre BM3	44.04	20.95	35.46
Type Oléastre BM K	44.95	15.49	28.07
Type Oléastre BM4	54.29	14.30	33.41
Type Oléastre BMR	44.21	21.36	39.16
Type Oléastre BM M	53.69	18.09	41.76
Type Pich. Maroc M1	47.45	25.83	48.96
Type Pich. Maroc M6	55.97	22.95	46.2
Type Pich. Maroc G9	56.72	22.65	49.64
Type Pich. Maroc G10	53.06	21.98	47.17
Type Pich. Maroc S1	52.35	22.46	42.88
Type Pich. Maroc S2	55.17	21.73	44.78
Dahbia	53.43	21.74	38
Picholine du Languedoc	56.8	21.9	50.61
Picual	57.4	23.23	54.39
Ascolana Tenera	55.45	22.6	50.41
Ascolana Dura	45.73	16.9	31.14
Gordal	63.81	16.37	45.10
Manzanille	44.91	23.83	44.30
Cucco	49.39	25.14	49.75

Thus, these results confirmed the oil contents recognized for certain varieties, proven in their origin ecological areas (*Loussert and Brousse, 1978*), although that management practices are traditional in our local pedoclimatic conditions. Also, in the studied sample of the oleaster types noticeable oil contents were remarkably obtained for the types BM2 (23.76%), BM3 (20.95%), BMR (21. 36%), BMM (18.09%).

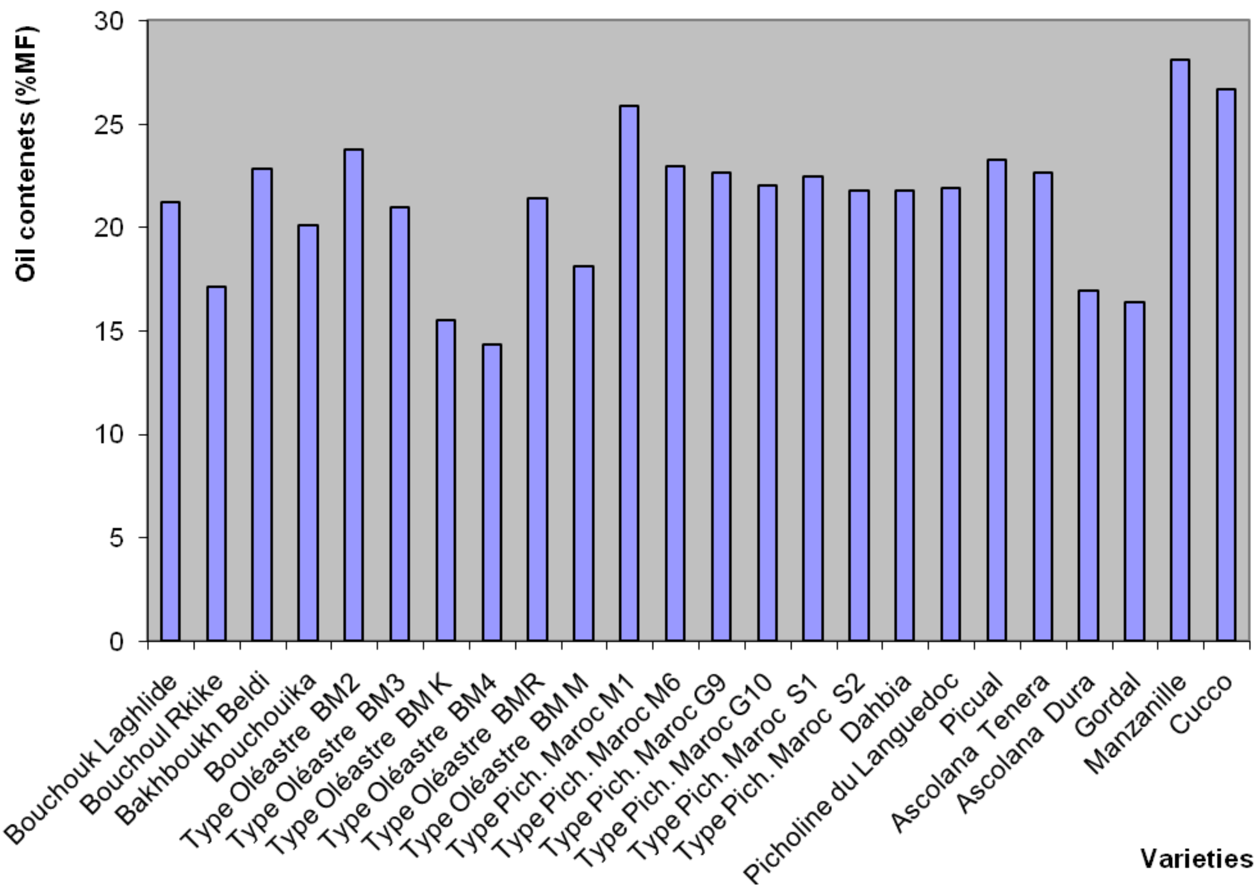
It's suggested the utility of the major agronomical characteristics evaluation of this material and its local valuation as well as local genetic resources guaranteed the best adaptation. Although the pulp stone ratio is often low (2.78-3.68) (Table 3). Some studied oleaster types have presented more important oil contents which are valuable source of material for selecting new native cultivars. So, the general character of these oleaster types (small seize of fruit), may not be as a big handicap to their domestication and diffuseness, and it is known that fruit of many better oil varieties have small size (Arbequine, Moraiolo, Leccino, Mastoidis, Koroneiki, Verdal, Chemlali, Sabine) (average weight of 0.7-2.5 g) (*Loussert and Brousse, 1978; Miranovic, 1986; Trigui, 2002; Breton, 2005).*

It's reported that in Southern Australia, similar oil contents (15.55% to 25.65%), were recorded in the types of oleasters, vegetatively propagated with interested morphological and pomological characters and an oil extracted from them have very higher organoleptic and gustatory characteristics (*Wirthensohn et al. 2001; Margaret, 2004*). In Tunisia, performing types of oleasters, selected from local populations, have given a high oil content and quality characterized by an interesting fatty acid composition better than those obtained in the dominated Chemlali variety, widely dispread in arid grown land (oleic acid: 69%-78%, linolenic acid: 6%-15%, palmitic acid:15% (*Baccouri et al. 2004 and 2008*).

Also, the variation in oil content expressed into fresh and dry matter, attributed to practiced agricultural techniques, presented the possibility of revaluation of the studied plant material adapted to its natural habitat (microclimate) and in which improvement of agricultural technics (cutting, irrigation, and fertilization) can contribute positively to the increase in its agronomical performance.

In fact, most olive varieties reacted strongly to irrigation and fertilization and valued at the best

Figure-1. Oil contents (%FM) of studied foreign and local varieties and local types of olive tree.



inputs and take advantage or efficiency of very low irrigation water. In Italy, Spain, Greece, United States and Morocco, studies on several tested varieties (Picual, Arbequina, Leccino, Kalamata, Itrana, Koroneiki, Picholine Marocaine, Frantoio, Ascolana Tenera, Maiatica, Kalomon, Nocellera del betice..) showed that the autumnal drought stress and shading from August to December of fruiting branches occasioned a net loss of olive oil (*Proietti,1994; Berenguer et al. 2006*) and the complementary or supplied irrigation even so deficiency applied to oldest trees during the growth of the fruit (July, August, October) enabled to increase production size (extend, largeness) and humidity of fruits at harvest and influenced favorably the biosynthesis, accumulation, extractability and oil content, as well as its chemical composition and therefore its optimum quality, organoleptical and sensorial characteristics (fatty acids, acidity, polyphenols, tocopherols, β-carotene, pheophytins, chlorophylls, flavour, savor, bitterness, oxidative stability, peroxides index, sugars), whatever fruit charge trees and high humidity of fruits correlates negatively with fruit size (r^2:0,89), oil yield (r^2:0,7654) and polyphenol content (*Singh et al. 1986; Chartzoulakis et al. 1992; Berenguer et al. 2006; Al Maaitah et al. 2009*).

Polyphenols are responsible for the bitterness of the self-oxidation resistance and stability of olive oil extracted and their content correlates positively with bitterness (r^2:0.9747)(*Ilela et Dettori, 1986, Agabbio, 1977; Lavee, 1990, Famiani,1991, in Alessandri, 1997; Andrich et al.1992; Chartzoulakis et al.1992; Salas et al.1997; Ismail et al. 1999; Gucci et al. 2004; Pastor et al. 2005; Berenguer et al. 2006; Aganchich et al. 2008).*

For fruit humidity, significant differences recorded between studied transplanted varieties and local types. The Gordal and Bouchouk Rkike varieties presented the highest humidity than others varieties. The varieties Ascolana Dura, Cucco and Manzanille, type Picholine Marocaine M1 and oleastre type BM3, BMK, BMR, have the lowest percentage of humidity. On the contrary, Bouchouk Laghlide, Bouchouika, Bakhboukh Beldi, Dahbia, Picholine du Languedoc, Picual, Ascolana Tenera, Picholine Marocaine varieties types, G9, G10, S1, S2, M6, type oleasters BM2, BM4, have presented an intermediate percentage of fruit humidity.

The humidity decreased slowly as fruit ripeness progressed, and along harvesting, the fruit lose water easily, because of the break of sealing protective of epicarp lenticels (skin) and metabolic process occurred inside the drupes (*Cimato, 1990 and 1996; AlMaaitah et al. 2009*).

The final oil content narrowly correlated with maturity index (based on the superficial and profound pigmentation of olives) is determined both by the genetic potential of varieties, agricultural practices, environmental and climatic conditions (season), size and moisture of fruit at harvest (mesocarp), preparation techniques of the olive paste, and density and planting system (*Rotundo, 1988; Pannelli et al. 1990; Lavee and Wodner, 1991; Pandolfi et al. 1994; Sanchez Casas et al. 1999; Lavee and Wodner, 2004; Al Maaitah et al. 2009; Zarrouk et al. 2009; Katsoyannos et al. 2015)*.

Under irrigation, the oil biosynthesis and its accumulation are stimulated during the most period of development and maturity of fruits hanged down from the trees. The colour changes and distribution of ripeness drupes were used to indicate the right moment just as the final oil content of fruit present on the trees is highest and the choice of the optimum ripeness and the harvest dates (*Rotundo, 1988; Lavee and Wodner, 1991and 2004; Al Maaitah et al. 2009*).

In the Italian oil variety (olivo da olio) and Jordanian varieties (Nabali, Aboshoka), fruit swelling, promoted the accumulation of oil in fruits hanged on the trees (lipogenesis), which increased gradually during the progression of maturation (October-December), reached its maximum (mid-December) and apparently stabilized at complete blackening of the epicarp of population drupes, and it is only at this date that the fruits have completed their maturity and contained the highest oil richness (end of December). In reality, the biosynthesis of oil in unripe olives (green, tainting or turning) (lipogenesis), continued, at least at a slower rhythm throughout all the winter (late January) and coincided with continues, progressive and excessive natural drop of black ripe fruits (abscission) (*Rotundo 1988; Al Maaitah et al. 2009)*

At Greek varieties (Koroneiki, Megaritiki), the paste preparation technique of the olive(whole, pitted) has no influence on oil yield obtained in the case of green fruits, whereas significant differences in percentage oil was observed between varieties (10% -30%) in ripe whole olive as pitted ripe fruit oils gave a lower yield (*Katsoyannos et al. 2015*).

In oil varieties (Koroneiki, Arbequina) and table varieties (Ascolana Tenera, Manna, Coratina), irrigation during critical periods (May to September), improved water efficiency (number fruits per twigs) and increased the productivity of olive trees, fruit weight and oil yield compared to the control (non-irrigated) (*Gatto, 1989; Dettori et al. 1989; Michelakis, 1990; Sole Riera, 1990).* In Greek variety Cobrançosa and argentine variety Farga, the application of deficit irrigation (30% to 50% ETc), increases moisture and oil content of fruit compared to the total irrigation (100% ETc) (*Fernandez-Silva et al., 2013;Monteleone et al. 2013*).

It reduced the stearic acid rate in the fruit of cultivar Coratina (*Gatto, 1989*), decreased the biosynthesis of oleic acid and polyphenols and promoted the linoleic acid and hydroxytyrosol levels, which are the contents, are significantly different from those tacken up from oil proceeding of traditional olive orchards planted in rainy conditions or dry areas (non-irrigated).

The reduction of the polyphenol content of oils extracted from ripe fruits is also dependent to the high solubility of these substances in the water content in these fruits and to the intense activity of enzymes (phenylalanine ammonium lyase, lipase, lipoxygenase), catalyzed their degradation instead of unsaturated fatty acids (oleic, linoleic and linolenic) *(Chimi, 2008).*

When polyphenols, particularly diphenols (hydroxytyrosol, oleuropein and caffeic acid) are present in greater quantities in the olive, finished product (oil), which is better protected against oxidation and its oxidative stability is prolonged (*Chimi, 1990 and 2008).* The irrigation also influenced the components of the relish or taste (perfume, freshness, savor, flavor, degree of fruitiness, bitterness and pungency...), which contributed forcibly to the quality of oil, taken into account the positive and interesting characters they transmit (*Salas et al. 1997; Pastor et al. 2005; Berenguer et al. 2006).* The fertilization of soil with nitrogen, promoted vegetative growth and set fruiting, improved productive efficiency, retarded ripening and lipogenesis and influenced the characteristics of the olive (high oil contents and elevated polyphenols and tocopherols proportions), guaranteed for oil extracted, improved oxidative stability and interesting qualitative characteristics (relish, savor, and flavor).As to the supply of soil of potassium accelerated olive maturation and stimulated lipid biosynthesis.

A positive correlation exists between the accumulation of nitrogen, phosphorus, potassium and boron in fruits and oil content; between the fruit weight and the rate of phosphorus and boron, and between the oleic acid content and copper level in the fruit. On the contrary a significant negative correlation was founded between the weight of the fruit, the oil content and the rate of calcium, linoleic acid and magnesium, zinc, manganese and oleic acid (*Jordado and Lietao 1990*). As for the phosphorus, it improves the palmitic acid level (*Scaramuzzi and Roselli, 1986; Fantanazza, 1988; Cimato, 1990; Sandro and Girolano, 1993; Cavusoglu and Oktar, 1994; Michelakis, 1992; Alessandri, 1997; El Antari, 2003; BenTemime et al. 2004; Gucci et al. 2004; D' Andria et al. 2004; Pastor et al. 2005; Chimi, 1990 and 2008).*

CONCLUSION

It's evidenced that the Picholine Marocaine cultivars and the oleaster types (BM2, BM3, BMR), with noticeable and interesting oil contents (22% to 25 %) are also significantly performant than other studied varieties (Picual, Picholine du Languedoc, Ascolana Tenera) planted in the same pedoclimatic at Ouazzane region and which are distinguished by highest oil yield.

Also, in the studied sample oleaster types, noticeable oil contents were remarkably obtained for the types BM2 (23.76%), BM3 (20. 95%), BMR (21.36%), BMM (18.09%).

It's demonstrated that except the Picholine Marocaine type M1 (25.83%), these local types are at the least rich in oil than Manzanille variety (23.83%) and offered the possibility to recover the extraordinary indigenous germoplasm and to select interesting type among the local genetic pool and foreign varieties of different origins thus present and disposable at this time in the Ouazzane region.

It's also justified the great interest of enlarged and extended the varietal profile of Moroccan olive orchards or grooved by adaptative diversification to north areas of Morocco. This will not fail to have an impact on the competitive of this vital sector of agricultural and the economy in Morocco, regarding the future planning of the olive oil sector.

Moreover, additional chemical characterization of monovarietal genuine extra-virgin olive oils, used as a main natural functional food and as an integral ingredient of the Mediterranean diet universally recognized, based on analytical determinations of quality parameters (free acidity, peroxide values, iodine , UV spectrophotometric characteristics, total phenols…) and chemical profiles (fatty acid, sterols…) compared between domestic and foreign olive cultivars, will contribute to a better characterization and management of the present genetic resources as registration of found varieties and local types in national and international databases.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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