Chemistry of Natural Compounds, Vol. 43, No. 2, 2007

THE CHEMICAL COMPOSITION OF FRUITS OF *Pistacia atlantica* DESF. SUBSP. *atlantica* FROM ALGERIA

H. Benhassaini,[1] M. Bendahmane,[2] and N. Benchalgo[2]

UDC 547.915

The chemical composition of the fruits of the north algerian ecotype Pistacia atlantica *subsp.* atlantica *was determined and compared to other fruits of different species in the genus growing in south Algeria and other Mediterranean regions. These fruits were analyzed for their dry matter, protein, crude oil, ash, fatty acids, and phytosterol content. The main fatty acids identified by gas chromatography were oleic (54.15%), linoleic (28.84%), and palmitic (12.21%) acids. The fruits of the north ecotype were found to be rich in protein, oil, fiber, and unsaturated fatty acids, suggesting that they may be valuable for food uses. The sterols isolated were campesterol, stigmasterol,* β*-sitosterol, and* Δ^5*-avenasterol with* β*-sitosterol as the major constituent (85%±0.85). The biochemical data indicated an elevated MUFA rate (~56%) in pistacia oil which may be important against certain pathologies for its nutritional and preventive virtues.*

Key words: *Pistacia atlantica* subsp. *atlantica*, biochemical composition, GC/MS, fatty acids, phytosterols.

The mountain Atlas Pistachio trees (*Pistacia atlantica* Desf. subsp. *atlantica*) grow wildly in arid and semiarid regions of Algeria. Recent taxonomic verifications showed the existence in north Africa of a subspecies, called *Pistacia atlantica* Desf. subsp. *atlantica*, [1]. Its leaves are used as a stomachic, while its fruits and oleoresin are used in medicine [2]. Pistacia oil is nutritive and of excellent quality and has a fluid consistency and nice odor and savor [3]. Only one study has revealed the chemical characteristics of *Pistacia atlantica* drupe oil in the south region of Algeria [4]. Little has been undertaken on the analysis of these biochemical compound drupes [5]. The aim of this study was to determine the principal characteristics and the fatty acid composition of *Pistacia atlantica* Desf. subsp. *atlantica* that grows in north Algeria (north ecotype).

The biochemical composition of *Pistacia atlantica* Desf. subsp. *atlantica* fruits are given in Table 1. The dry matter, crude energy, and crude oil of our north ecotype species were lower than those reported for *Pistacia atlantica* of the south ecotype [6, 7]. However, the moisture, protein, and ash rate calculated according to AFNOR norms [8–10] were higher. There was no significant difference in the chemical composition of *Pistacia atlantica* fruits from the south and north ecotype of Algeria excepted for crude oil and moisture. However, there was a significant difference between the *Pistacia atlantica* fruit of the north ecotype and *Pistacia atlantica* from Iran for all constituents except for crude protein [6].

The oil content in our studied species *Pistacia atlantica* is generally more than 39%. The fatty acid composition of our fruit oil compared to other ecotype species [11] is indicated in Table 2. The content of palmitic acid and palmitoleic acid significantly differed between the Algerian north ecotype *Pistacia* and the Iranian one. The higher level of oleic acid and lower level of linoleic acid of the north ecotype make the *Pistacia atlantica* fruit oil more stable to oxidative alterations. The polyunsaturated fatty acid (PUFA) content of north and south *Pistacia atlantica* ecotype of Algeria which are rich in oil (over 30%) is higher than that of Iranian *Pistacia atlantica* which is rich in (MUFA) (Table 2). These changes in oil composition may be due to maturation and environmental and growing conditions that affect the fatty acid composition of fruits as reported by other authors [12, 13]. The sterols are very important due to their antioxidant activity and health benefits [14, 15]. The composition of the sterol fractions is given in Table 3. The major component of the north ecotype *Pistacia atlantica* sterol fraction was *β*-sitosterol (85%), witch is also found in considerable amounts in *Pistacia vera* nut of the Turkey variety [16–18] and in *Pistacia atlantica* of the south ecotype.

1) Department of environmental sciences, Djillali Liabes University, Sidi-Bel-Abbes, 22000, Algeria, fax 048 54 43 44, e-mail: ecoreve@yahoo.fr; 2) Department of Biology, Djillali Liabes University, Sidi-Bel-Abbes, 22000, Algeria. Published in Khimiya Prirodnykh Soedinenii, No. 2, pp. 103-105, March-April, 2007. Original article submitted January 3, 2006.

0009-3130/07/4302-0121 ©2007 Springer Science+Business Media, Inc.

TABLE 1. Comparison between Chemical Composition of Algerian (North Ecotype) and Iranian *Pistacia atlantica* Species

Parameters,%	*Pistacia atlantica*	
	Algerian north ecotype	Iranian ecotype
Moisture	21.26±1.24	14.87±1.32**
DM (dry matter)	78.74±0.48	95.13±0.15**
Crude oil	39.80±1.37	26.80±3.05**
Crude fibres	12.60±0.71	32.43±1.52**
Crude proteins (N×6.25)	10.39±0.66	8.20±0.40*
Ash	5.54±0.11	2.07±0.06**
Starch	5.43±0.35	5.23±0.29*

Values are mean ± standard deviation (n = 5), *p<0.05; **p<0.001.

TABLE 2. Comparison of Fatty Acid Composition of Iranian, Turkey *Pistacia terebenthus,* and Algerian (North Ecotype) *Pistacia atlantica* Fruit Oils

Fatty acids (FA)	*Pistacia atlantica* (Iranian ecotype)	*Pistacia terebenthus* (Turkey)	*Pistacia atlantica* (Algerian north ecotype)
	Concentration, %		
(12:0)	-	0.1±0.02	0.07±0.02**
(14:0)	0.07±0.00	0.1±0.03	0.09±0.01**
(16:0)	17.29±1.41	21.30±0.21	12.21±0.48**
(16:1 n-9)	6.09±0.60	3.4±0.10	1.77±0.06**
(18:0)	2.35±0.18	2±0.32	2.39±0.12*
(18:1 n-9)	54.66±0.89	52.3±0.17	54.15±0.30*
(18:2 n-6)	18.51±2.27	19.7±0.40	28.84±0.23**
(18:3 n-6)	0.59±0.02	0.6±0.01	0.42±0.46*
(20:0)	0.02±0.11	0.2±0.01	0.05±0.01**
Total saturated FA	19.71±0.39	23.5±0.14	14.76±0.15**
Total monounsaturated FA	60.75±0.79	57.7±0.13	55.92±0.18**
Total polyunsaturated FA	19.12±0.80	20.5±0.14	29.31±0.23**

-: absent; values are mean ±standard deviation (n = 5), *p<0.05; **p<0.001.

The content of individual sterols was significantly different between different species. The stigmasterol, which is absent in the south ecotype *Pistacia atlantica*, is twofold higher in *Pistacia atlantica* of the north ecotype (11%) than in *Pistacia vera* of Turkey (6.4%); however, the cholesterol was not identified in our samples.

The presence of these sterols in *Pistacia* oil conferred also a high nutritional value since they represent the precursors of provitamin D [19]. It has been shown that campesterol and β-sitosterol play an important role in lowering blood cholesterol [14, 20]. Among the metabolites which are supposed to reduce cholesterol absorption, phytosterol has attracted large interest because it has recently been reported that a significant uptake of β-sitosterol (3 g/day) could reduce cholesterolemia in non-insulin-dependant diabetics [14, 21] and also reduced the risk of coronary heart disease [22, 23].

Furthermore, the FA fraction seems to be very similar between *Pistacia atlantica* of Algeria and that growing in the Zagrossian region of Iran except for palmitoleic and linoleic acids [7]. These observations indicate that fruits from different climates can have very close biochemical composition [15, 16]. However, the difference observed in the south and north ecotype of Algeria for the palmitic acid could probably be due to the special environmental conditions (strong heat in the south). This characteristic faculty is called an adaptative or surviving strategy.

TABLE 3. Comparison of Sterol Composition of Turkish *Pistacia vera* (Uzun Variety) and Algerian (North Ecotype) *Pistacia atlantica* Oils

Sterol composition	*Pistacia vera* Turkish (Uzun variety)	*Pistacia atlantica* Algerian (north ecotype)
	Concentration, %	
β-Sitosterol	82.30±0.04*	85±0.85**
Campesterol	0.55±0.01*	4±1.10**
Stigmasterol	6.40±0.01*	11±0.35**
δ 5-Avenasterol	1.90±0.16*	3.80±0.10**

Values are mean ±standard deviation (n = 5), *p<0.05; **p<0.001.

Our study completes the investigations carried out on the oil fruits of *Pistacia atlantica* from south ecotype of Algeria. It takes into account also the differences that exist between various species of the same genus according to different environmental conditions and different origins. The analytical results show the high oil content of atlas pistachio (85.23%), which is more higher than that reported by other authors [7, 8]. According to the vegetable oil classification, in unsaturated fatty acids we can classify the oil of pistachio (north ecotype) as an oleolinoleic oil type. Because of much interest in the Atlas Pistacia mountain tree, it is important to promote large cultivation and production of this species in arid and semi-arid regions of Algeria. Moreover, many epidemiological and experimental studies have demonstrated that the ingestion of a high quantity of phytosterols reduce the risk of developing colon cancer [13, 17]. The high sterol fraction detected in both fruit ecotypes of *Pistacia atlantica* species ensures the availability of this component, which is only synthesized in plants.

EXPERIMENTAL

Plant Material. About 1 kg of *Pistacia atlantica* drupes was harvested in September, the beginning of the fall season period which coincides with the maturation stage of the fruits. The fruits were collected from plants growing wild in Tlemcen (north region of Algeria); this zone is under Mediterranean climatic influence. Prior to laboratory experiments, a strict selection of mature, similar size, and healthy seeds was performed. The drupes were cleaned of dust, dirt, and stones, and broken and immature fruits were discarded. Their moisture content was measured uponarrival in the laboratory.

Chemical Analysis. Samples were ground and the dry matter (DM), total nitrogen and ash, and detailed lipid profile composition of the drupes were studied using a subtraction method between the dry matter and diverse nutrients; vitamins were not considered. The dry matter is obtained by heating the drupes at 103°C ± 2°C, and 5 g of desiccated product was weighed till the residue reaches constant weight according to the French Agency of Normalization (A.F.N.O.R. 1986). The contents of water, minerals, and ash are determined by classical methods (A.F.N.O.R. 2001), whereas the bioassay of total nitrogen is processed by the Kjeldhal method (A.F.N.O.R. 2002).

GC-MS Analysis. For lipid fraction analysis, we used a method which identifies and qualifies simultaneously the fatty acid and phytosterol components [24]. The standards used were C: 17 for FA and dihydrocholesterol for sterols; they were added to calculate the final yield. Methylation of these compounds is performed at 80°C during 2 hours, and 5 ml of KCl (0.9%) was added to the media following the ice bath cooling. Two extractions were performed, one with ethyl ether and the other with chloroform–methanol (2:1, v/v); the organic phases were gathered, combined and then submitted to nitrogen evaporation. The fatty acids were separated from sterols by thin layer chromatography (Si 60) in hexane–ether solvent (7:3, v/v) and revealed by Primulin, which allows also to visualize different compounds; then the FA were eluted with hexane–ether (1:1, v/v), and sterols with petrol ether. At the end of the evaporation, the FA were processed by hexane and injected in a gas phase chromatograph (Varian 3400) coupled to a mass spectrometry recorder (MS, Schimadzu CR3A). The identification and qualification of these components were carried out with a complete range of commercial standards. Following extract evaporation, the sterols were silylated in the BSTFA-TMCS at 70°C during 30 min and injected in a "Delsi DI 2000" chromatograph equipped with an ionization flame detector which was connected to a "Schimadzu CR 3A" integrator. The retention time with 5-cholestane for phytosterols was determined using commercial standards.

Statistical Analysis. Results were analyzed for statistical significance by using variance analysis.

ACKNOWLEDGMENT

We are indebted to Mr. Thierry Marchand of "Centre de nutrition humaine de Nancy" (France) for his helpful comments and experimental assistance.

REFERENCES

1. D. E. Parfitt and M. L. Badenes, in: *Proceedings of the National Academy of Sciences of the USA*, California, Davis, CA, 94, **15**, 7987 (1997).
2. H. Benhassaini, M. Benabderahmane, and K. Chikhi, *Ethnopharmacologia*, **30**, 38 (2003).
3. P. H. Mensier, *Encyclopédie biologique " Dictionnaire des Huiles Vegetales*" T II, Edit Paul Lechevalier, 1957, 522.
4. M. Yousfi, B. Nedjmi, R. Bellal, D. Ben Bertal, and G. Palla, *J. Amer. Oil. Chem. Soc*., **79**, 1049 (2002).
5. A. Saffarzadeh, L. Vincze, and J. Csapo, *Acta Agraria Kasposvariensis*, **1**, 41 (2000).
6. A. Saffarzadeh, L. Vincze, and J. Csapo, *Acta Agraria Kasposvariensis*, **3**, 59 (1999).
7. M. Yousfi, B. Nedjmi, R. Bellal, and D. Ben Bertal, *Oleagineux, Corps gras, Lipides*, **5**, 425 (2003).
8. A.F.N.O.R, Norme francaise, V 04 – 401 (2001).
9. A.F.N.O.R, Norme francaise, V 04 – 407 (2002).
10. A.F.N.O.R, Norme francaise, V 04 – 404 (2001).
11. M. Ozcan, *J. Sci. Food Agric*, **84**, 517 (2004).
12. P. Ozenda, *Flore du Sahara*, Editions CNRS, 1983, 622.
13. G. Richter, *Metabolisme des Vegetaux, Physiologie et Biochimie*, Presses Polytechniques et Universitaires Romandes, 1993.
14. F. Nigon, C. S. Lacrosniere, D. Chauvois, C. Neveu, J. Chapman, and E. Bruckert, *Sang, Thrombose, Vaisseau*, Ed. John. Libbey Eurotext, **8**, 483 (2000).
15. D. Lutjohann, I. Bjorkhem, U. Beil, and K. Von Bergmann, *J. Lipid. Res.*, **36**, 1763 (1995).
16. M. Yildiz, S. Turcan Gurcan, and M. Ozdemir, *Fett/Lipid*, **100**, 3, 84 (1998).
17. F. Satil, N. Azcan, and K. H. C. Baser, *Chem. Nat. Comp.*, **39**, 322 (2003).
18. M. Ozcan, *J. Sci. Food Agric*, **84**, 517 (2004).
19. I. Ikeda, Y. Tanabe, and M. Sunago, *J. Nutr. Sci. Vitaminol.*, **35**, 361 (1989).
20. X. Pelletier, S. Belbraouet, D. Mirabel, F. Morchet, J. L. Perrin, X. Pages, and G. Debry, *Ann. Nutr. Metab.*, **39**, 291 (1995).
21. Y. Grandefeldt, Y. Bjorck, and J. Hagander, B, *Eur. J. Clinic Nutr.*, **45**, 489 (1991).
22. W. B. Kannel, W. P. Castelli, T. Gordon, and P. M. McNamara, *Ann. Intern. Med*., **74**, 1 (1981).
23. S. A. RaoAvj, *Nutr. Cancer,* **18**, 43 (1992).
24. G. Lepage and C. Roy, *J. Lipid. Res.*, **27**, 114 (1986).