Characteristics of Safflower Seed Oils of Turkish Origin

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ABSTRACT: Technological characteristics of oils extracted from seventeen varieties of safflower seeds (*Carthamus tinctorius* L.) of Turkish origin were investigated for their utilization prospects in the food industry and in other industrial sectors. Standard procedures were applied to determine the technological characteristics of seventeen varieties of safflower seeds and the safflower seed oils; fatty acid compositions were determined by gas–liquid chromatography. Results show that safflower seed oils are suitable both for food and industrial purposes.
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KEY WORDS: *Carthamus tinctorius* L., safflower, safflower seed oil, technological characteristics.

Turkey has favorable climatic and agricultural conditions for the cultivation of a wide variety of oilseeds. However, Turkey's present oilseed production is not sufficient to supply the established vegetable oil extraction capacity of 1.1 million tons/year. This results in a shortage of oil for food and industrial uses. The gap between domestic oil production and consumption may be eliminated through increasing the amount of imports each year (1). However, it is also necessary to consider the contribution of domestically grown minor oilseeds to the food industry and other industrial sectors in Turkey. Safflower is an oilseed that has been grown for centuries in the semi-arid conditions of Central Anatolia. It has been cultivated locally for its oil, meal, and flower. The oil was consumed as a good quality edible oil, a natural dye (Carthamin) was extracted from its flowers, and the meal served as a livestock feed (2,3). Yet it was not recognized or grown as a major oilseed crop until recently.

Safflower (*Carthamus tinctorius* L.) belongs to the tribe Cynareae of the Compositae family. It is a thistle-like annual with a penetrating taproot that grows 1.5–2.0 m deep. Being deep-rooted, safflower is somewhat drought-tolerant; it can capture the out-of-reach nutrients and moisture. This also means that it can improve the soil. Its rotation with other major crops is highly desirable, and it can be planted, cultivated, and harvested with conventional wheat-farming equipment. The seeds are white or cream in color, and their typical composition is 26–37% oil, 12–22% protein, 5–10% moisture, and 35–52% hull (4,5). Safflower seed originally contained 20–25% oil, which is rich in linoleic acid. In the past several decades, varieties with higher oil content (34–37%) and mutant types with high levels of oleic acid have been developed. The fatty acid composition of a vegetable oil determines its best commercial uses. High-linoleic safflower oil was once largely used in the preparation of paints, alkyd resins, varnishes, and automobile finishes. Today, there is growing demand in the edible oils industry for polyunsaturated and monounsaturated safflower varieties. It also may be a potential raw material for vegetable oil-based liquid fuel production in the near future. In Turkey, safflower is cultivated in the Central Anatolia and Thrace regions within the scope of certain projects supported by the Ministry of Agriculture and Forestry. In the Thrace region, where sunflower is the predominating oilseed, the yield for safflower is almost the same as that of sunflower (2000–2500 kg/hectares). This study is an investigation on the seed and oil characteristics of varieties of safflower that are grown in the Central Anatolia region of Turkey, and will be the basis of further studies on the various utilization prospects of the crop (2,3,6–9).

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MATERIALS AND METHODS

The materials for this study (17 varieties of safflower seed) were provided by Eskişehir Agricultural Research Institute (EZAE, Eskişehir, Turkey). The original identification codes used by EZAE were adopted in our studies. Reagents and solvents used in the laboratory analyses were of pure chemical grade.

The weight and hull content of each variety were calculated as the average of 50 seeds. Moisture content was determined by drying ground seeds to constant weight at 105°C in a constant-temperature drying chamber (10). The oil content and composition of each sample were determined from mechanically ground seed, which was subjected to Soxhlet extraction using *n*-hexane as the solvent. Solvent removal was performed under reduced pressure using a rotary evaporator. Oil characteristics of all varieties were determined according to standard methods of oil and fat analysis (10,11). Samples were analyzed in triplicate, and the results were given as the mean of triplicate analysis.

The fatty acid composition of safflower seed oils was de-

TABLE 1
Technological Characteristics of Turkish Safflower Seeds

Safflowerseed variety[a]	Average weight (10^{-5} kg)	Average hull content (wt%)	Moisture content (wt%)	Oil content (wt%, dry basis)
5.154.2	4.6	38	7.3	33.4
5.196.1	5.2	43	7.0	34.3
5.62.1	3.6	41	8.0	24.6
5.135	4.7	39	7.5	29.0
5.118.1	5.4	37	8.3	21.5
613.3	5.1	44	7.7	26.1
614.1	6.2	46	7.7	29.8
5.70	4.4	48	8.2	25.2
512.3	6.4	39	7.7	25.6
5.37	5.6	51	8.4	27.2
5.76	4.8	47	8.5	23.2
5.75	6.3	43	8.3	23.5
5.77	4.5	49	8.0	18.5
5.122	4.1	50	7.8	29.6
5.124	4.7	42	8.2	31.0
5.38.1	3.8	45	8.2	28.2
605.2	6.3	48	7.8	26.8

[a]Identification codes were adopted from those used by the Eskişehir Agricultural Research Institute (Eskişehir, Turkey).

termined by gas chromatography using a Varian (Palo Alto, CA) Aerograph Model 3700 gas chromatograph fitted with a flame-ionization detector, operating at 265°C, and a stainless-steel column (2 m × 5 mm) packed with 10% DEGS on Chromosorb W (Sigma-Aldrich Chemie GmbH, Deisenhofen, Germany) operating at 180°C. The injection block temperature was 255°C, and the flow rate of the carrier gas, nitrogen, was 30 mL/min. Fatty acid methyl esters were prepared using BF_3–methanol reagent (12).

RESULTS AND DISCUSSION

Characteristics of 17 varieties of safflower seeds of Turkish origin are summarized in Table 1. The hull content of the seeds varied between 37–51% and were within the lower limits specified in the literature. Varieties with hull contents up to 62% have been reported (4). Lower hull content improves the nutritional value of the meal and influences the production cost of the oil. Moisture content of the seeds was between

TABLE 2
Technological Characteristics of Turkish Safflower Seed Oils[a]

Safflower seed variety[b]	Refractive index (n^{20}) (–)	Acid value (mg KOH/g)	Saponification value (mg KOH/g)	Iodine value	
				Hanus method (g I/100 g)	Wijs method (g I/100 g)
5.154.2	1.4757	2.8	190.6	93.6	92.9
5.196.1	1.4760	3.9	185.8	143.7	138.5
5.62.1	1.4780	2.4	195.6	137.7	144.6
5.135	1.4770	1.5	191.0	143.5	144.3
5.118.1	1.4777	2.6	195.0	138.7	144.2
613.3	1.4770	1.0	191.2	141.8	146.1
614.1	1.4763	1.4	193.3	134.0	136.7
5.70	1.4774	1.4	191.1	148.9	148.3
512.3	1.4770	1.3	192.2	140.5	144.2
5.37	1.4770	1.7	188.3	140.0	141.0
5.76	1.4761	1.8	191.2	139.3	137.1
5.75	1.4770	1.7	192.4	140.6	140.5
5.77	1.4770	1.8	190.1	139.5	138.7
5.122	1.4774	2.0	186.5	140.0	139.6
5.124	1.4774	1.6	191.0	145.1	143.6
5.38.1	1.4760	1.3	191.0	138.7	147.3
605.2	1.4770	1.5	189.8	138.9	135.3
Literature values	1.4690–1.4710[c] (Ref. 14)	0.4–10.0 (Ref. 13)	188–194 (Ref. 14)	—	140–150 (Ref. 14)

[a]Results are the mean of triplicate analysis. [b]See footnote a in Table 1. [c]Refractive index at 25°C.

TABLE 3
Fatty Acid Composition of Safflower seed Oils (wt%)

Safflower seed variety[a]	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$
5.154.2	8.1	1.0	73.9	17.0
5.196.1	7.2	1.7	10.6	80.5
5.62.1	8.8	1.0	9.7	80.5
5.135	9.6	—	13.2	77.2
5.118.1	7.2	1.8	12.0	78.7
613.3	6.9	1.6	10.6	80.9
614.1	8.2	1.9	11.6	78.3
5.70	7.0	1.4	8.2	83.4
512.3	7.3	1.6	10.8	80.3
5.37	8.1	2.2	11.5	78.2
5.76	7.0	1.9	13.7	77.4
5.75	6.6	1.7	10.7	81.0
5.77	7.3	1.9	13.6	77.2
5.122	7.5	1.9	9.9	80.7
5.124	9.5	3.6	13.6	73.2
5.38.1	8.2	2.1	11.2	78.5
605.2	7.5	0.8	8.7	83.0
High linoleic (Ref. 14)	6–7.5	1–3	13–15	61–79
High oleic (Ref. 4)	4–8	—	74–79	11–19

[a]See footnote a in Table 1.

7–8.5%. Variety 5.77 had the lowest oil content (18.5%), whereas oil contents of 5.196.1 and 5.154.2 seeds were higher than 33%. Higher oil content increases the commercial value of the seed.

Technological characteristics of the safflower seed oils and some literature values are given in Table 2. Experimental values were generally in accordance with the literature values (4,13,14). Variety 5.154.2 had a lower iodine value due to its chemical composition. Fatty acid compositions of the oils are given in Table 3. Among these varieties, 16 contained a high concentration of linoleic acid (73–83%), and variety 5.154.2 had high oleic acid. According to their fatty acid compositions and iodine values, oils of the 16 varieties can be classified as drying oils and they can be feedstocks in the production of various oleochemicals. Furthermore, growing interest in health-conscious diets makes both polyunsaturated and monounsaturated safflower oils valuable raw materials for the edible oils industry. Variety 5.154.2, due to its high oleic acid content, may be more attractive for potential food uses where shelf stability and longer frying life are important.

This study covers the oil and seed characteristics of a large group of safflower cultivars of Turkish origin. Results show that safflower seed oils are suitable for both food and industrial purposes. Encouraging the cultivation of selected varieties in Turkey can be economically beneficial.

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