JOURNAL OF FOOD AND DRUG ANALYSIS 23 (2015) 201–209

Available online at www.sciencedirect.com

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journal homepage: www.jfda-online.com

Original Article

Physicochemical properties of *Terminalia catappa* seed oil as a novel dietary lipid source

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ARTICLE INFO

Article history:
Received 8 March 2014
Received in revised form
16 June 2014
Accepted 17 June 2014
Available online 27 September 2014

Keywords:
edible oil
oil refining
storage stability

ABSTRACT

Terminalia catappa Linn (TC) is an ornamental tree planted extensively in many countries. It has been known for a long time that the seeds are edible but no research has focused on the realm of its use as food. Our previous data showed that the seed contains high levels of oil content (600 g/kg) and possesses the optimum fatty acid balance indicated in fat dietary guidelines. This study aims to investigate the physical and chemical properties and the possibility of using TC seed oil as a new dietary lipid. The effects of extraction conditions, partial refining process, and storage stability on TC oil properties were conducted compared with soybean oil. The results showed that physicochemical properties including the density, refractive index, melting point, acidity, free fatty acid, saponification value, unsaponifiable, peroxide, and fatty acid composition of the extracted oil were comparable with soybean oil and their values followed the dietary standard of edible oil.

1. Introduction

Belonging to the family Combretaceae, *Terminalia catappa* Linn (TC) is naturally occurring and widespread in the subtropical and tropical zones of the Indian and Pacific Oceans, and is planted extensively in many countries as an ornamental tree. Most of the research on TC has mainly focused on biological and phytochemical studies of leaves, bark, and whole fruit extracts as a database for medicinal benefits, not in the realm of food application [1–5]. TC fruit extracted by petroleum ether, methanol, and aqueous solution possess antidiabetic activity [6], and the kernel of TC also has aphrodisiac properties [7]. Ajayi et al [8] evaluated the short-term toxicology of

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http://dx.doi.org/10.1016/j.jfda.2014.06.007
1021-9498/

three kinds of oilseeds in rats, and found that oil obtained from TC seeds had the least deleterious effect, and was more suitable for consumption. In addition, Oliveria [9] indicated that the oil content of *T. catappa* (583.0 g/kg dry matter) is comparable to that of other oilseeds such as peanut, rapeseed, and sunflower.

Our previous report [10] also showed that the seed kernels of this plant contain high amounts of oil—about 60%. The main fatty acid contents are the monounsaturated fatty acid (MUFA), oleic acid (C18:1), and the polyunsaturated fatty acid (PUFA0, linoleic acid (C18:2), which were determined at 32.4% and 30.3%, respectively. In addition, the fatty acid balance of TC seeds—1.2:1.1:1 for saturated fatty acid (SFA):MUFA:PUFA—is close to the fat dietary guideline of the current National Cholesterol Education Program (NCEP) and American Heart Association (AHA) compared with other dietary vegetable oils such as palm, soybean oil, sesame, olive, and coconut oils [11]. The oil is a pale yellow liquid, and is also similar to almond oil in flavor and odor. To date, there are no dietary oils containing the fatty acid balance following the fat dietary guidelines of the NCEP and AHA. These finding suggest a promising potential capacity to develop TC oil as a healthy dietary oil.

In oil manufacturing, the solvent extraction process is typically done using hexane due to its extraction power, and low boiling point and cost. After removing hexane, the crude oil goes through the refining process to remove undesirable components with minimal damage to desirable components. The common oil refining process includes degumming, neutralization, bleaching, dewaxing, and deodorization [12]. Degumming removes phospholipids and lipoproteins, through hydration, using water and either citric or phosphoric acid, followed by centrifugation [13]. For neutralization, free fatty acids are removed by a sodium hydroxide solution and the sodium salts of the free fatty acids (soaps) are separated by centrifugation [14]. The pigments naturally present in the crude oil (including chlorophylls and carotenoids) are removed by adsorption on bleaching earth [14]. In this study, we focused on partial refining processes including degumming, neutralization, and bleaching.

To evaluate the possible use as dietary oil, the physicochemical *characteristics* of the oil, effects of extraction and refining on oil quality, and the shelf-life storage test are very important factors. No compositional data of TC oil in terms of being dietary oil have been reported, and no studies have been conducted on its potential as a new oilseed. Therefore, the present study analyzed the physicochemical *characteristics* of TC oil extracted under different conditions and to determine the effect of partially refining including degumming and neutralization on chemical properties of TC oil. The shelf-life storage study of partially refined TC oil was also evaluated compared with soybean oil.

2. Methods

2.1. Seed materials and chemical materials

Natural samples of TC with partially dried fruits (with gray-colored pericarp) were collected from the campus of Naresuan University, Phitsanulok, Thailand during July–August and October–November. The fruit was cleaned and oven-dried at 60°C for 12 hours. The shell was cracked to remove the single seed (kernel) and dried at 60°C for 2 hours. The seeds were then ground in a coffee grinder (CBG5 series, Black and Decker Canada, Brockville, Ontario, Canada) for 10 seconds to a fine powder followed by lipid extraction. Soybeans (Raitip; Thai Cereal World, Nonthaburi, Thailand) were bought from a Makro supermarket (Siam Makro Public Company, Phitsanulok, Thailand) and they were directly ground and kept under the same conditions as TC fine powder.

2.2. Lipid extraction

Lipid extraction was carried out with *n*-hexane (250 mL) and 50 g samples (ground dried seeds). Soxhlet extraction was done using the Soxhlet apparatus while maceration extraction conditions were conducted with and without Grant OLS 200 orbital shaker (175 rpm) and temperature at 55°C as adapted from Yong and Salimon's study [15]. The oil extraction by maceration was carried out for 4 hours. The extracted lipids were obtained by filtering the solvent to remove the solid before the hexane was removed using rotary evaporator apparatus at 40°C. The extracted seed oil was subsequently analyzed physicochemically.

2.3. Analytical methods

All analytical determinations were achieved in triplicate. Values of each parameter are expressed as mean ± standard deviation. The samples of the lipid were analyzed for their quality characteristics using the following standard procedures.

2.4. Physical analysis of seed oil

The viscosity of seed oil was determined using Brookfield DV-I with a spindle of S00 at 100 rpm at room temperature. To determine its color, the CIELab coordinates (L*, a*, and b*) were directly read using Hunter Lab DP9000 S/N 90905.

Specific gravity was determined according to the Association of Official Analytical Chemists (AOAC) method No. 40.1.08 (1990) [16]. A 25 mL specific gravity bottle was used. The bottle was weighed (W_0) and then filled with oil, a stopper inserted and then reweighed to give W_1. The oil was substituted with water after washing and drying the bottle and weighed to give W_2. The specific gravity was calculated from the following equation:

$$\text{Specific gravity} = \frac{(W_1 - W_0)}{(W_2 - W_0)} \quad (1)$$

A differential scanning calorimeter (DSC; Diamond; PerkinElmer, Waltham, MA, USA) was used to determine the melting point of the sample. The oil samples were homogenized and filtered through filter paper and heated at 50°C to demolish all fat crystal remains and cooled again to room temperature. The samples (each about 16 mg) were then put into the hermetically sealed aluminum pans for analysis by the DSC operating in the temperature range of −50°C to 50°C at