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Fatty acid composition of poppy seeds with different colours

Farklı renkli haşhaş tohumlarının yağ asidi bileşimleri

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ABSTRACT

In this study, physicochemical properties (oil content, protein, moisture, refractive index values) and major fatty acid compositions of poppy seeds with different colours (blue, brown and white) were investigated. The colour coordinates (L*, a*, and b* values) of each seed were measured with a chromameter. Fatty acid compositions of the seeds were determined by Gas Chromatography (GC). No significant differences were observed in the level of protein and extracted oil. In contrast, moisture of seeds and refractive index values of the extracted oils were statistically different. Major fatty acid components were found to be linoleic acid (71.25–72.16 g 100 g^{-1}), oleic acid (14.29–16.08 g 100 g^{-1}) and palmitic acid (9.93–10.65 g 100 g^{-1}). There were significant differences in linoleic and oleic acid content of the seed depending on the colour values (P<0.01).

MAKALE BİLGİSİ

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***Anahtar Kelimeler*:**

Haşhaş tohumu
Tohum rengi
Yağ asidi

ÖZ

Bu çalışmada, farklı renkte haşhaş tohumlarının (mavi, kahverengi ve beyaz) fizikokimyasal özellikleri (yağ içeriği, protein, nem, refraktif indeks değerleri) ve yağ asidi bileşimi incelenmiştir. Tohumların renk koordinatları (L*, a* ve b* değerleri) bir kromometre ile ölçülmüştür. Tohumların yağ asidi bileşimi Gaz Kromatografi (GK) yardımıyla belirlenmiştir. Tohumlar arasında yağ ve protein düzeyleri açısından farklılık belirlenmemiştir. Buna karşın, tohumların nem ve ekstrakte edilen yağların refraktif indeks değerleri istatistiksel olarak farklı bulunmuştur. Tohumlarda temel yağ asidi bileşenleri linoleik asit (71.25–72.16 g 100 g^{-1}), oleik asit (14.29–16.08 g 100 g^{-1}) ve palmitik asit (9.93–10.65 g 100 g^{-1}) olarak belirlenmiştir. Renk değerlerine bağlı olarak tohumların linoleik ve oleik asit içerikleri önemli düzeyde farklılıklar göstermiştir (P<0.01).

1. Introduction

Oilseeds are major source of food components such as fat, protein and carbohydrate with potential application as nutraceuticals and functional foods. Despite the vast range of seed oils sources, world production is dominated by palm, soybean, rapeseed, and sunflower oils with 45.1, 39.8, 22.6, and 12.6 million tons produced per year, respectively (FAO 2010). In recent years, oils from the other plant species are gaining importance as an interesting segment of food because many of them contain significant amounts of oils and/or high proportions of nutritionally, medicinally or industrially desirable chemicals. Fatty acids, mineral compounds, amino acids, carbohydrates and vitamins can be given as examples of these chemicals.

Consumers are especially interested in essential fatty acids with emphasis on the health potential of polyunsaturated fatty acids. It is considered that these fatty acids play a natural preventive role in cardiovascular disease and in alleviation of some other health problems since they promote the reduction of both total and high density lipoprotein (HDL) cholesterol (Melgarejo and Artes 2000).

Poppy seed and its oil appear to be of good quality for human consumption since it is generally rich in polyunsaturated fatty acids and minerals (Eckey 1954; Krzymanski and Jonsson 1989; Luthra and Singh 1989). They are obtained by grounding or pressing the fruits of *Papaver somniferum* L. The poppy seed oil is a rich source of linoleic acid (68 g 100 g^{-1}) which makes it good oil for nutrition as a high percentage of linoleic acid is desirable for lowering the cholesterol levels in the human system and thus prevents coronary heart disease (Peter 2001). The reported health benefits of oils rich in linoleic acid in lowering serum cholesterol levels is an indication of the nutritional significance of the usage of poppy seed oil (Gottenbos 1988).

The opium poppy is a multipurpose crop that is used as a medicinal or ornamental plant as well as a source for seeds and

seed oil (Levy and Milo 1998). World production of poppy seed is 93,125 tonnes obtained from 142,220 ha. Turkey is the largest producer of poppy seed in the world accounting for about 39.63% of total world production (FAO 2010). Poppy is an important industrial crop grown for pharmaceutical and food applications in Turkey since ancient times (Bozan and Temelli 2003).

Poppy seeds contain 50 g 100 g^{-1} of edible oil with a pleasant aroma and taste like almond. The oil is a rich source of linoleic acid (68 g 100 g^{-1}) which makes it good oil for nutrition. Poppy seed oil is used widely for culinary purposes as a cooking medium or as salad oil. It has a high digestibility coefficient of about 96% at a daily intake of 50 g (Peter 2001). The oil has also been used in the manufacture of paints and varnishes as well as in cosmetics and other industrial products (Bozan and Temelli 2003). Today poppy seed oil is also used as adjuvant for pharmaceutical and medicinal diagnostics besides its application as a high quality and delicious edible oil (Krist et al. 2005). Poppy seed oil is used, for example, as a carrier for cancerostatics in the treatment of hepatocellular carcinoma (Risse et al. 2004), and as a carrier for cyclosporine A (Tibell et al. 1995).

Poppy seed samples of various origins have been analysed for oil content, fatty acid and mineral composition by many research groups. Oil contents between 33 and 49.1 g 100 g^{-1} were reported (Eklund and Agren 1975; Bernath 1998). The differences between white and blue seed varieties were compared in this respect by a Swedish research group: the white variety contained 40 g 100 g^{-1} oil and the blue only 33 g 100 g^{-1} (Eklund and Agren 1975; Bernath 1998). The contents of palmitic acid (7.8–30.66 g 100 g^{-1}), stearic acid (1.4–10.9 g 100 g^{-1}), oleic acid (13.2–36.8 g 100 g^{-1}), linoleic acid (18.4– 80.0 g 100 g^{-1}), and linolenic acid (trace–9.4 g 100 g^{-1}) were reported to vary over wide ranges (Bernath 1998).

Although fatty acids and certain chemical compositions of poppy seeds studied here are well known, there was inadequate information about individual differences of these chemical compositions in regard to their seed colours. Therefore, the objective of this work was to investigate the oil yield, fatty acid, protein and some physicochemical characteristics (moisture and refractive index values) of poppy seeds with different seed colours. This study will contribute to the knowledge of the some important chemical properties of these seeds. Further knowledge on poppy seed composition may lead to different uses in the food industry such as the development of functional foods or medicinal, pharmaceutical and other non-food industrial applications.

2. Materials and Methods

Poppy seeds (*Papaver somniferum* L.*)* with different colours were purchased from the local markets. All seeds were ground into fine powder using a coffee grinder (National, Osaka, Japan). Solvents used for all analysis were chromatographic grade. The water was produced by an ultrapure (18.2 MΩ cm at 25 ºC) purification system (Millipore, MA, USA).

2.1. Physicochemical characteristics of poppy seeds and their oils

The moisture levels of the seeds and refractive index values of the oils were estimated according to methods recommended by the AOAC with the method number of 969.18 (AOACa, 1990). For protein analysis, (N×6.25) a Kjeldahl digestion method was used, according to 950.48 of AOAC (AOAC 1995). Protein contents were analysed by using a VAP50 Kjeldahlmeter (Gerhart, Germany). The oils were extracted from the seeds with soxhlet extractor using petroleum ether (40–60 ºC) for 8 h according to the method of AOAC 960.39 (AOAC 1990b). The ratio of solids to solvent used was 1:10. The oil was then recovered by evaporating of the solvent using rotary evaporator and residual solvent was removed by flushing with 99.9% nitrogen. The extracted lipid was weighed to determine the oil content.

2.2 Colour analysis

The colours of poppy seeds were quantified by using a Minolta (CR-400) chromameter (Japan). Five colour measurements were taken for each treatment, resulting in numeric values for three chromatic scales (L*, a*, b*). L* is the brightness ranging from no reflection for black (L* = 0) to perfect diffuse reflection for white (L* = 100). The value "a*" is the redness ranging from negative values for green to positive values for red. The value "b*" is the yellowness ranging from negative values for blue and positive values for yellow (McGuire, 1992). A special white plate was used to calibrate the chromameter: L=96.86, a=-0.07 and b=1.98.

2.3. Determination of fatty acids

Extracted oils were prepared for the GC-FID analysis as converted Fatty Acid Methyl Esters (FAMEs) according to the method of David and co workers with some modification (David et al. 2005). Briefly; 100 mg oil sample was weighed in a 20 ml test tube (with screw cap) and 10 ml hexane was added and dissolved. A 100 µl 2 N potassium hydroxide in methanol was added into the tube and vortexed for 30 s. The tube was centrifuged and clear supernatant was transferred into a 2 ml auto sampler vial. FAMEs were separated and quantified using an HP 5890 Series 2 Plus GC System (Hewlett Packard, USA) equipped with a flame ionization detector. Chromatographic separation was achieved by using a MN FFAP column (50 m × 0.32 mm × 0.25 µm). The temperature program was as follows: 1) 50 ºC for 1 min; 2) increase to 200 ºC at a rate of 25 ºC min^{-1}; 3) increase to 230 ºC at a rate of 3 ºC min^{-1}; 4) 230 ºC for 18 min. The temperature was set at 250 ºC for the injector and at 280 ºC for the detector. Nitrogen was used as the carrier of the gas and perfused at a flow rate of 1 $mLmin^{-1}$. 1 µL of the sample was injected into the GC for analysis. After the injection, a representative chromatogram was obtained as shown in Fig 1. There were five major peaks were determined. The peaks were aligned according to their carbon number and the location of the double bonds (C16:0, C18:0, C18:1, C18:2, C18:3). The percentage of each fatty acid was calculated from the ratio of the peak area to the total area of all peaks.

2. 4 Statistical analysis

All analyses were performed on duplicate samples and the results were statistically analysed by ANOVA ($P < 0.01$). Significant means were subjected to analysis by Duncan's multiple range test ($P< 0.05$). All statistical analyses were performed using the Statistical Analysis System (SAS Institute, Cary, NC, USA).

3. Results and Discussion

General chemical analysis results of poppy seeds with

different colours are given in Table 1. The oil content found in the poppy seeds examined here were ranked as brown, white and blue based on their ratios in seeds. The highest level of oil (51.74) was found in brown seeds. However, oil contents of the seeds were not significantly different (P>0.05). In a previous study, poppy seeds were sorted as yellow, white and blue based on their seed oil contents (Azcan et al. 2004). However, in that study, researchers did not evaluate the results statistically. Therefore, it is not clear whether the differences among the seeds were true or result from experimental errors. Refractive index value of brown poppy seeds oils was significantly lower than that of white and blue coloured seed oil. There was no significant difference (P>0.05) among the protein contents of the seeds while moisture contents of the seeds were significantly different (P<0.01). The moisture contents of the seeds were found slightly higher than the study of Ozcan and Atalay (2006). The difference in moisture contents of seeds may be due to the storage in environments with different relative humidity.

L*, a* and b* values of poppy seeds, which was visually observed as different colours, were also significantly different (P<0.01) from each other (Table 2). It was found that white poppy seeds had the highest "L*" value (brightness) and positive "b*" value (yellowness). On the other hand, brown seeds had the highest positive "a*" value (redness).

The fatty acids contents of poppy seed that have different colours are illustrated in Table 3. A sample chromatogram is shown in Fig. 1.

As seen in Table 3, there was no significant difference (P>0.05) among the palmitic acid, stearic acid and linolenic contents of the seeds while oleic and linoleic acid contents were significantly different (P<0.01). Palmitic acid and stearic acid contents of brown poppy seeds, and linolenic acid contents of white seeds were higher than other varieties. In addition, the highest oleic acid was obtained in blue poppy seeds and the highest linoleic acid was found in brown poppy seeds (P<0.01).

As mentioned in earlier reports, the proportions of oleic and linoleic acids determine the quality of oil and its end use (Harris et al. 1980; Green 1986; Singh et al. 1998). Linoleic acid is also known to lower cholesterol concentrations in human blood and thus helps to prevent atherosclerosis and heart attacks. High linoleic oils are used in polyunsaturated oils and margarines. In our study, the highest proportion of linoleic acid was found in brown poppy seeds. This finding suggests that the oils obtained from the brown seeds can be utilised as a healthy product in polyunsaturated oils and margarine. In general, linoleic acid is known to be the dominant fatty acid of all poppy seed oils. From a nutritional point of view, poppy seed oil is a good source of essential fatty acids, especially linoleic acid, as compared to the other edible oil seeds (Nergiz and Ötleş 1994).

In addition, high oleic acid is more suited to cooking and salad (Singh et al. 1998). The maximum oleic acid content of blue seeds determined in our study was at level of 16.08 g 100 g^{-1}. The oils obtained from the blue poppy seeds can thus be suggested for cooking and salad oils.

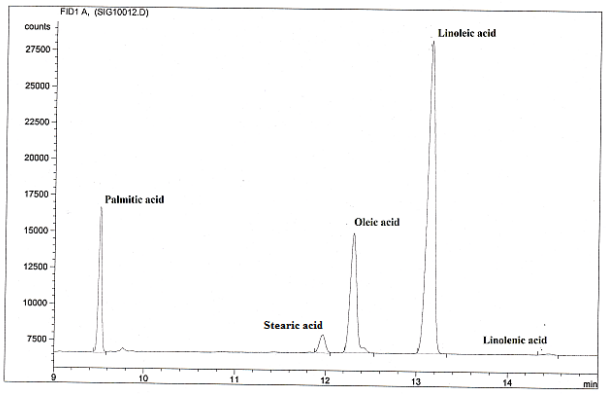

Figure 1. Gas chromatogram of fatty acids.

The opium poppy may be an ideal oil seed crop for the food industry because of its low linolenic acid content and high linoleic acid (Singh et al. 1998). No difference was observed in linolenic acid contents among the poppy seeds studied here. The highest level of linoleic acid was found in the brown poppy seeds at the level of 72.16 g 100 g^{-1}. For this reason, the brown poppy seeds may be suggested as an ideal oil seed for the food industry.

In general high amounts of linolenic acid are unsuitable for oil food products due to its instability and reversion of flavour associated with autoxidation (Smouse 1979; Green 1986; Singh et al. 1998). In addition, it was reported that the maximum of 3 g 100 g^{-1} linolenic acid is desirable for edible oils (Thomas and Von Bruck 1985). In this study, the highest percentage of linolenic acid was found in the white poppy seeds at the level of0.61 g 100 g^{-1}. Therefore it was concluded here that the oils obtained from the white poppy seeds may not be preferable as plant oils since it is prone to autoxidation that cause off-flavour

Table 1. Some physicochemical characteristics of poppy seeds and their oils.

Seed colours	Moisture (%)	Oil (g 100 g^{-1})	Protein (%)	Ref. Index
Brown	5.39±0.18^{b}	51.74±1.13	26.64±2.08	1.4716^{b}
White	5.33±0.58^{b}	50.68±1.50	26.07±4.22	1.4723^{a}
Blue	5.91±0.73^{a}	44.29±9.34	24.83±2.83	1.4722^{a}

Means ± standard error. Means in a row with different letters are significantly different (P<0.05) by Duncan's multiple range tests.

Table 2. Colour coordinates of poppy seeds.

Seed colours	L*	a*	b*
Brown	40.41±0.58^{b}	6.21±0.27^{a}	14.97±0.46^{b}
White	60.94±0.88^{a}	5.02±0.21^{b}	16.91±0.38^{a}
Blue	34.01±1.22^{c}	1.28±0.14^{c}	1.94±0.36^{c}

Means ± standard error. Means in a row with different letters are significantly different (P<0.05) by Duncan's multiple range tests.

Table 3. Fatty acid compositions of poppy seed oils (g $100g^{-1}$).

Seed colours	Palmitic acid (C16:0)	Stearic acid (C18:0)	Oleic acid (C18:1)	Linoleic acid (C18:2)	Linolenic acid (C18:3)
Brown	10.65±0.45	2.56±0.05	14.29±0.34^{c}	72.16±0.32^{a}	0.33±0.14
White	10.30±0.69	2.50±0.10	15.10±0.26^{b}	71.50±0.75^{ab}	0.61±0.05
Blue	9.93±0.21	2.44±0.05	16.08±0.20^{a}	71.25±0.13^{b}	0.31±0.13

Means ± standard error. Means in a row with different letters are significantly different (P<0.05) by Duncan's multiple range tests.

compounds in these oils.

4. Conclusion

This study presents a view of the chemical characteristics of poppy seed with different seed colour and could serve as a starting point to define quality standards since there are little specifications available for this plant oil. The data obtained here suggest the potential value-added use of these seed oils as dietary sources of essential fatty acids for optimal human health. According to our study, we found that the major fatty acids in the seed oil were linoleic, oleic and palmitic acid. Linoleic acid has some abilities to lower blood cholesterol levels in humans, and thus may contribute to the reduced risk for atherosclerosis and other cardiovascular diseases. The highest proportion of linoleic acid was determined in brown poppy seeds. This finding suggests that the brown poppy seeds may have the quality of oil and its end use. Furthermore, the seeds could be used in some foods to improve their nutritional value with a balanced fatty acid composition. Thus, extracted oils from this poppy seeds may be used to make suitable oil blends with other oils that contain low levels of these compounds.

The results obtained from this study may contribute for the usage of poppy seeds in various commercial areas. This work also contributes to the knowledge of the nutritional properties of these seeds.

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