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Chemical composition of *Nigella sativa* L. seeds

Cevdet Nergiz & Semih Ötleş

Food Engineering Department, Engineering Faculty, Ege University, 35100 Bornova, Izmir, Turkey

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Nigella sativa L. is an annual herbaceous plant which is cultivated for its seeds and is classified as an edible plant. The proximate chemical composition of Turkish *N. sativa* L. seeds was investigated. The compositions of fatty acids and sterols of the extracted oil were studied. The contents of total polyphenols and tocopherols of the oil were also determined, and an analysis of water-soluble vitamins and minerals in the seeds was carried out.

INTRODUCTION

Nigella sativa L., which belongs to the Ranunculaceae family, is cultivated in various parts of the world and is especially grown in East Mediterranean countries. Its seeds are employed in some parts of Germany, France and Asia as a condiment. The seeds, on account of their aromatic nature, are used as a spice in cooking, particularly in Italy and Southern France. They are also used as a carminative and diuretic by oriental people (Hedrick, 1972).

Nigella sativa L. is cultivated in the areas of Afyon, Burdur and Isparta of Turkey (Baytop, 1984). The seeds are sold in the markets to be used as a condiment and native medicine. The major components of Russian and Egyptian *N. sativa* L. seeds have been reported in earlier studies. Babayan *et al.* (1978) studied fatty acid and amino acid compositions of *N. sativa* L. seeds imported from the Middle East, and reported that the seeds showed a composition of 21% protein, 35·5% fat, 5·5% moisture and 3·7% ash, the rest being total carbohydrate. Compounds which have antimicrobial activities were found in the volatile oil of *N. sativa* L. seeds by Egyptian workers (El-Alyf *et al.*, 1975). No published study has reported the composition of *N. sativa* L. seeds grown in Turkey. Literature data on chemical composition of *N. sativa* L. seeds are very limited. The purpose of the present investigation was to determine the proximate composition and some micro-constituents of Turkish *N. sativa* L. seeds.

MATERIALS AND METHODS

Samples of *N. sativa* L. seeds were purchased from a local market in Izmir. Moisture content was determined by oven-drying at 103°C. Total nitrogen content was determined using the standard Kjeldahl method (Association of Official Analytical Chemists (AOAC), 1980). Digestion and distillation were carried out on the Kjeltec apparatus (Model 1002, Tecator Co.). Crude protein was expressed as 6·25 × N. Crude fibre was determined according to the standard method (AOAC, 1980), by calculating the loss in weight of dried residue remaining after digestion of a fat-free sample with 0·25 M H_2SO_4 and 0·6 M NaOH under specified conditions. Ash content was determined by incineration of the sample in a muffle furnace at 600°C for 16 h. Calcium and iron were determined by using an air–acetylene flame atomic absorption spectrophotometer (Pye Unicam model SP 8), and potassium and sodium were also determined by flame emission techniques on the same atomic absorption instrument. Total fat content was obtained by the Soxhlet extraction method using *n*-hexane as described by IUPAC Method 1.122 (IUPAC, 1979). Carbohydrate content was obtained by subtracting the sum of protein, fat, ash and moisture from 100.

For the tocopherol analysis, high-performance liquid chromatograph (HPLC) was used (Carpenter, 1979). Total polyphenols were determined according to Nergiz and Ünal (1991). Fatty acid methyl esters were prepared by methylation of the lipids according to IUPAC method 2.301 (IUPAC, 1979). Gas chromatography (GC) of the methyl esters was conducted on a Packard GC apparatus (Model 439), equipped with a hydrogen flame ionization detector. The carrier gas was nitrogen, at a flow rate of 30 ml/min. A glass column, of 200 cm × 0·5 cm o.d., packed with DEGS 10% on 80–100 mesh Chromosorb was used for fatty acid analysis. The column temperature was 180°C. For the sterol analysis, saponification, extraction of the unsaponifiable matter and thin-layer chromatography (TLC) were carried out according to IUPAC method 2.304 (IUPAC, 1979). Composition of the sterols was determined by GC, with 3% SE-30 on 80–100 mesh Gas Chrom. The column temperature was 240°C. Analysis of water-

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soluble vitamins was done by HPLC; vitamins were extracted by digestion of a ground sample with 0·05 M H_2SO_4 followed by enzymic digestion with Takadiastase and Papain, adjusting to pH 4·5. The solution was incubated in an oven at 35 ± 1°C overnight. Prepared sample solution (10 μl) was injected and separated on a Waters 3·9 mm i.d. × 30 cm μ-Bondapak C_{18} column, isocratically at ambient temperature with a water–methanol mixture (78:22, v/v), using a constant concentration of PIC B6 (1-hexanesulphonic acid Na salt) with a flow rate of 0·3 ml/min (Ötleş, 1991).

RESULTS AND DISCUSSION

The proximate and mineral compositions of *N. sativa* L. seeds are shown in Table 1. The results indicate that crude fibre, protein, fat, ash and total carbohydrate are in a good agreement with the values reported by Babayan *et al.* (1978). A comparison of the mineral content of the seeds with the literature values indicates that the major differences are in the amounts of calcium and potassium. These were reported as 0·582% and 1·06%, respectively, by Babayan *et al.* (1978). In our study, potassium was found to be higher (1180 mg per 100 g), whereas calcium was lower (188 mg per 100 g). This may be due to differences in geographic and climatic factors. From these results, we can conclude that the seeds have high protein, fat and potassium contents. Fatty acid and sterol compositions of the oil extracted from the seeds are given in Table 2; this table shows that the major fatty acid is linoleic, as reported by Babayan *et al.* (1978), whereas in earlier studies, which were summarized by Babayan *et al.* (1978), oleic acid was given as the major one. The present study also confirmed that eicosadienoic acid was found in the oil of *N. sativa* L. seed. Arachidic acid was also found to be a trace component.

In the *N. sativa* L. seed oil, β-sitosterol was the dominant sterol (69·4%); campesterol and stigmasterol were 11·9% and 18·6%, respectively. This resembles the sterol composition of the seed oil of *Annona*, which belongs to the Annuacae family (Mannino & Amelotti, 1975): which is 11·2% campesterol, 19·0% stigmasterol and 69·2% β-sitosterol. However, the sterol composition of the oils is closely related to the botanical family of the plant, and there may be some differences within the family as a result of the environment of the seed. On the other hand, β-sitosterol obtained on the packed column is likely to include delta-5 avenasterol, which is not separated on the column used. The sterol composition of *N. sativa* L. seed oil has not been reported elsewhere.

The contents of polyphenols and tocopherols were also determined (Table 3). The oil contained α, β- and γ-tocopherols, and their amounts were found to be 40 μg/g, 50 μg/g and 250 μg/g, respectively. The contents and compositions of the tocopherols of the seeds have not been reported in the literature. The seed oil was found to be rich in polyphenols (1744 μg/g). Further work should be carried out on the phenols of the seed oil, because they are composed of several phenolic compounds and their effects may vary with type and concentration (Sosulski, 1979; Nergiz, 1991). These compounds may be considered as a major factor in the use of the seeds as a native medicine and as a flavouring agent in several foods.

Table 4 summarizes the vitamin composition of *N. sativa* L. seed, as well as its relative contribution to the Recommended Dietary Allowances. The results show that the vitamin contents of the seeds, particu-

Table 1. Proximate and mineral composition of *N. sativa* L. seeds; mean of three determinations ± SD

Proximate composition (%)	
Moisture	6·4 ± 0·15
Ash	4·0 ± 0·29
Fat	32·0 ± 0·54
Crude protein	20·2 ± 0·82
Crude fibre	6·6 ± 0·69
Carbohydrate	37·4 ± 0·87
Minerals (mg per 100 g)	
Calcium	188 ± 1·5
Iron	57·5 ± 0·5
Sodium	85·3 ± 16·07
Potassium	1 180 ± 10·0

Table 2. Fatty acid and sterol composition of *N. sativa* L. seeds (as percentages); mean of three determinations ± SD

Fatty acids	
Myristic	1·2 ± 0·04
Palmitic	11·4 ± 1·0
Stearic	2·9 ± 0·24
Oleic	21·9 ± 1·0
Linoleic	60·8 ± 2·67
Arachidic	trace
Eicosadienoic	1·7 ± 0·11
Sterols	
Campesterol	11·9 ± 0·99
Stigmasterol	18·6 ± 1·52
β-Sitosterol	69·4 ± 2·78

Table 3. Content of tocopherols and polyphenols of the oil extracted from *N. sativa* L. seeds (μg/g); mean of three determinations ± SD

Total tocopherols	340 ± 8·66
α-Tocopherol	40 ± 10·0
β-Tocopherol	50 ± 15·0
γ-Tocopherol	250 ± 13·0
Total polyphenols	1 744 ± 10·6

Table 4. Vitamin composition of *N. sativa* L. seeds; mean of three determinations ± SD

Vitamin	Found (μg per 100 g)	RDA[a] (%)
B_1 (thiamin)	831 ± 11·36	55·3
B_2 (riboflavin)	63 ± 3·32	3·5
B_6 (pyridoxin)	789 ± 8·89	35·9
PP (niacin)	6 311 ± 16·52	33·2
Folic acid	42 ± 4·58	10·0

[a] Recommended Dietary Allowances (Anon., 1980).

larly those of vitamin B_1, B_6 and niacin, were found to be high. There are no data on vitamins of *N. sativa* L. seeds in the literature.

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