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ORIGINAL PAPER

Determination of the Fatty Acid Composition of Acorn (*Quercus*), *Pistacia lentiscus* Seeds Growing in Algeria

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Abstract The fruits of two plants from Algeria (*Quercus* and *Pistacia lentiscus*) were investigated. The paper reports the chemical characteristics and the fatty acid composition of the oil extracts from the fruits. The black fruits of *P. lentiscus* has the highest crude fat of 32.8%, followed by the red fruits with 11.7%, and the lowest value of 9% in *Quercus* (acorn). The acid value was highest in red fruits of *P. lentiscus* oil (24.0 mg KOH/g), followed by the black fruits oil and lowest in acorn oil. The relatively high iodine value in the oils indicates the presence of many unsaturated bonds. Saponification value was highest in the *Quercus ilex* oil (166.7 mg KOH/g), while the lowest value was in the black fruits of *P. lentiscus* oil. Gas-liquid chromatography revealed that the three dominant fatty acids found are: palmitic C16:0 (16.3–19.5%), oleic C18:1 (55.3–64.9%), linoleic C18:2 (17.6–28.4%). The oils contain an appreciable amount of unsaturated fatty acids (78.8–83.5%).

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Introduction

Pistacia lentiscus L.is an evergreen shrub of the Anacardiaceae family. This dioecious species can reach 3 m height and grows in arid areas. It typifies the Mediterranean region and it is commonly dispersed in Algeria over the entire littoral. The fruits, galls, resin and leaves of the *P. lentiscus* have a long tradition in folk medicine dating from the times of the ancient Greeks. It's used in eczema treatment, paralysis, diarrhoea, throat infection, renal stones, jaundice, asthma and stomach-ache, and as astringent, anti-inflammatory, antipyretic, antibacterial, antiviral, pectoral and stimulant [1–4]. Fruits of *P. lentiscus* give an edible oil which is rich in unsaturated fatty acids as oleic and linoleic [5]. In Algeria the oil of the fruit is used by the population in traditional medicine in many ways, as an anti-diarrhoeal and also as constituent of cattle feed. Ample studies about the phytochemical composition of the resin, the leaves and the galls of the *P. lentiscus* have been carried out [6–9] but in contrast, fewer studies have been done to characterize the composition of the fruit oil [5].

The genus *Quercus* includes more than 300 species growing in temperate ecosystems. A lot of species of the *Quercus* are very characteristic of the Mediterranean area. Two species, *Q. ilex* L., *Q. suber* L., are characteristic of Algeria where the *Quercus* grows in the interior region of the country. The *Quercus* is considered as a fruit tree for the production of acorns to feed pigs. Meat products of such pigs are rich in oleic acid, making them healthier. They are also used to produce firewood and charcoal. The local population consumes the *Quercus* fruit and is also

used as traditional local feed resource. The *Quercus* fruit is poor in protein but rich in starch and fat [10]. Although a detailed study of the lipid composition of three species of *Quercus* Spanish origin have been published [11], no studies have been done to characterize the oil composition of the acorn fruit of Algeria.

A better knowledge of the lipid composition of these fruits may lead to an enhanced new application of these fruits as a raw material for the synthesis of chemical or pharmaceutical products on the basis of the qualitative and quantitative composition of saponifiable and unsaponifiable matters. The aim of this work is to learn more about the fruits oils of *P. lentiscus* and *Quercus* in order to confirm results of previous works on the same species in other countries, and to compare them with those of other edible vegetables oils.

Experimental Procedures

Samples

Acorn fruits were provided by a local herbalist for each species included in the study, (*Quercus ilex and Quercus suber*), while *P. lentiscus* fruits were collected from three trees from Tipaza region in the north of Algeria. The fruits were divided in two groups according to the skin colors; black and red fruits. Oils were extracted from the whole fruit of *P. lentiscus,* while in the case of *Quercus* extraction was done after removing the hulls. For *P. lentiscus* and *Quercus*, the results of oil extract were the mean of three different samples collected randomly from the same region.

Fat Extraction

The seeds were milled into powder using a manual mill and extracted with hexane in soxhlet apparatus in order to determine the amount of oil in the fruits, followed by agitation at room temperature for 24 h for the different analysis. The extract was filtered and dehydrated with anhydrous sodium sulphate. The solvent was refiltered, evaporated under vacuum at 40 °C and the dried crude oil was kept in brown bottles at 6 °C.

Determination of the Chemical Properties of the Oils

Acid value, saponification value and the iodine value were determined in duplicate according to the procedure described by the AOCS [12].

Purification of Triglycerides(TAG)

To purify the neutral triglycerides fraction, 600 mg of the oil were filtered through a column made with 10 g of silica gel. TAG were eluted with 100 ml of benzene [13].

GC-MS Analysis of Fatty Acids Methylic Esters (FAMS)

FAME from the total oils or the purified TAG were prepared by acid catalysed esterification method using boron trifluoride–methanol complex 12% w/v. The analysis was performed in duplicate with an HP-5890 Series II chromatograph using a fused –silica capillary Carbowax column (60 m × 0.25 mm, 0.2 μm film thickness). The temperature programming was 120 °C for 2 min, then increased by 3 °C/min till 160 °C, kept for 20 min then increased by 1 °C till 180 °C, kept for 1 min then cooled. The injector temperature was held at 220 °C. Hydrogen was used as carrier gas. Mass Spectrometry(MS) conditions are electron –impact ionisation energy 70 eV, accelerating 4 kV, emission current 100 μA and ion source temperature of 200 °C. Each FAME present in the oil was identified by comparison of its retention time and mass spectrum with those of authentic compounds.

All experiments were carried out in triplicate unless otherwise stated; results are expressed as means ± SD.

Results and Discussion

Table 1 shows the determined amount of oil in the seeds and the chemical properties of the fruit oils extracted from *P. lentiscus* and *Quercus*. The crude fat content of the *P. lentiscus* fruit varied from 32.8% for black fruits to 11.70% red fruits (w/w). The amount extracted from the acorn was 9% (w/w) from the two species of *Quercus*, which is consistent with previous findings that reported an

Table 1 Chemical characterization of the oils

	Oil (%)	AV (mg KOH/g)	SV (mg KOH/g)	IV (Wijs)
Pistacia (black)	32.8 ± 0.8	7.7 ± 0.3	147.8 ± 0.2	87.3 ± 0.2
Pistacia (red)	11.7 ± 0.5	24.0 ± 0.5	154.6 ± 0.1	109.0 ± 0.1
Quercus ilex	9.0 ± 0.2	5.3 ± 0.2	166.7 ± 0.2	85.8 ± 0.2
Quercus suber	9.0 ± 0.2	5.1 ± 0.1	160.3 ± 0.1	78.6 ± 0.1

AV acid value, *SV* saponification value, *IV* iodine value

oil content of 7–10% [11, 14]. These results indicated that the black fruit of *P. lentiscus* can be considered as an oleaginous seed as in peanut, olive, sunflower and cotton seeds which possess (30–45% oil content) [15]. Although the acorn cannot be considered as an oil-bearing seed, its oil content was in the range of other vegetable materials that are used for their health components or their industrial or pharmaceutical applications, as in the case of wheat germs (less than 10% fat content)[16].

The acid value was high in the four oils and specifically in the red *P. lentiscus* fruit (24.0 mg KOH/g) which indicates that the oils contain a huge amount of free fatty acids. High values of the acidity in the oils are perhaps due to the bad conservation of the fruits before extraction and analysis or to the incomplete ripeness of the seeds. The relatively high iodine value in the four oils may be indicative of the presence of many unsaturated bonds and would certainly contain more unsaturated fatty acids and can thus be grouped as drying oils. Saponification values varied among in the oils and were highest in the *Quercus* (160.3–166.7 mg KOH/g); the lowest value was in red seeds oil of *P. lentiscus* (130.5 mg KOH/g). Because there is an inverse relationship between saponification value and weight of fatty acids in the oils, it can be assumed that the oils hold fatty acids with 16–18 carbon atoms with a significant amount of saturated fatty acids in the case of the *P. lentiscus* oil.

Except for the acid value, the chemical examinations of the oils as used in this study were in agreement with the other vegetables oils reported in the literature [15].

The FAME composition of the oils of the species is shown in Table 2. Seven fatty acids were identified in the seed oils. Individual percentages of each fatty acid are given in Table 2. The saturated fatty acids in the oils or triglycerides are palmitic and stearic; however palmitic acid was the major saturated fatty acid constituent, ranging from 16.3 to 19.5% in the oils and from 13.00 to 22.1% in the triglycerides of the oils. Stearic acid was detected in lower amount in the fruit oil of *P. lentiscus* only (0.7–1.7%).

Concerning the unsaturated acids, C18:1 and C18:2 were detected in all oils. C18:1 acid was determined to be the dominant fatty acids in the oils and TAG with 55.3–64.9% in the oils and 49.9–70.1% in the TAG. For the C18:2 acid the content was from 17.6–28.4% in the oils and 16.1–32.5% in the TAG. C18:2 acid was found only in the acorns seeds in very tiny amount that did not exceed 0.93% in the two oils. C16:1 acid was found only in two oils of *P. lentiscus* fruit with 1.0% in the red seed and 2.1% in the black one. However C20:1 acid was detected in the oil and TAG of *Quercus suber* species only. The content was ranged from 0.5–1.11% respectively.

The unsaturated fatty acids were predominant in all oils as confirmed by the iodine value test (78.6 and 109.0). However, the oleic acid was the main fatty acid in the present study. Oleic and linoleic acids are the major fatty acids reported in Spanish acorn oil (*Quercus ssp*) [11]. Also, our results for *P. lentiscus* fruit oil agree well with the data recorded by Ucciani in his dictionary [5].

Our study of the fatty acid composition in the acorn showed identical values for oleic acid in the olive oil. The monounsaturated fatty acids such as oleic acid have great importance because of their nutritional implication and effect on oxidative stability of oils [17].

The profile of fatty acids confirms the similarity between *Quercus* and *P. lentiscus* oils and other edible vegetable oils such as sunflower, peanut, cotton, olive and avocado. The unsaturated/saturated ratio (ratio of the sum of unsaturated FA to the sum of saturated FA) was generally high,

Table 2 Fatty acid composition of the oils

	Oil				Triglycerides			
	P. lentiscus		*Quercus*		*P. lentiscus*		*Quercus*	
	Black fruit	Red fruit	*Quercus ilex*	*Quercus suber*	Black fruit	Red fruit	*Quercus ilex*	*Quercus suber*
C16:0	19.5 ± 0.2	16.3 ± 0.3	16.5 ± 0.5	17.0 ± 0.4	22.1 ± 0.4	16.8 ± 0.6	13.0 ± 0.8	15.1 ± 0.5
C16:1	2.1 ± 0.2	1.0 ± 0.1	–	–	–	–	–	–
C18:0	1.7 ± 0.1	0.7 ± 0.1	–	–	–	–	–	–
C18:1	55.3 ± 0.8	53.5 ± 0.9	65.0 ± 0.8	63.8 ± 0.6	56.9 ± 0.7	50.7 ± 1.1	70.1 ± 1.6	66.0 ± 1.4
C18:2	21.4 ± 0.3	28.5 ± 0.4	17.6 ± 0.2	17.8 ± 0.5	21.0 ± 0.9	32.5 ± 1.1	16.1 ± 0.6	17.0 ± 0.6
C18:3	–	–	0.9 ± 0.2	0.9 ± 0.2	–	–	0.8 ± 0.2	0.8 ± 0. 2
C20:1	–	–	–	0.5 ± 0.1	–	–	–	1.1 ± 0. 2
SFA	21.2	17.0	16.5	17.0	22.1	16.8	13.0	15.1
USFA	78.8	83.0	83.5	83.0	77.9	83.2	87.0	84.9
U/S	3.7	4.8	5.0	4.8	3..5	4.9	6.7	5.6

SFA saturated fatty acids, *USFA* unsaturated fatty acids, *U/S* unsaturated/saturated fatty acids, *C* number of carbon atoms in the fatty acid

and this high value gives these oils a good prevention of oxidation.

Based on our study, the seeds of *P. lentiscus* and *Quercus* are good sources of oil. The oils have similar but not identical fatty acid composition and contain a many amount of unsaturated fatty acids. Better knowledge on the composition properties of the seeds would assist in efforts to achieve industrial application of these plants. The data on chemical composition of the fruits should be useful for educational purposes and for compiling local food composition tables.

Further studies are needed for the valorisation of unsaponifiable matters in the oils of *P. lentiscus* and *Quercus* and also to determine composition of the amino acid and phenolic compounds.

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