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Original Article

Fatty Acid Composition of the Fruits of Four Varieties of *Pistacia vera* L.

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Abstract

The oil content, fatty acid compositions of pistachio nut (*Pistacia vera* L.) samples corresponding to four different varieties (Achouri, Adjmi, Batouri and Mateur), all cultivated in Algeria were determined. The fatty acid profiles of the oil extracted by the Soxhlet apparatus from four main commercial pistachio varieties, were determined by gas chromatography: palmitic (C16:0), palmitoleic (C16:1), margaric (C17:0), margarolic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), and linolenic (C18:3), oleic acid has been found as the most common monounsaturated fatty acid. Linoleic acid has the highest percentage among polyunsaturated fatty acids. There have been significant differences among pistachio cultivars regarding unsaturated fatty acids. Based on the oleic to linoleic acid (O/L) ratio, a quality index was determined for these four varieties: Achouri (3.39) > Batouri (3.12) > Adjmi (2.89) > Mateur (2.88). Principal Component Analysis (PCA) showed the pistachio varieties division into three distinct groups: Adjmi and Mateur (rich in C18.2), Batouri (rich in C16.1, C18.3 and C18.1), Achouri (rich in C16.0, C18.1).

Keywords: Classification, Fatty acid, Gas chromatography, Oil, Pistachio, Varieties.

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1. Introduction

Nowadays Pistachio nut (*Pistacia vera* L.) is one of the most popular tree nuts in the world [1]. It is known by its high nutritional value. The pistachio kernels are a good source of fat, mainly the ones with low saturated fatty acids (SFAs) and high unsaturated fatty acids (UFAs) which plays an important role in human diet. The most advantageous fatty acids includes linolenic, linoleic and oleic acids, as they reduce the level of cholesterol in the blood and have also cardio protective effects [2]. According to the California Pistachio Commission, the pistachio contains more magnesium and copper than milk, bread and potatoes [3].

Pistachio contains 50-70% fat and larger part of that are unsaturated fatty acids. About 80% of unsaturated fatty acids are oleic and linoleic acid. Unsaturated fatty acids have several benefits on the human health such as preventing accumulation of cholesterol and arteriosclerosis. Essential fatty acids are important because they are the only substance synthesizing prostaglandin, which prevent erythrosine from accumulating in blood [4].

The oil extracted from the pistachio kernels is rich in oleic and linolenic acids, both playing a crucial role in therapeutic thanks to their nutritional attractive properties. Expert Consultation Committee determined that replacement of carbohydrates by mono unsaturated fatty acid (MUFA) increases HDL-cholesterol [5]. Also, the increase in stability over oxidation of vegetable oil is attributed to oleic acid [6, 7]. Essential fatty acids are necessary in human diet for a good health and the reproduction. The linoleic acid, as a rich source of omega-3 group, plays an important role in the development and the maintenance of the nervous system, the physiological functions of human organs and reduces LDL-total cholesterol level [8, 9].

The composition of pistachio cultivated in large plantations in Syria is known to some extent. However, no in-depth investigation into Turkish pistachio nut oil has been carried out to date [10, 11].

The aim of this study is to identify the fatty acid composition of four varieties of pistachio nuts using Gas Chromatography (GP) method. This work is part of an ongoing larger university research project on Pistachio in Algeria.

The novelty of this research work is that the cultivation of pistachio has been introduced only recently in Algeria. The research field on the *Pistacia vera* L. species is almost not exploited. The pistachio varieties planted in the Mascara University orchard are of Syrian origin. This work, which consists of determining the composition of fatty acids types in these varieties, is the first to be carried out in Algeria. In addition, the oil yield and its composition differs from orchard to orchard, country to country and continent to continent. Soil, topography and climatic factors are the elements that affect the growth and development of plants and therefore the biochemical and physiological indices of plants at all levels [12].

2. Materials and Methods

2.1. Plant Material

The different samples of the pistachio varieties are: Achouri, Batouri, Adjmi and Mateur. The four samples were collected during the full maturity of the fruit at Mascara University orchard (Algeria). The samples were stored at room temperature before analysis. The plant material was obtained from a pistachio orchard (35 ° 22 '24 .23 " N, 0 ° 11 '02 12' 'E, Alt 475 m) identified by a confirmed taxonomist according to the herbarium code, with the specimen voucher (N° HAM01-69) registered at the Department of Agronomic Sciences Herbarium, Faculty of Nature and Life Sciences.

2.2. Oil Extraction

The sample preparation process includes two steps: Oil extraction and transesterification. Oil extraction was carried out according to the method of Bligh and Dyer (1959) [13]. The Oil of 5 g fruits were extracted using hexane solvent for 2h using automatic Soxhlet equipment (Gerhardt Soxtherm) and the triplicate analysis were reported for each variety. Fatty acids were then transformed into their methyl ester using methanolic sodium hydroxide solution in order to be analyzed by Gas Chromatography (GP).

2.3. Chromatographic Conditions

A gas chromatograph (7890N series, Agilent Technologies, Santa Clara, CA, USA) with a flame ionization detector and split/splitless injector is used to carry out the analysis of the fatty acid methyl esters (FAMEs). Separation was performed based on a DB-WAX fused silica capillary (100 m × 0.32 mm, ID 0.25 µm, BP20 0.25 UM; Perkin Elmer, Austin, TX, USA).

The FID and injector temperatures were set at 220 °C and 280 °C, respectively. A volume of µL of FAMEs, dissolved in petroleum ether (split ratio of 1:100), was injected directly into the gas chromatograph for analysis. The "hot needle injection" technique was used in order to improve the repeatability. Oven temperature was maintained at 50 °C for one minute, then increased to 200 °C at a rate of 25 °C/min and then gradually increased at three °C/min to reach 230 °C, which was maintained for 13 min. Thus, the total time of one GC run was about 30 min. The peak areas of the FAMEs were determined by the Chem Station software, and then used for multivariate data analysis.

2.4. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is an extremely powerful tool to extract synthetic information from a large amount of quantitative data to process and interpret. Analysis of experimental data with a PCA method allow to reduce the dimensionality of a large number of interdependent variables into a new set of uncorrelated variables called principal components (PC). PCA is applied to data series to construct several groups according to similar variance properties at different time scales. The first PC represents the highest variance in the original variable, followed by the second, third and other components. This method provides useful information using a smaller set of variables and is relatively easy to interpret. The objectives of a PCA are as follows [14]:

• The individual's graphic representation, in a 2-dimensional plane, showing the similarities between them.

• The variables graphic representation, on the same level by explaining at best the initial connections between them.

3. Results and Discussion

Fat content and fatty acids composition of the nuts produced in Mascara region (North West Algeria) are shown in Fig. 1, Fig2, Fig. 3, Fig. 4, Fig. 5, and in Table 1. Kernel fat contents of the four studied varieties varied from 42.44 % to 52.61 % based on dry matter percentage, whose oil content of the Achouri variety is

Table 1. Oil content (%) and fatty acid composition (%) of the four varieties of pistachio.

Varieties	Oil content	C16:0 (Palmitic)	C16:1 (Palmitoleic)	C17:0 (Margaric)	C17:1 (Margarolic)	C18:0 (Stearic)	C18:1 (Oleic)	C18:2 (Linoleic)	C18:30 (Linolenic)
Batouri	45.77	10.06	0.79	0.02	0.07	2.29	65.65	21.00	0.12
Achouri	52.61	11.25	0.73	0.02	0.07	1.28	66.80	19.65	0.13
Adjmi	42.44	10.11	0.74	0.02	0.06	1.29	65.12	22.51	0.14
Mateur	44.06	10.97	0.66	0.01	0.06	1.39	64.44	22.30	0.06

almost the same as that of the Momtaz variety [15].

Figures 1, 2, 3 and 4 show a typical GC chromatogram of FAMEs grown in experimental farm of Mascara University.

Gas chromatography mass spectrometry (GC-MS) was carried out to identify the fatty acid composition of pistachio kernel oil Palmitic acid (C16:0) (10.06% to 11.25%) as saturated fatty acid, and oleic acid (C18:1) (64.44% to 66.80%) and linoleic acid (C18:2) (19.65% to 22.51%) as unsaturated fatty acids, are the major compounds in the chromatogram. Other types of fatty acids, including palmitoleic acid (C16:1), stearic acid (C18:0), margaric acid (C17:0), linolenic acid (C18:3) are found as minor compounds.

Yildiz et al., (1998) [16] and Okay (2002) concluded that oleic acid was the dominant fatty acid in all varieties of pistachio [17].

Table 1 shows the ranges mean values of fatty acids content for the four pistachio cultivars. The results show that the sum of oleic and linoleic acids accounts for almost 85% of the total fatty acids measured in pistachio samples, which is also observed for other nuts, such as peanut [18]. As it can be seen in Table 1, in the varieties of Achouri, Adjmi, Batouri, and Mateur, the oleic acid content is Mateur < Batouri-Adjmi < Achouri, while for linoleic acid, this trend was Achouri < Mateur < Adjmi and Batouri. These results are in agreement with those obtained by Esteki et al., (2019) [19].

It is well-known that varieties and environmental factors affect the composition, and consequently the price, of food from plants. For nuts, oil is one of the main derived products, and therefore, its quality and characteristics of its fatty acid profile are very important. The storage quality of nuts depends on the relative ratio of their saturated and unsaturated fatty acids [19]. The oxidative rancidity of most nut oils increases with increasing levels of polyunsaturated fatty acids; therefore, the higher the unsaturation, the lower the quality of the oil. The ratio of oleic to linoleic acid (O/L) (which is called the *quality index*) is commonly used as a measure to predict the shelf life and stability of the oil. A higher O/L value represents greater chemical stability and longer shelf life. The quality index of the cultivars that are analyzed in this work is reported in Figure 2 and 3. The highest quality index of 3.39 corresponds to Achouri, and the lower of 2.88-2.89 was recorded for Adjmi and Mateur.

3.1. PCA Results

All the calculations were made using the FactoMineR package under R. The first two axes represent respectively 61.05% and 31.79%, for a total of 92.84%. The latter is a

very satisfactory rate and gives us the opportunity to overlook the other factors. Figure 6 represents the variables and individual's projection on the 1x2 factorial plane.

The first factor in Figure 6a shows the opposition of two groups of variables. The first group, projected on the positive side of the axis, consists of C16.1, C18.3, C17.0, C17.1 and C18.1. While the second group, is formed by C18.2 only.

The second factor in Figure 6a makes it possible to form two opposite groups. The first consists of C18.2 and C18.0. However, on the negative side the two variables C16.0 and C18.1 form a group.

Finally, the analysis of Figure 6a, taking into account the two factors, makes it possible to distinguish four groups of variables " C16.1, C18.3 and C17.0", ", C17.1 and C18.1.", "C16.0" and "C18.2".

The analysis in Figure 6b allows the differentiation of the four pistachio varieties. The Batouri variety is closely related to C16.1, C18.3, C17.0, C17.1, C18.1 and their values are higher than the other elements, while the values of C18.2 are lower. The Mateur variety is completely the opposite of the previous variety. The Achouri (Adjmi) variety is rich (poor) in C16.0, C18.1 and poor (rich) in C18.0, C18.2. In summary, this study showed the division of pistachio varieties into four distinct groups (Table 2).

4. Conclusion

The determination of the pistachio oil composition is an initial step to make accurate classification assessments. In this study, the extracted oils (four pistachio varieties: Achouri, Adjmi, Batouri and Mateur) were evaluated by Gas Chromatography method.

The determination of fatty acid and composition pistachio varieties showed that fat contents of Mateur and Achouri cultivars were higher than other varieties. According to the fatty acid composition, Adjmi and Batouri varieties are similar to the renown Damghan pistachio cultivars.

By comparing the fatty acid content of the four varieties, the amount of linoleic acid as essential fatty acid is the highest in the Batouri variety.

Therefore, the nutritional value of the Syrian varieties cultivated in the experimental farm at University of Mascara-Algeria is considerable. PCA analysis showed the pistachio varieties division into four distinct groups: Batouri (rich in C16.1, C18.3 and C18.1), Achouri (rich in C16.0, C18.1), Adjmi (rich in C18.0, C18.2) and Mateur (rich in C18.2). These satisfactory results provide very qualified information for new plantation program and should be

Table 2. Classification of pistachio varieties according to the ACP.

Varieties	Rich on	Poor on
Batouri	C16.1, C18.3, C17.0, C17.1, C18.1	C18.2
Mateur	C18.2	C16.1, C18.3, C17.0, C17.1, C18.1
Achouri	C16.0, C18.1	C18.0, C18.2
Adjmi	C18.0, C18.2	C16.0, C18.1

considered as important quality factors for marketing.

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Figures:

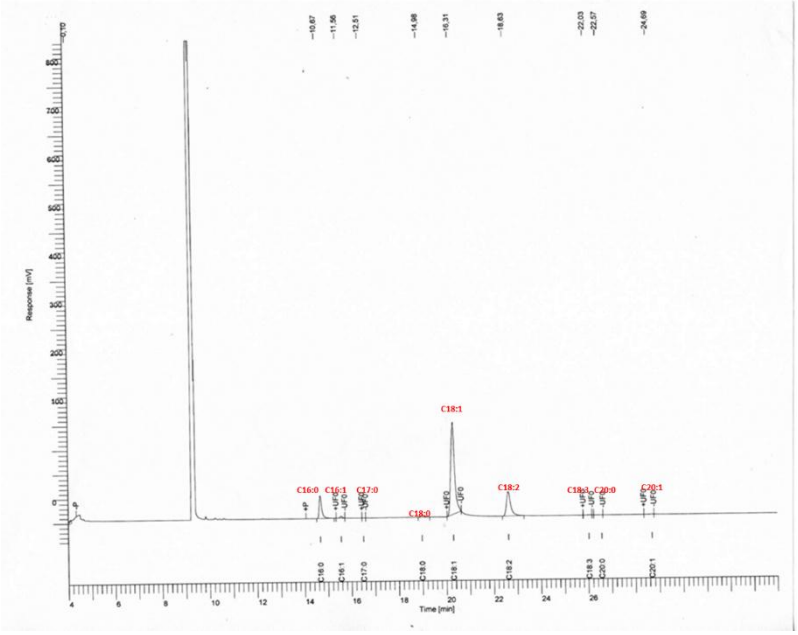

Figure 1. Representative fatty acid methyl esters gas chromatography (GC) chromatogram of Achouri variety.

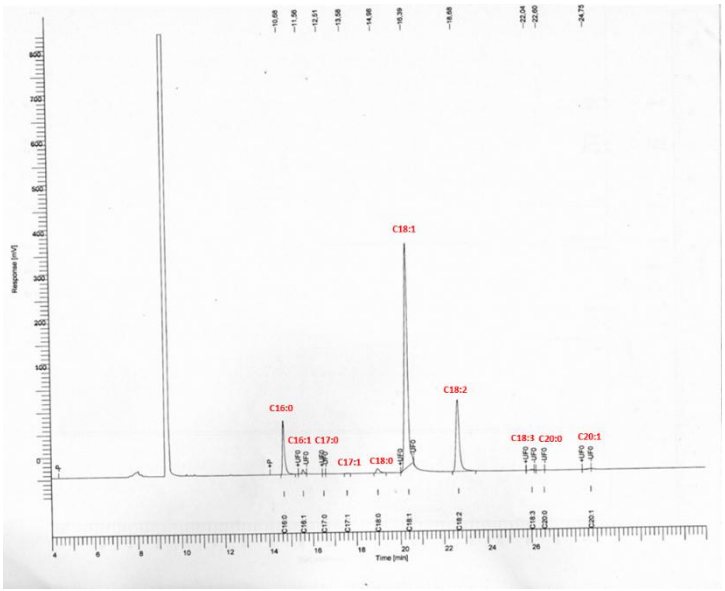

Figure 2. Representative fatty acid methyl esters gas chromatography (GC) chromatogram of Adjmi variety.

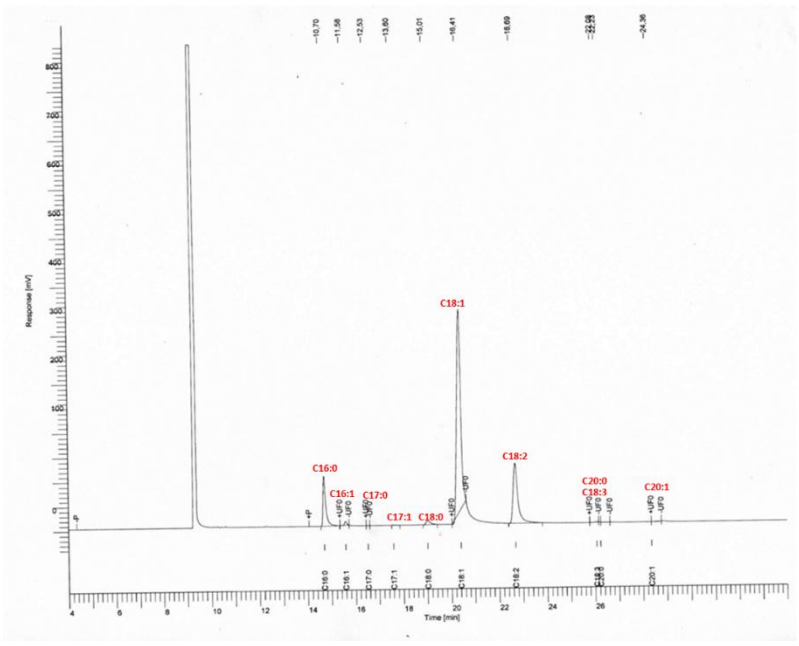

Figure 3. Representative fatty acid methyl esters gas chromatography (GC) chromatogram of Batouri variety.

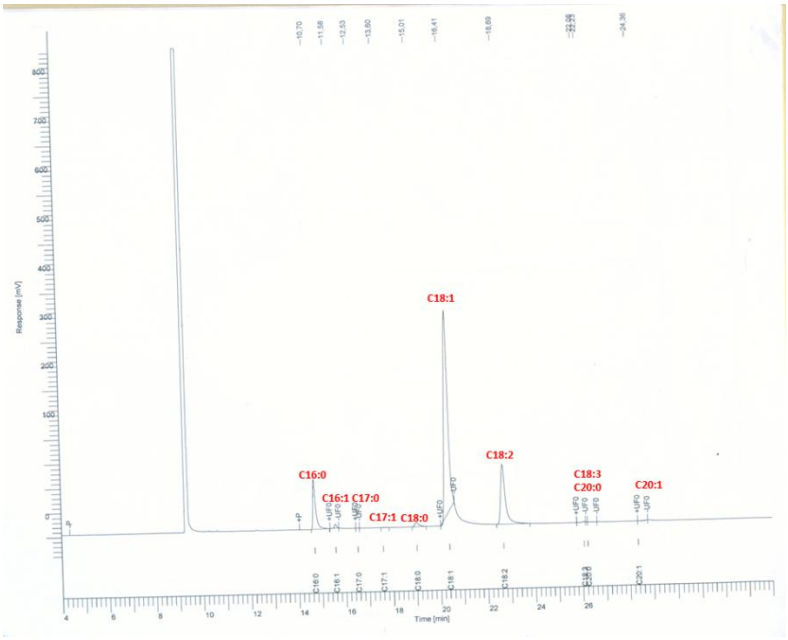

Figure 4. Representative fatty acid methyl esters gas chromatography (GC) chromatogram of Mateur variety.

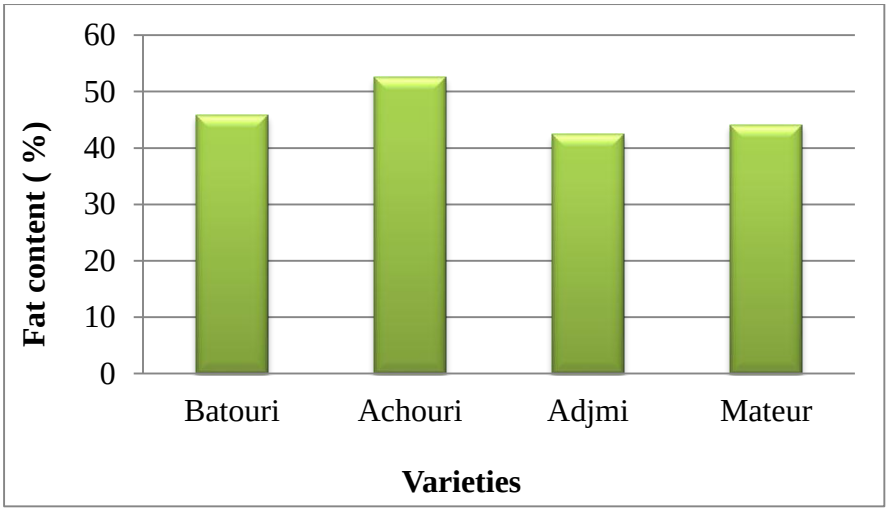

Figure 5. Fat content of four pistachio varieties.

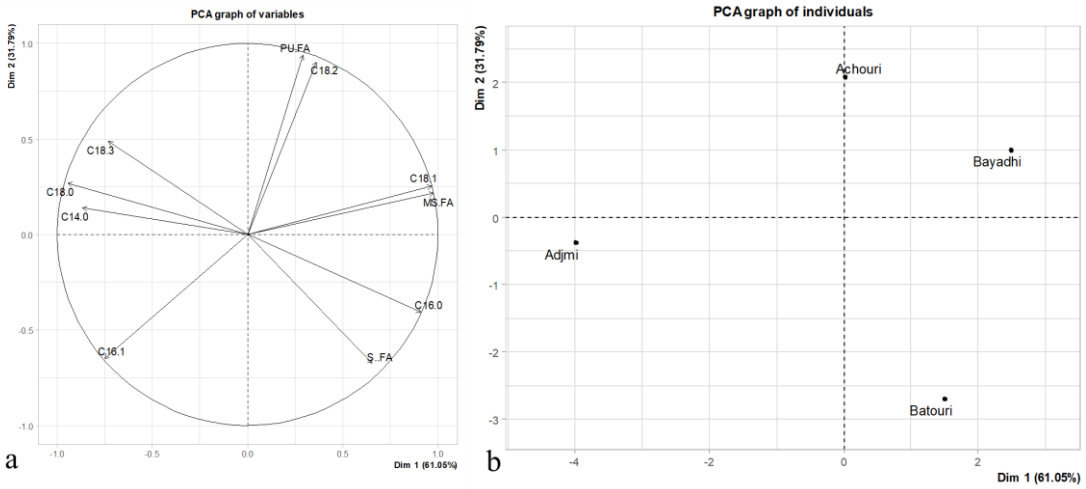

Figure 6. Variables (a) and individuals (b) projection on the 1x2 plane.