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Chemical composition and oxidative stability of flax, safflower and poppy seed and seed oils

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Abstract

Three seeds of Turkish origin, flax, poppy and safflower were analyzed for their proximate, fatty acids, tocols (tocopherols and tocotrienols) and total phenolic composition, and oxidative stability of their oil. The major fatty acid in the flax oil was α-linolenic acid, comprising 58.3% of total fatty acids, whereas poppy and safflower oils were rich in linoleic acid at 74.5% and 70.5% level, respectively. The amount of total tocols was 14.6 mg/100 g flax, 11.0 mg/100 g poppy and 12.1 mg/100 g safflower seed. Flax and poppy oil were rich in γ-tocopherol as 79.4 mg/100 g oil and 30.9 mg/100 g oil, respectively, while α-tocopherol (44.1 g/100 g oil) was dominant in safflower oil. Only α- and γ-tocotrienol were found in the oils. Oxidative stability of oils was measured at 110 °C at the rate of 20 L/h air flow rate, and poppy oil (5.56 h) was most stabile oil followed by safflower oil (2.87 h) and flax oil (1.57). There were no correlation between oxidative stability and unsaturation degree of fatty acids and tocol levels of the oils. All of the seeds investigated provide a healthy oil profile and may have potential as a source of specialty oils on a commercial scale.

Keywords: Flax, poppy and safflower seeds; Fatty acid; Tocol; Phenolics; Oxidative stability

1. Introduction

Oilseeds are major source of raw materials such as fat, protein carbohydrate with potential application as nutraceuticals and functional foods. They also might provide low-cost renewable resource of high value-added compounds such as tocopherol and phytochemicals. Seed oils are the main source of dietary ingredients related to their fatty acid composition and tocopherol content. The oil rich in unsaturated fatty acids, which are believed to be beneficial agents, and with high level of tocopherols are now added into infant formula and various food products and available as nutraceutical supplements in many countries (Oomah and Mazza, 1999; Moyad, 2005; Lampi et al., 2002). Moreover, not only oil components but also remaining meals after oil extraction are the important source with their protein, carbohydrate and non-nutritive but bioactive compounds such as phenolics (Naczk and Shahidi, 2006).

Oxidative stability is an important parameter in evaluating the quality of oils and fats, and oxidative stability of seed oils is greatly affected by their fatty acid composition and minor components such as tocopherol and tocotrienols. The oxidation process mainly involves the degradation of polyunsaturated fatty acid (PUFA) and the generation of free radicals, which cause to loss of functional properties and nutritional value (Gordon, 2001). Both tocopherols and tocotrienols are important antioxidants in stabilizing of unsaturated fatty acids in foods and provide an effective protection against oxidative stress together with other antioxidants, such as phenolics, in the human body (Papas, 1998; Comb, 1998; Lampi et al., 1999).

Flax, poppy and safflower seeds subjected to our study are considered to be important seed crops in the oilseed market. Particularly, flaxseed (*Linum usitatissimum*) is fast becoming a new food in many diets due to health benefits

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of its oil, fiber components and phytochemicals such as lignans (Mazza, 1998). Main physiological benefits of flax oil are attributed primarily to the high α-linoleic acid (ALA) content (Burdge and Calder, 2005). Safflower is the seed of *Carthamus tinctorius* L., which has been grown for a long time for oil production and for coloring purposes. Today this crop supplies oil, meal, birdseed, and foots (residue from oil processing) for the food and industrial products markets, although this crop is now primarily grown for the oil. The importance of safflower seed oil is in its linoleic acid content, which is a required product with high-PUFA claims (Smith, 2005). Poppy (*Papaver somniferum* L.) has been grown since ancient times for its oil rich seeds and the opium, which is exuded from its incised seed capsules. While alkaloids from poppy capsules and straw are widely used in the pharmaceutical industry, its seeds are used extensively in various baked products (Bernath, 1998; Singh et al., 1998).

Although proximate and fatty acid composition of three seeds and seed oils subjected to this study are well known, there were inadequate information about their oxidative stability under accelerated conditions and their minor components. Therefore, the objectives of this study were to determine the oil composition in terms of fatty acid and tocol (tocopherol and tocotrienol) contents and to evaluate oil composition–oxidative stability relationship.

2. Methods

2.1. Materials

Commercial flax, poppy and safflower seeds were supplied from a local producer in Central Anatolia (Eskisehir and Konya) and kept below −20 °C until used. All reagents (Analytical and HPLC grade) used were E. Merck or Sigma Aldrich.

2.2. Analysis of seed samples

The seeds were ground by using a coffee grinder. Moisture content and ash value were determined according to AOCS Methods (Af 2-54) (AOCS, 1993). Crude protein ($N \times 6.25$) was determined using LECO FP-428 Nitrogen and Food Protein Determinator. Carbohydrate content was estimated by difference of the other components. Oil from seeds was extracted using *n*-hexane for 5 h followed by solvent removal under vacuum at 40 °C. Tocols were obtained from the seeds according to slightly modified method of Oomah et al. (1997). The grinded seed was homogenized in HPLC grade methanol and then the samples were centrifuged. The supernatant was removed and residue resuspended in methanol, and the homogenization and centrifugation steps were repeated. The supernatants were combined and methanol was removed under nitrogen. The dried residue was redissolved in hexane, and then placed in a 2 ml ambercript vial and stored at −20 °C until analysis. Free phenolics from defatted plant material (3 g) was extracted with 40 ml of 70% aqueous methanol in a shaker bath set at 40 °C for 30 min and filtered. Extraction procedure was repeated 3 times. The filtrates were combined and methanol was evaporated at 40 °C by rotavapor until dryness. Free phenolics extracted with ethyl acetate. Ethyl acetate phases were evaporated under vacuum at 40 °C until dryness. In order to obtain esterified phenolic compounds from defatted seeds, samples (5 g) and 150 ml of 1.2 M HCl in 50% aqueous methanol (v/v) were mixed. These were carefully mixed and shaked at 80 °C for 1 h in a shaker water bath (Lab-Line Shaker Bath 3540, USA). The extract was cooled, filtered and methanol was evaporated. The water phase was extracted with 75 ml of ethyl acetate three times. Ethyl acetate phases were evaporated under vacuum at 40 °C until dryness.

Total phenolic content was determined by spectrophotometrically using Folin–Ciocalteau reagent after addition of 20% Na_2CO_3 solution at 765 nm against blank. Results were expressed as gallic acid equivalent in dry matter (Hoff and Singleton, 1977).

2.3. Analysis of extracted oils

Fatty acid composition: Fatty acid content of oil samples was determined according to the method described by Bozan and Temelli (2002). The fatty acid methyl esters (FAME) were then analyzed by gas chromatography (Varian 3600 GC, Mississauga, ON). The system was equipped with an auto sampler (Model 8200, Varian) and a flame ionization detector. The data were processed by a computer using Class-VP data processor (Shimadzu Corporation, Columbia, MD). Helium was used as the carrier gas. The FAMEs were separated on a fused silica capillary column (50 m × 0.32 mm, BPx-70, SGE Column, Pty. Ltd, Victoria, Australia) with the film thickness of 0.25 mm. The detector temperature was set at 230 °C. Initial injector temperature was held 70 °C for 3 min, then increased at 150 °C/min to 230 °C and held for 17 min. Initial column temperature was 50 °C for 0.1 min and increased to 170 °C at the rate of 25 °C/min, held at 170 °C for 1 min, then increased to 180 °C at the rate of 2 °C/min, and then increased to 230 °C at the rate of 10 °C/min and held for 3 min.

Tocol content: Tocols (tocopherols and tocotrienols) were analyzed by high performance liquid chromatography (HPLC). The Varian 9010 HPLC system (Varian, Mississauga, ON) was equipped with HP 1050 series auto injector. The detector used was a Shimadzu-RF 535 fluorescence detector (Shimadzu, Corporation, Columbia, MD) with wavelengths set at 330 nm for emission and 298 nm for extinction. Tocols were separated on a normal phase column (Supelcosil-LC-Diol, 25 cm × 4.6 mm ID, 5 mm particle size, Supelco, Oakville, ON) with the mobile phase flow rate at 1 mL/min. The mobile phase was a mixture of *n*-hexane:isopropanol (99.4:06, v:v). The data were integrated and analyzed using Shimadzu Class-VP Chromatography Laboratory Automated Software system (Shimadzu Corporation, Columbia, MD). Standards of tocopherol α, β,