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Physico-Chemical Characteristic and Fatty Acids Compositions of Cottonseed Oils

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ABSTRACT

In this study, three cotton genotypes of species *Gossypium hirsutum* L., Cukurova 1518, PAUM 15 and BA 119 were investigated for their some physicochemical properties of oils such as free fatty acids, peroxide value, iodine value, unsaponifiable matter, total carotenoid and tocopherol contents and fatty acids composition in Cukurova region in Turkey. Seed oil content ranged 17.2-19.6% and PAUM 15 was found to be genotype with the highest oil content. The range of other physicochemical properties and their values are as follows; free fatty acids 1.7-2.8%, peroxide value 5.3-6.0 meq O_2 kg^{-1}, unsaponifiable matters 2.1-2.3%, iodine value 102-110, total carotenoid content 119-140 mg kg^{-1}, total tocopherol content 887-920 mg kg^{-1}, linoleic acid 52.00-55.82%, palmitic acid 24.85-25.63%, oleic acid 14.06-17.00%, stearic acid 3.01-3.13% in the cottonseed oils. PAUM 15 was determined to be more suitable for food consumption as edible oil due to its highest oil content and quality characteristics than the others genotypes.

Keywords: Cottonseed oil; Fatty acids; Physicochemical properties

Pamuk Yağlarının Fiziko-Kimyasal Özellikleri ve Yağ Asitleri Kompozisyonu

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ÖZET

Bu çalışmada, Türkiye'nin Çukurova Bölgesi koşullarında, *Gossypium hirsutum* L. türüne ait, Çukurova 1518, PAUM 15 ve BA 119 pamuk genotiplerinden elde edilen yağların serbest yağ asitleri, peroksit sayısı, iyot ayısı, sabunlaşmayan madde miktarı, toplam karotenoid, toplam tokoferol içerikleri gibi bazı fizikokimyasal analizleri ile yağ asitleri kompozisyonu araştırılmıştır. Tohumlarda yağ içeriği % 17.2-19.6 arasında değişmiştir. Elde edilen yağlarda serbest yağ asitleri % 1.7-2.8, peroksit sayıları 5.3-6.0 meq O_2 kg^{-1}, sabunlaşmayan maddeler % 2.1-2.3, iyot sayıları 102-110,

toplam karotenoid içerikleri 119-140 mg kg^{-1}, toplam tokoferol içerikleri 887-920 mg kg^{-1} aralığında değişmiştir. Linoleik asit, palmitik asit, oleik asit ve stearik asit oranlarının, sırasıyla % 52.0-55.82; % 24.85-25.63, % 14.06-17.0 ve % 3.01-3.13 aralığında değiştiği saptanmıştır. PAUM 15 genotipinin en yüksek yağ verimi ve yağ kalitesine sahip olmasından dolayı diğer genotiplere kıyasla yemeklik yağ olarak tüketime daha uygun olabileceği belirlenmiştir.

Anahtar Kelimeler: Pamuk yağı; Yağ asitleri; Fizikokimyasal özellikler

1. Intruduction

Cotton is one of the most important commercial crops of Turkey and is the single largest natural source of fibre. It plays a dominant role in industrial economy as the backbone of textile industry. 65% of country's textile products are exported, and 80% of these products consist of cotton weaving (Mert et al 2015). However cottonseeds contain oil significant amount. Oil content of cottonseeds changes between 12-25% (Kohel 1998; Mert et al 2004). Oil is obtained from cottonseeds as by products that meet an important part of Turkey oil consumption. Cottonseed oil is the second most common oil being used today besides sunflower oil. As the most important vegetable oil source in Turkey, sunflower is first ranked with 1.38 million tons, followed by cottonseed with 1.28 million tons, soybean 180,000 ton, peanut 141,000 tons and rapeseed 101,000 tons (Kolsarıcı et al 2015).

Cottonseed oil is usually used in vegetable oil mixtures (Metin et al 2003), cooking and salad oil, in the preparation of margarine, shortening, mayonnaise and sauces, also to less extend in canned fish and smoked meat (Gümüşkesen 1999; Karaosmanoğlu et al 1999; Sekhar & Rao 2011).

Crude cottonseed oil, which has an aroma resembling peanut and walnut, has a blurry appearance (Paralı 2003). Color of crude cottonseed oil can vary from brunette yellow to dark red due to significant amount of color pigment passing to oil during extraction (O'Brien 1998; Orhevba & Efomah 2012). In addition triglycerides, nonglyceride components such as gossypol, phospholipids, sterols, pigments, tocopherols and carbohydrates are found in this oil with the amount of about 2% (O'Brien 1998). Cottonseed oil also has a rich source of minerals, it includes vitamin B and oil soluble vitamins such as A, D, E, K (Lukonge 2005; Sawan et al 2006).

The important component of cottonseed oil is tocopherols, natural antioxidants. However, amount of tocopherols that present in oil declines significantly during the refining process. Therefore crude cottonseed oil when compared to refined cottonseed oil and soybean oil is rich in terms of amount of tocopherol and, more resistant to oxidation (Saxena et al 2011; Sekhar & Rao 2011). Fatty acid composition of cottonseed oil is the one of important properties (Lukonge 2005; Ping et al 2009). Cottonseed oil has a 2:1 ratio of polyunsaturated to saturated fatty acid. It is described as naturally hydrogenated because its fatty acid profile generally consists of 70% unsaturated fatty acids, including 18% mono-unsaturated (oleic) and 52% poly-unsaturated (linoleic), and 26% saturated (primarily palmitic and stearic) acids. These make the oil stable for frying without the need for additional processing or the formation of trans-fatty acids (Sekhar & Rao 2011). As with other vegetable oils quality of cottonseed oil usually comes from fatty acid composition and unsaponifiable matters mentioned. Their amount and oil yield varies depending on genotype, ecological conditions of region process and storage conditions (Baydar & Turgut 1999; Reddy & Aruna 2009).

The objective of this study was to determine crude seed oil yield, fatty acid composition and typical characteristic properties in the seed oil of three different cotton genotypes grown in Cukurova Region.

2. Material and Methods

This study was conducted at the Cotton Research and Application Center of Cukurova University, Adana, in 2006-2007 cotton growing season. The experiment was set in a randomized complete block design with three replications. Cukurova 1518, PAUM 15 and BA 119 cotton genotypes (*Gossypium hirsutum* L.) were used as plant materials.

The plants and rows spacing were kept at 20 and 70 cm, respectively. Plots were fertilized with 80 kg ha^{-1} N and 80 kg ha^{-1} P_2O_5 before planting using diammonium phosphate (DAP) fertilizer, and an additional nitrogen (as urea) dose of 80 kg ha^{-1} was top dressed 50 days after planting. Other inputs like irrigation and insecticides were applied at proper time and as when required. All other cultural practices including weeding were uniformly adopted in whole experiment throughout the growing period to minimize the environmental variations.

In order to remove of cottonseed lints completely delintation process was performed to seeds. Analysis such as seed index (the weight of 100 seeds in g), hull (%), kernel (%), seed moisture content (%), seed oil content (%) in seed and free fatty acid (%), peroxide value, unsaponifiable matter, iodine value, total carotenoid and tocopherol contents, fatty acid profiles in cottonseed oil were carried out. All tests were performed in triplicate.

In order to determine oil content cottonseeds were crushed in blender and dried at 103±2 °C till the constant weight. Crude oils of seeds were extracted with the soxhlet method for 6 h. Recovered crude oils were taken to a rotary evoparator at 35 °C (Anderson 2004). Obtained oil samples were filtered and stored at 4°C in dark glass bottles prior to analyses.

Determination of free fatty acidity, peroxide value, unsaponifiable matter and iodine value were carried out following the analytical methods described in IUPAC (1991).

Carotenoid compounds were determined at 470 nm, in cyclohexane using the specific extinction values by the method of Minguez-Mosquera et al (1991). The carotenoid contents are expressed as mg lutein per kg of oil.

Total tocopherols were evaluated by the method of Wong et al (1988). 200 mg of the oil sample was weighed accurately into a 10 mL volumetric flask. 5 mL of toluene were added by pipette and the oil was taken into solution. 3.5 mL of 2.2'-dipyridine and 0.5 mL of $FeCl_3.6H_2O$ were added in that order. This solution is made up to 10 mL with 95% aqueous ethanol. After kept for 1 min, the absorbance was measured at 520 nm against a blank solution. The tocopherol contents were expressed as mg kg^{-1} α-tocopherol.

For the determination of fatty acid composition, the methyl esters were prepared by vigorous shaking of a solution of oil in n-heptane (0.1 g in 2 mL) with 2 N methanolic potassium. The analysis of fatty acid composition was performed by using a Shimadzu GC apparatus (Model 14 B) equipped with a hydrogen flame ionization detector (FID) and a capillary column DB-23 of 60 m length x 0.25 mm i.d. and 0.25 μm of film thickness (Agilent J & W, US). Helium was used as carrier gas and the temperatures of injector, oven and detector were 270, 230 and 280 ºC, respectively. The results were expressed as peak area (relative) percent. The injection volume was 1 μL (IOOC 2001).

Statistical analysis was carried out by using SAS software and procedures (SAS 2005). Data were analysed according to PROC GLM procedures. The means were compared using Duncan's multiple comparison tests at 5% significance level.

3. Results and Discussion

The whole seeds compositions of three cotton genotypes are shown in Table 1. Seed index in cotton genotypes ranged from 9.6 (Cukurova 1518) to 10.3 (PAUM 15) g. Sharma et al (2009) reported seed index range of 3.69 to 5.38 g for *G.arboreum* and 6.01 to 7.71 g for *G.hirsutum*, whereas Agarwal et al (2003) observed a range of 4.65-9.41 g in upland cotton. The values for hull percentage and kernel ranged from 36-40% and 60-64%, respectively. Depending on the genotype, species and ecological

factors, hull contributed about 30-50% to the weight of cotton seed (Sundaram 1974). These values are in agreement with those reported by Sharma et al (2009). Seed oil contents were found 17.2% in BA 119, 17.8% in Cukurova 1518 and 19.6% in PAUM 15. Sharma et al (2009) observed seed oil content varied from 14.4% to 18.7% in desi cotton entries, whereas in American cotton, its value ranged from 15.8% to 20.2%. Gotmare et al (2004) have reported seed oil content ranging from 17.61% to 19.54% in six races of *G. arboreum*. Our results are in agreement with those obtained by these researchers. This situation supported by findings of Ikurior & Fetuga (1987) and Sun et al (1987) which indicate that genotypes and regional variation affects oil content of cotton seed.

Free fatty acids (FFA) content (%), peroxide values (meq O_2 kg^{-1}), iodine number (g), unsaponification matter (%), total carotenoid (mg kg^{-1}), total tocopherol (mg kg^{-1}) for cottonseed oils are shown in Table 2. The FFA content of cotton seed oil ranged from 1.7% (PAUM 15) to 2.8% (Cukurova 1518). Free fatty acids (generated as a result of hydrolysis of triglycerides) are good indicator of oil quality (Sharma et al 2009). O'Brien (2001) and Sharma et al (2009) have reported that FFA content range for crude cottonseed oil was 0.43 to 0.70% and 0.5 to 0.6%, respectively whereas Orhevba & Efomah (2012) specify this value as 5.7%. These differences might be due to genotype, region grown, climate, storage in unsuitable conditions (high moisture content) (O'Brien 1998).

The peroxide value which is used as an indicator of oxidation of oils was found to be 5.3-6.0 meq kg^{-1} indicating that the oil is fresh. This is because fresh oils usually have peroxide values below 10 meq kg^{-1} (Orhevba & Efomah 2012).

In cottonseed oils amount of unsaponifiable matters varied between 2.1-2.3% and it was determined it did not change according to genotypes. The iodine value which gives the degree of unsaturation in vegetable oils was found to be 102, 104, 110 g 100 g^{-1} for cottonseed oil PAUM 15, Cukurova 1518 and BA 119, respectively.

Table 1- Composition of whole seeds of cotton varieties

Çizelge 1- Pamuk çeşitlerinin tohum özellikleri

Variety	*Seed index (g)*	*Hull (%)*	*Kernel (%)*	*Seed moisture content (%)*	*Oil (%)*
Cukurova 1518	9.6^{b*}	36^{b}	64^{a}	7.7^{a}	17.8^{b}
PAUM 15	10.3^{a}	38^{ab}	62^{ab}	6.7^{b}	19.6^{a}
BA 119	9.8^{ab}	40^{a}	60^{b}	6.8^{b}	17.2^{b}
Mean	9.9	38	62	7.1	18.2
Range	9.6-10.3	36-40	60-64	6.8-7.7	17.2-19.6

*, in each column values with different letters are statistically different (P<0.05)

Table 2- Physicochemical characteristics of cottonseed oil

Çizelge 2- Pamuk yağının fizikokimyasal özellikleri

Variety	*Free fatty acid (% oleic)*	*Peroxide value (meq O_2 kg^{-1})*	*Unsaponifiable matter (%)*	*Iodine value*	*Total carotenoid (mg kg^{-1})*	*Total tocopherol (mg kg^{-1})*
Cukurova 1518	2.8^{a*}	5.7	2.3	104^{b}	140^{a}	904^{b}
PAUM 15	1.7^{c}	5.3	2.2	102^{b}	119^{b}	920^{a}
BA 119	2.3^{b}	6.0	2.1	110^{a}	127^{b}	886^{c}
Mean	2.2	5.6	2.2	105.3	128.6	903.3
Range	1.7-2.8	5.3-6.0	2.1-2.3	102-110	119-140	886-920

*, in each column values with different letters are statistically different (P<0.05)

Similar results were obtained by Sharma et al (2009) and O'Brien (2001) who reported that iodine value range for cotton seed oil was 98-113 and 101-113, respectively. In other study, cotton seed oil iodine value was very low (97.4) (Orhevba & Efomah 2012). Degree of unsaturation of oil varies depending on genotype obtained oil, climate and geographical factors and oil processing method. As degree of unsaturation (number of double bonds) of oil and iodine value increases, sensitivity to oxidation that is peroxide value increases (Orhevba & Efomah 2012). It seems that the lowest iodine value between cotton genotypes had by PAUM 15 genotype which also has the lowest peroxide value.

It was determined carotenoid contents of cottonseed oil changed between 119-140 mg kg^{-1}. The oil obtained from Cukurova 1518 was highest content of carotenoid and BA 119 genotype followed this. Carotenoid content of oil is related to colour of oil and oxidative stability (O'Brien 1998).

Total tocopherol content of cotton seed oils ranged from 886 to 904 mg kg^{-1}. While highest tocopherol content was determined in the oil obtained from PAUM 15, lowest content of tocopherol was determined in BA 119. That tocopherol content varied according to cotton genotypes. Tocopherol is significant feature because it has antioxidant structure which prevents oil to oxidation and it has vitamin E property which increases nutritional value of oil (Psomiadou & Tsimidou 2002).

The fatty acids composition for cottonsseed oils are shown in Table 3. The linoleic, palmitic, oleic and stearic acids were the principal fatty acids for all genotypes analyzed. The values of miristic, palmitoleic, linolenic, arachidic did not exceed 1%. It was determined content of oleic acid varied between 14.06-17.00% in cotton seed oil according to genotypes. Highest oleic and linoleic acid contents were found oils obtained from genotypes of BA 119 (17.00%) and PAUM 15 (55.82%), respectively. Sharma et al (2009) have reported highest oleic and linoleic acid contents of 24.81% and 52.78% in cotton genotypes, respectively. Obtained results support the results of Lukonge (2005) that indicate there was a negative correlation between oleic acid and linoleic acid. Specifically, the oxidative stability of cottonseed oil can be lower than for other vegetable oils such as olive oil and canola oil because of its high concentration of linoleic acid (Dowd et al 2010). Highest palmitic and stearic acid contents were detected oils in BA 119 (25.63%) and Cukurova 1518 (3.13%), respectively. The concentration of palmitic acid (16:0), a saturated fatty acid, is higher in cottonseed oil (~24%) than in many other vegetable oils. Higher levels of saturated fatty acids contribute functionality in food systems (Dowd et al 2010). BA 119 genotype has high oleic acid content revealed it is more resistant to oxidation than other genotypes. The results obtained are in accordance with O'Brien (1998) and Baydar & Turgut (1999) who reported that indicate fatty acid composition of seeds vary according to genotype and environmental factors.

Table 3- Fatty acids profiles of cottonseed oil of cotton varieties (%)

Çizelge 3- Pamuk çeşitlerine ait tohum yağlarının yağ asiti profilleri (%)

Fatty acids	*Cukurova 1518*	*PAUM 15*	*BA 119*	*Mean*	*Range*
Myristic (C14:0)	0.79	0.78	0.80	0.79	0.78-0.80
Palmitic (C16:0)	25.52	24.85	25.63	25.33	24.85-25.63
Palmitoleic (C16:1)	0.55	0.54	0.57	0.55	0.54-0.57
Stearic (C18:0)	3.13	3.01	3.12	3.08	3.01-3.13
Oleic (C18:1)	15.11	14.06	17.00	15.39	14.06-17.00
Linoleic (C18:2)	54.01	55.82	52.00	53.94	52.00-55.82
Linolenic (C18:3)	0.14	0.14	0.12	0.13	0.12-0.14
Arachidic (C20:0)	0.29	0.30	0.31	0.30	0.29-0.31

4. Conclusions

The major findings of the current study are: 1) that genotype differences in characteristics of cottonseed oil exist under field conditions, 2) highest oil content and amount of tocopherol obtained from 'PAUM-15' while the highest oleic and linoleic acid content was found in 'BA119' and 'PAUM 15', respectively, 3) the highest carotenoid content was found oil obtained from 'Cukurova 1518', 4) that the genotype PAUM-15 has larger genetic potential for cottonseed oil %, linoleic acid content and total tocopherol among genotypes investigated, 5) due to genotype x environment interactions, genotypes should be evaluated in more than a single environment.

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