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Partial Characterisation of Oak Acorns Oil Extracted from Moroccan *Quercus Suber* L.

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ABSTRACT

There is a paucity of literature on the nutritional profile of Moroccan *Quercus suber* L. acorns oil, and its importance has not been fully exploited to date. Therefore, this work aimed to characterise, for the first time, the Moroccan *Quercus suber* L. acorns oil, to compare results with those of previous works performed on the same species, as well as its characteristics with those of olive oil. The oil was extracted by using the Soxhlet apparatus. Free fatty acids, peroxide value, iodine value, refractive index, and saponification value were determined according to AOCS recommended practices. The fatty acids and sterols were analysed by GC-MS, while Tocopherol was analysed with HPLC. The percentage of the oil expressed as dry weight was 5.2-5.5%. The fatty acid composition showed that the most abundant fatty acids were oleic (64.7-67.0%), linoleic (16.6-19.2%), and palmitic (11.1-11.5%). The HPLC analysis revealed high levels of Tocopherols content (2123-3566 mg/kg oil). The amounts of γ-tocopherol, α-tocopherol, and δ-tocopherol were 1777-3052 mg/kg oil, 272-378 mg/kg oil, and 74-136 mg/kg oil, respectively. Sterol composition shows that β-sitosterol is the main component (86.9%-87.2%), followed by stigmasterol (3.8-4.1%), Δ^5-avenasterol (2.9-3.0%), and campesterol (2.6-2.8%). Cholesterol, Δ^7-stigmasterol, and Δ^7-avenastrol were present in minimal amounts. The current results show that Moroccan *Quercus suber* L. acorns oil can be an excellent natural source for cosmetic and pharmaceutical product applications. Therefore, more investigations are required to understand the nutritional potentials of this oil and its bioactivity.

***Keywords*:** *Quercus suber*, Acorns oil, Fatty acids, Tocopherols, Sterols.

Introduction

There are about 600 known oak tree species distributed throughout the world, one of which is Oak acorns.[1] The tree belongs to the Fagaceae family and extends across the Northern Hemisphere in America, Europe, Asia, and North Africa.[2] Oak acorns have essential nutritional and health benefits. They have been consumed as food by humans and animals for thousands of years in the Mediterranean countries. For example, in some countries of North Africa such as Morocco, Algeria, and Tunisia, oak acorns are consumed by humans as green snacks, roasted, boiled, ground, and mixed with milk, in the form of bread and prepared as couscous, and even used as cattle feed.[3-5] In Portugal and Spain, oak acorns are used as feeds for pigs in a loose-housing system.[6-8]

The main component of oak acorns is starch which accounts for 48-50% [9] while their oil content is less than 12%.[10] They are also considered good sources of fibres, proteins, polyphenols, minerals (such as P, K, Ca, and Mg), vitamins (A and E), and unsaturated fatty acids.[1,9] Oak acorns have been associated with significant biological activities such as antioxidant, anti-inflammatory, antibacterial, anti-diabetic, and anticancer effects.[1,9] These activities have been harnessed in food products based on acorns such as bread, pasta, biscuits, beverages, cakes, and cookies.[11-15]

In recent times, acorns oil has attracted the attention of the scientific community.[10,16] The three primary fatty acids found in acorn oil are oleic (C18:1), linoleic (C18:2), and palmitic (C16:0) acids.[6] Tocopherols and phytosterols are present in high amounts in acorns oils.[10,17,18] Acorns oil has been used in the dietary industry since the nineteen sixties.[6] The oil is also used in cosmetic preparations and combined with other ingredients like avocado oil and beeswax to treat skin irritation and eczema.[19] Studies have shown that acorns oil possess similar nutritional quality and physicochemical properties as olive oil.[10, 19,20, 21]

Quercus suber L. is one of the principal extending oak tree species in the western Mediterranean basin. This tree species is a slow-growing, medium-sized, evergreen. It is the source of cork, mainly used to produce bottle stoppers and other products such as insulation panels, floor and wall tiles, and sound-proofing materials in the car industry.[22] Three oak species, namely: *Quercus suber* L., *Quercus rotundifolia* L., and *Quercus canariensis*, are distributed in Morocco.[23] *Quercus Suber* L. is spread over an estimated 384.280 ha, which includes the Rif, the Middle Atlas, the Central Plateau, and the western Meseta. It is, however, scarcely distributed in the High Atlas.[24] The industrial valorisation of this tree in Morocco is focused on its barks to produce some wood products such as bottle stoppers. The acorns are consumed mainly, while less importance is attached to the oil. Unfortunately, the nutritional profile of the Moroccan *Quercus suber* L. acorns oil has not been explored scientifically. Therefore, this work aimed to determine the physicochemical properties, the fatty acids, tocopherols, and sterols contents of the Moroccan *Quercus suber* L. acorns oil. A comparative study of the oil characteristics with the same species in some western Mediterranean countries and olive oil is also explored.

Materials and Methods

Plant material

Two *Quercus suber* L. acorns samples were collected during the maturation season in November 2020 and identified by the Department of Water and Forests, Ministry of Agriculture, Maritime Fisheries, Rural Development and Water, and Forests. A voucher number (YRQS-271120) was deposited at the Laboratory of Applied Chemistry and Environment, Faculty of Science and Technology,

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Hassan 1st University (Settat, Morocco). The first sample was randomly collected from its natural distribution areas in the forest of Rommani (QSAR), located at an altitude of 426 m in the Middle West of the country. The second was obtained from the Maamora forest in Sale (QSAS), a coastal city located at an altitude of 122 m in the Northwest of Morocco. Healthy, ripe fruits that had fallen to the ground without insect deterioration or mechanical damage were collected for this study. The cotyledons were carefully removed from the ripened fruits, dried in an oven at 50°C, and the dried cotyledons were ground into powder.

Oil extraction
The oil was extracted with Soxhlet apparatus [25] using hexane as solvent. The extracted oil was filtered, poured in a sterile bottle and stored in a cool place away from light until analysis. The oil content is expressed by the ratio of oil weight to acorns kernels weight.

Physical and chemical constants
Free fatty acids, peroxide value, iodine value, refractive index, and saponification value were determined according to AOCS recommended practices Ca 5a-40, Cd 8b-90, Cd 1c-85, Cc 7-25, Cd 3-25; respectively.[26]

Fatty acids composition
To determine the Fatty acids (FA) composition, the fatty acids methyl esters (FAME) were prepared in triplicate according to (ISO 12966-2:2017).[27] The analysis was done by GC Clarus 580 GC_G12086, equipped with an N2 PFloW. The column used for FAME was the CP-Wax 52CB column (30 m × 0.25 mm ID, 0.25 µm film thickness). Helium gas was used at a flow rate of 1.5 ml/min. The oven temperature was started at 100°C for 2 minutes; then it was increased to 6°C/min until 240°C. The injector and detector temperatures were 260°C and 280°C, respectively, with a split ratio of 1:80. The content of FA was determined as a percentage of total FA recovery according to (ISO 12966-4:2015).[28]

Tocopherol analysis
To analyse tocopherols, the HPLC was equipped with a microsilica column (AscentisSupelco SI; 250 x 1.0 mm, 5-µm particle size). The detection was performed using a fluorimeter detector at a wavelength of 290-330 nm. The mobile phase was n-hexane/ isopropanol (99:1, v/v) with a flow rate of 50 µL/min and injection volume of 2 µL. The method was validated according to the Eurachem guidelines for each component (α-tocopherol, γ-tocopherol, and δ-tocopherol).[29]

Sterols
To determine the sterols content, the oil was saponified with potassium hydroxide in ethanolic solution after the addition of α-cholestanol as an internal standard. Then, the unsaponifiable matter was extracted with ethyl ether. The sterols and triterpene dialcohols fraction were separated from the unsaponifiable matter by thin-layer chromatography (TLC) on a basic silica gel plate. The fractions recovered from the silica gel were transformed into trimethylsilyl ethers.[30] After this pretreatment, the sterols were analysed by capillary column gas chromatography (chromatograph 6890 GC) equipped with an Agilent 19091J-413 column (30 m long, 0.32 mm diameter internal and 0.25 µm of the film thickness) and helium (flow rate 2 mL/min) as a carrier. The temperature of the injector and the detector were 325 K and 300 K, respectively, while the column temperature was isothermal at 270 K. The injection volume was 1µL for each analysis, and a ratio of 1:100 was used for the split injection mode.

Results and Discussion

Oil content
The Percentages of oil in QSAR and QSAS, expressed as dry weight, are represented in Table 1. The QSAR oil content (5.5%) was equivalent to QSAS oil (5.2%). These results were in the same range as those reported for Portuguese and Spanish *Q. suber* L. acorns oils,[6-8,31-33] but lower than those reported for Algerian *Q. suber* L. acorns oil.[16,21,34] Compared to olive oil content (12-30%),[35] the obtained results indicate that QSAR and QSAS oil is low for commercial production as cooking or frying oils. Nevertheless, these acorns oils may be used in cosmetic, pharmaceutical and industrial applications, as in the case of amaranth and wheat germ with an oil content of about 6.34% and 10%, respectively.[10]

Organoleptic and physicochemical characteristics
The organoleptic characteristics show that QSAR and QSAS oils have a sweet taste and smell, maroon colour, and viscous. The physicochemical characteristics constants of the oils: free fatty acids (FFA), peroxide value (PV), iodine index (II), refractive index (RI), and saponification value (SV) are presented in Table 2. Low acidity values were detected for QSAR oil (1.07 g/100g oil) and QSAS oil (1.02 g/100g oil). These values are equivalent to those reported for Algerian *Q. suber* L. acorns oil.[21] The peroxide index of QSAR oil (1.1 meq/kg oil) was approximately comparable to that of QSAS oil (0.9 meq/kg oil) but lower than those reported by (Lopes and Bernardo-Gil, 2005) for *Q. suber* L. acorns oil of Portugal,[6] and little higher than those of Makhlouf *et al* for *Q. suber* L. acorns oil of Algeria.[16] These results show that QSAR and QSAS oils are significantly protected against oxidation. QSAR and QSAS oils iodine index was 87 mg I_2/g oil and 88 mg I_2/g oil, respectively. As shown in Table 2, these two values are considered higher than that determined by Lopes and Bernardo-Gil,[6] and lower than that mentioned by Makhlouf *et al*.[16] Based on this index, the QSAR and the QSAS oils are categorised as non-drying oils according to Duel and Tr, who noted that an iodine value above 100 indicates that the oil is a drying oil while below 100 it is a non-drying oil.[36] Refraction index, which increases with increased levels of unsaturated fatty acids in the oil, was found for QSAR oil (1.466) and QSAS oil (1.457) to be similar to the previously reported values of *Q. suber* L. for Portugal and Algeria acorns oils.[6,16] Saponification values (191-195 mg KOH/g), which are inversely related to the mean molecular mass of fatty acids, were higher than Algerian *Q. suber* L. oil.[21] These values indicate that the two oils samples contain fatty acids with 16-18 carbon atoms. In comparison with olive oil, QSAR and QSAS oils showed closely similar physicochemical properties.[10, 37]

Fatty acids
Fatty acids type and quantity influence the chemical, physical and functional proprieties of acorns oil.[38] As listed in Table 3, the most abundant fatty acids in the QSAR and QSAS oils were, respectively, oleic (67.0%, 64.7%), linoleic (16.6%, 19.2%), and palmitic (11.1%, 11.5%). For both samples, low levels of stearic acid (2.5, 1.8%) and linolenic acid (0.9%, 1.2%) were recorded, respectively. Lauric and myristic acids were detected only for QSAS oil with slight amounts (0,4% and 0,1%, respectively). In both oils (i.e. QSAR and QSAS), low amounts of palmitoleic, heptadecanoic, heptadecenoic, arachidic, and eicosenoic were detected (0.6% and below). The minor variations in fatty acid levels observed between the two samples might be related to the abiotic factors such as sampling date, time of year [39] and localisation of the collected samples.[40] The oleic, linoleic and palmitic fatty acids percentages agreed with earlier findings by (Lopes and Bernardo-Gil, 2005) for Portuguese *Q. suber* L. acorns oil.[6] In comparison with that of Spain, results showed that oleic fatty acid percentage in the samples under study was higher, linoleic fatty acid was lower, while the palmitic fatty acid percentage was in the same range.[7,8,33] On the other hand, oleic and linoleic fatty acids percentages obtained in our study were in agreement with results reported for Algerian *Q. suber* L. oil, while the palmitic fatty acid percentage was lower.[21,34] Abiotic factors such as sampling date and year and localisation of the collected samples could explain the variations in fatty acid levels observed between the two samples and those of other countries.[39,40] As listed in Table 3, QSAR and QSAS oils' fatty acid composition was compared to olive oil, particularly in the three most abundant fatty acids (oleic, linoleic and palmitic acids),[37] which formed together about 95% of the fatty acids content. Since the concentration of oleic acid in this fruit is equivalent to that of olive oil and considerably higher than its concentration in other fruits generally considered as natural sources of oleic acid such as peanut (38.41%) and walnut (21%),[41] QSAR and QSAS oils may be regarded as healthier for the human diet.

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Table 1: Percentages of oils content expressed as dry weight

	QSAR	QSAS	*Q. suber* L. of Portugal.[6, 31]	*Q. suber* L. of Spain.[7, 32, 8, 33]	*Q. suber* L. of Algeria.[21, 16, 34]	Olive oil.[35]
Oil content	5.5%	5.2%	5.2 - 6%	2.06 - 7.3%	6.1 - 9%	12 - 30%

Table 2: Oils physicochemical constants

	QSAR	QSAS	*Q. suber* L. of Portugal.[6]	*Q. suber* L. of Algeria	Olive oil
FFA(g/100g1 oil)	1.07	1.02	-	1.13[21]	< 3.3[37]
PV (meq/kg oil)	1.1	0.9	6	0.83[16]	≤20[37]
II (mg I_2/g oil)	87	88	81	125.28[16]	75-94[10]
RI (293 K)	1.466	1.457	1.4643	1.453[16]	1.4677-1.4705[10]
SV (mg KOH/g)	191	195	-	160.3[21]	184-196[10]

FFA: Free fatty acids. PV: Peroxide value. II: Iodine index. RI: Refractive index. SV: Saponification value.

Table 3: Fatty acid composition of the oils (%)

	QSAR	QSAS	*Q. suber* L. of Portugal.[6]	*Q. suber* L. of Spain.[7, 8, 33]	*Q. suber* L. of Algeria.[21, 34]	Olive oil.[37]
Lauric (C12 : 0)	-	0.4	-	-	-	-
Myristic (C14 : 0)	-	0.1	0.10	0.10 - 0.31	-	≤ 0.03
Palmitic (C16 : 0)	11.1	11.5	12.08	10.54 - 14.36	17.0 – 19.8	7.50-20.00
Palmitoleic (C16 : 1)	0.3	0.2	0.07	0.17 - 0.50	-	0.30 - 3.50
Heptadecanoic (C17 : 0)	0.2	0.1	-	0.10 - 0.19	-	≤ 0.40
Heptadecenoic (C17 : 1)	0.2	0.1	0.10	-	-	≤ 0.60
Stearic (C18 : 0)	2,5	1,8	1.34	1.20 - 2.74	3.1	0.50-5.00
Oleic (C18 : 1)	67.0	64.7	66.44	57.95 - 63.13	63.8 – 67	55.00-83.00
Linoleic (C18 : 2)	16.6	19.2	17.03	20.73 - 21.95	9.7 - 17.8	2.50-21.00
Linolenic (C18 : 3)	0.9	1.2	1.00	1.15 – 2.60	0.9	≤ 1.00
Arachidic (C20 : 0)	0.6	0.2	0.26	0.26 - 0.71	-	≤ 0.60
Eicosenoic (C20 : 1)	0.5	0.4	0.72	0.11 - 0.60	0.5	≤ 0.50
Behenic (C22 : 0)	-	-	0.24	0.08 - 0.35	-	≤ 0.20
Lignoceric (C24 : 0)	-	-	0.30	0.23	-	≤ 0.20
ΣUSFA	85.5	85.8	85.36	81.37 – 85.96	76.7 – 83	-
ΣSFA	14.4	14.1	14.32	13.05 – 18.64	17 – 22,9	-
ΣUSFA/ ΣSFA	5.9	6.1	5.96	4.36 – 6.58	3.3 – 4.8	-

ΣUSFA: total unsaturated fatty acids.
ΣSFA: total saturated fatty acids.

This fatty acid has shown essential benefits on human health by increasing HDL, decreasing LDL and exerting a positive influence on lipid metabolism and plasma lipoproteins levels according to Akcan *et al*.[7] Furthermore, total unsaturated fatty acids (ΣUSFA) and total saturated fatty acids (ΣSFA) of QSAR and QSAS oils were in agreement with those of Portugal and Spain. Compared with Algeria, the (ΣUSFA) were higher and (ΣSFA) were lower. These differences can be explained by the low fractions of palmitic and stearic acids present in QSAR and QSAS oils compared to those of Algeria. QSAR and QSAS oils had (ΣUSFA/ ΣSFA) ratios of about 5.9 and 6.1, respectively. Due to the high amount of oleic and linoleic fatty acids, this high ratio was in accordance with previous results reported for the *Quercus* species.[19] The predominance of USFA confer QSAR and QSAS oils some important medicinal activity such as decreasing the plasma concentration of total and LDL cholesterol, enhancing metabolic and cardiovascular events,[42] and may as well help reduce the risk of developing some diseases like rheumatoid arthritis or asthma, diabetes, and perhaps even cancer.[43]

Tocopherols

Tocopherols are known as natural antioxidants. Their presence in acorns oil is often correlated with the abundance of unsaturated fatty acids. Dietary tocopherols have a high antioxidant activity that protects cells, muscle, and other tissues against oxidative stress.[7] γ-tocopherol is considered the highest antioxidant form of tocopherols.[44] Furthermore, *α*-tocopherol play a significant protective role against major human diseases, including cardiovascular disease, cancer, and dementia.[45] As represented in Table 4, a good amount of tocopherols was detected in QSAR and QSAS oils (2123 mg/kg oil) and (3566 mg/kg oil), respectively. Results noticeably revealed that *γ*-tocopherol was the most abundant compound of the total tocopherol content in both QSAR and QSAS oils with 83.7% and 85.6%, respectively,

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followed by *α*-tocopherol (12.8%, 10.6%) and *δ*-tocopherol (3.5%, 3.8%). The contents of tocopherols in the studied oils are higher than those reported for Portuguese, Spanish, Algerian and Tunisian *Q. suber* L. acorns oils (Table 4). This variation could be attributed to various oil extraction techniques utilised,[46] and sampling date and the year.[39] Furthermore, QSAR and QSAS oils tocopherols amount exceeds those of other vegetable oils such as olive oil (200 mg/kg oil),[37] peanuts (398.6 mg/kg oil), sunflower (634.4 mg/kg oil) and soybean (1797.6 mg/kg oil).[47] This indicates that the *Q. suber* L. acorns oil is expected to have high resistance against oxidation. The abundance of *γ*-tocopherol in the studied oils was in accordance with the previous results reported for *Quercus* species except for the case of *Q. rubra* species which contains *β*-tocopherol as a predominant tocopherol homologue.[19,48] *γ*-tocopherol, which is the primary form of tocopherols homologues in many plant seeds, gives QSAR and QSAS oils some important aspects. *γ*-tocopherol possessed significant activity in detoxifying electrophiles such as reactive nitrogen oxide species (RNOS). *γ*-tocopherol is well absorbed and accumulates to an important degree in some human tissues, yet it is also rapidly metabolised to the water-soluble metabolite 2,7,8-trimethyl-2-(*β*-carboxyethyl)-6-hydroxychroman (*γ*-CEHC). *γ*-CEHC displays natriuretic activity, which may be physiologically significant. Moreover, *γ*-tocopherol and *γ*-CEHC, in contrast with *α*-tocopherol, possess anti-inflammatory activity. Results from recent epidemiologic studies propose a possible protective influence of *γ*-tocopherol against cardiovascular disease and prostate cancer.[49] Concerning *α*-tocopherol characteristics, it has a natural function of cell signalling. Recent experiments have indicated that *α*-tocopherol is the precursor of a more active form of vitamin E. Although *α*-tocopherol is not a physiological antioxidant.[50] Thus, with the combination of both *γ*- and *α*-tocopherol, QSAR and QSAS oils can be considered as an excellent natural source of these compounds for applications in cosmetic, dietary and pharmaceutical products.

Sterols

Sterols are known to have an extensive range of biological activity. In addition to their anti-inflammatory, anti-pyretic and anti-diabetic properties, sterols improve immune functions and may reduce the possibility of many types of cancer.[51] As well, they reduce serum low-density lipoprotein (LDL)-cholesterol and atherosclerotic risk.[52] Table 5 delineates the percentages of different sterols in QSAR and QSAS oils. *β*-sitosterol with (86.9%, 87.2%), stigmasterol (4.1%, 3.8%), Δ^5-avenasterol (3.0%, 2.9%) and campesterol (2.6%, 2.8%) are the percentage content of the total sterol fraction of QSAR and QSAS oils, respectively. On the other hand, insignificant amounts were obtained for cholesterol, Δ^7-stigmasterol and Δ^7-avenastrol in QSAR and QSAS oils. The percentages of different sterols in QSAR acorns oil were almost similar to those of QSAS oil.

In comparison with the sterols fractions reported for Portuguese and Spanish *Q. suber* L acorns oils, we noted that QSAR and QSAS oils contain a higher fraction of *β*-sitosterol and Δ^5-avenasterol, but a lower fraction of campesterol.[6,8] Moreover, in comparison with Tunisian *Q. suber* L. oil, the samples under study has a lower fraction of *β*-sitosterol and a higher fraction of Δ^5-avenasterol.[18] The observed difference could be attributed to environmental conditions. Indeed, previous works have reported that the location could cause the determination of phytosterol content.[18] The comparison with the sterols fractions in olive oil indicated that the samples under study contain higher amounts of *β*-sitosterol and campesterol but a lower fraction of Δ^5-avenasterol. The abundance of *β*-sitosterol in the studied oils was in accordance with the previous results reported for *Quercus* species.[19] The predominance of *β*-sitosterol gives QSAR and QSAS oils their ability to inhibit cholesterol absorption, angiogenesis, cancer-cell growth, metastasis and invasion. In addition to this, it helps in benign prostatic hyperplasia and prostate cancer. Furthermore, this compound raised enzymatic and non-enzymatic antioxidants in cells, making it an effective anti-diabetic, neuroprotective and chemoprotective agent as well.[53]

Table 4: Tocopherol content of the oils (mg/kg oil)

	QSAR	QSAS	*Q. suber* L. of Portugal.[6]	*Q. suber* L. of Spain.[7, 8, 33]	*Q. suber* L. of Algeria.[16]	*Q. suber* L. of Tunisia.[18]	Olive oil.[37]
α-tocopherol	272	378	205	9.50 – 38	126.9	3.79 - 13.17	200
γ-tocopherol	1777	3052	1281[a]	21.16 – 257	389.60[b]	86.82 - 96.21	-
δ-tocopherol	74	136		0.94 – 12	13.66	-	-
Tolal (mg/kg oil)	2123	3566	1486	31.60 – 289	530.16	125.26 – 149.91	200

[a]This value for (*γ*-tocopherol + *δ*-tocopherol).
[b]This value for (*γ*-tocopherol + *β*-tocopherol).

Table 5: Sterols percentage in the oils (%)

	QSAR	QSAS	*Q. suber* L. of Portugal.[6]	*Q. suber* L. of Spain.[8]	*Q. suber* L. of Tunisia.[18]	Olive oil.[10]
Cholesterol	0.4	0.3	0.10	1.65	0.57- 4.91%	0-0.1
Campesterol	2.6	2.8	10.2	9.79	1.81 – 3.53%	0-0.5
Stigmasterol	4.1	3.8	3.61	3.89	1.30 – 1.84%	0-4.0
β-sitosterol	86.9	87.2	83.52	81.72	87.74–92.53%	75-80
Δ^5-avenasterol	3.0	2.9	0.36	0.88	1.21 – 1.61%	4-14
Δ^7-stigmasterol	0.1	0.1	0.11	0.09	0.33 – 0.7%	0-0.5
Δ^7-avenastrol	0.1	0.2	0.06	0.07	1.12 – 1.64%	-
Other sterols	2.8	2.7	2.04	1.99	0.13 – 0.25	-

Conclusion

This study investigated the partial characterisation of the oil extracted from Moroccan *Quercus suber* L. acorns. Parameters obtained were also compared with those of *Quercus suber* L. acorns oils from western Mediterranean countries and olive oil. Oleic acid and *β*-sitosterol were the major FA and sterols. The tocopherols and peroxide values may have been responsible for the high antioxidant

activity of this oil. The tocopherols content in the samples under study was of higher value than *Q. suber* L. acorns oils from other western Mediterranean countries. Furthermore, compared with olive oil, the studied oil exhibited similar nutritional quality and physicochemical properties. Results show that Moroccan *Quercus suber* L. acorns oil can be used in cosmetics and for pharmaceutical applications. Finally, and for better exploitation and valorisation of this oil, further studies are needed to determine their phenolic compounds, nutritional value, toxicity, bio-accessibility, and bioavailability properties.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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