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Characteristics, chemical composition and utilisation of *Albizia julibrissin* seed oil

I. Nehdi*

King Saud University, College of Science, Chemistry Department, Riyadh 1145, Saudi Arabia

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ABSTRACT

The physicochemical characteristics, fatty acid and triacylglycerol compositions, DSC profile and UV/vis spectrum of oil extracted from *Albizia julibrissin* seeds were determined in this study. The oil content and the moisture of the seeds were 10.50% and 1.56%. The free fatty acid, the peroxide value, the p-anisidine value, the saponification value, the iodine value were 2.54%, 6.61 mequiv. O_2/kg of oil, 1.98, 190.63 (mg KOH/g) and 111.33 (g/100 g of oil), respectively. The specific extinction coefficients K_{232}, K_{268} were 7.55 and 0.96, respectively. Linoleic acid ($C_{18:2}$, 58.58%), palmitic acid (C_{16}, 13.86%) and oleic acid ($C_{18:1}$, 10.47%) were the dominant fatty acids in the *A. julibrissin* seed oil. LLL (36.87%), OLL (21.62%), PLL (16.69%) and PLO + SLL (8.59%) were the abundant triacylglycerol representing > 83% of the seed oil (L: linoleic, O: oleic, P: palmitic, S: stearic). The DSC melting curves reveal that: melting point = −14.70° C and melting enthalpy = 54.34 J/g. *A. julibrissin* seed oil showed some absorbance in the UV-B and UV-C ranges. The results of the present analytical study show that *A. julibrissin* is a promising oilseed crop, which can be used for making soap, hair shampoo and UV protectors. Furthermore, the high level of unsaturated fatty acids makes it desirable in terms of nutrition.

1. Introduction

The species *Albizia julibrissin*, commonly named mimosa, powder-puff tree, silk tree, are widely distributed in Asia, Africa, Australia, and tropical and subtropical America (Zheng et al., 2004; Kim et al., 2007). It is native to Asia from Iran to Japan (Cheatham et al., 1996). The genus *Albizia* (also *Albizzia*) belonging to *Fabaceae*/*Leguminosae* family (*Mimosoideae* subfamily), consists of approximately 150 species (Wang et al., 2006). Most species are deciduous woody trees and shrubs. They are easily identified by their bipinnately compound leaves. Its wood can be used for building and furniture-making. The young leaves are edible (Zheng et al., 2004). *A. julibrissin* is an umbrella-shaped tree growing to 6 m tall (Lau et al., 2007), with a broad crown of level or arching branches. It resprouts quickly if cut or top-killed, and the *A. julibrissin* bark is dark greenish grey in colour and striped vertically as it gets older. The leaves are bipinnate, 20–45 cm long and 12–25 cm broad, divided into 4–12 pairs of pinnae, each with 10–30 pairs of leaflets; the leaflets are oblong, 6–12 mm long and 1–4 mm broad. From June to July, a head inflorescence of attractive pink flowers is produced at the top of the branch (Zheng et al., 2004). The sweetly scented flowers are a good nectar source for honeybees. *A. julibrissin* fruit consists of flat pods with bulging seeds, each pod 8–18 cm long, 1.5–2.5 cm wide and can be seen from June to February. Typically 5–10 oval-shaped seeds, about 1.25 in length, are produced per pod. Seeds and seed pods may be dispersed by wind, gravity and water.

Because of its graceful flowers and umbrella-like canopy, *A. julibrissin* has been widely planted along roadways or in gardens for ornamental purposes. It is also grown in sandy areas to prevent erosion.

The bark and flowers of the *A. julibrissin* tree are used in China as medicine (Lau et al., 2007). Bark extract is a sedative drug and an anti-inflammatory for treating swelling and pain of the lungs, skin ulcers, wounds, bruises, abscesses, boils, haemorrhoids and fractures, and has displayed cytotoxic activity (Higuchi et al., 1992; Ikeda et al., 1997; Pharmacopoeia, 2005). Asians administered *A. julibrissin* bark extract to patients to treat insomnia, diuresis, sthenia, and confusion (Zhu, 1998). The flowers have been commonly used to treat anxiety, depression and insomnia (Kang et al., 2007). The seeds are a source of oil (Wang et al., 2006) and furthermore they are used as a food for livestock and wildlife. Similarly, the seeds of the tree *A. julibrissin* have been shown to possess proteolytic enzymes which clotted milk readily, without developing any bitterness in cheese after 3 months of ripening (Otani et al., 1991).

A. julibrissin is one of several energy crops being tested in the Auburn University energy crop research program, showing an annual forage yield of 4.5 dry tons acre^{-1} (10.7 Mg ha^{-1} year^{-1}) from four harvests per year, and an average total biomass yield of 37.3 Mg ha^{-1} year^{-1} from one harvest per year over a 4-year period (Sladden et al., 1992).

To our knowledge, until now a physicochemical characterization of the oil produced from the seeds of *A. julibrissin* has not

* Corresponding author. Tel.: +966 14697118; fax: +966 4675992.
E-mail address: inahdi@ksu.edu.sa.

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been reported. This investigation was undertaken to determine the physicochemical properties, UV/vis spectra, fatty acid, triacylglycerol and thermal profiles of seed oil extracted from *A. julibrissin* grown in Tunisia, and to compare these results with those of the common soybean oil which is the most imported and consumed oil in Tunisia. This work also reports the possible uses of this new *A. julibrissin* seed oil and it alternative of soybean oil.

2. Materials and methods

2.1. Seed material

Mature pods of *A. julibrissin* were collected in February 2007 from two trees from Sidi thabet city (Tunisia). These trees are located in: latitude 48°24′N; longitude 13°74′E; altitude: 17 m. The seeds were directly isolated and then hand-picked to eliminate damaged ones. The selected seeds were oven-dried at 60 °C for 24 h. The dried seeds were milled in Basic IKA Werke Mill (MF10) then sieved using a 1 mm mesh sieve and stored at −15 °C until analyses. Crude soybean oil was purchased from an oil refinery located in Tunis (ETS Abdelmoula).

2.2. Lipid extraction

Oil was extracted from seeds using hexane. The ground dried *A. julibrissin* seeds (40 g) were placed into a cellulose paper cone and extracted with 400 ml hexane using a soxhlet extraction apparatus for 8 h. The solvent was removed via a rotary vacuum distillation at 40–50 °C flushing with nitrogen to blanket the oil during storage. The residue was weighed and stored at −20 °C until it was analyzed. The weight of the oil extracted from 40 g of the seed powder was determined to calculate the lipid content. The result was expressed as the lipid percentage in the dry seed powder.

2.3. Analytical methods

Analysis was carried out in triplicate. The values of different parameters were expressed as the mean ± standard deviation ($\bar{x} \pm$ S.D.).

2.3.1. Moisture

Moisture of the seeds was determined according to the AOAC Official Method 930.15 (AOAC, 1990).

2.3.2. Acid value and acidity (% free fatty acids)

The acid value and acidity of seed oil was determined according to the standard (ISO 660, 1996). Acidity was calculated using oleic acid factor.

2.3.3. Iodine value

The iodine value was determined according to the standard (ISO 3961, 1996).

2.3.4. Saponification value

The saponification value was determined according to the standard (ISO 3657, 2002).

2.3.5. Peroxide value

The peroxide value was determined according to the standard (ISO 3960, 2001).

2.3.6. Spectroscopic indices (K_{232}, K_{268}), UV/vis spectra

The spectroscopic indices, K_{232} and K_{268}, in the UV region, were determined according to the standard (ISO 3656, 2002) and the oil was diluted with isooctane. Three spectra (200–290 nm, 290–400 nm, and 400–800 nm) of oil solutions (0.1, 1, and 10%, v/v) in hexane were measured with a spectrophotometer (JASCO V-530, WITEG Labortechnik., Gmbh).

2.3.7. Anisidine value

The anisidine value was determined according to the standard (ISO 6885, 2006).

2.3.8. Thermal characteristics (DSC profile)

The thermal characteristics of seed oil were measured by using a differential scanning calorimeter (DSC-131, SETARAM, France). A flow of nitrogen gas (1.5 ml/min) was used in the cell cooled by helium (1.5 ml/min) in a refrigerated cooling system. The instrument was calibrated for temperature and heat flow with mercury (melting point, m.p. = −38.834 °C, ΔH = 11.469 J/g), tin (m.p. = 231.928 °C, ΔH = 60.22 J/g), indium (melting point, m.p. = 156.598 °C, ΔH = 28.5 J/g) and lead (melting point, m.p. = 327.45 °C, ΔH = 24.72 J/g). The oil samples (4–5 mg) were weighed in open solid fat index (SFI) aluminum pans (No. S08/HBB37408, SETARAM) with an empty pan used as a reference. The sample and reference pans were then placed inside the calorimeter and kept at −70 °C for 2 min. The temperature was increased from −70 to 70 °C at a rate of 5 °C/min. The samples were then kept at 70 °C for 1 min, and then decreased again, at the same rate, down to −70 °C. The scans were performed at 5 °C/min.

2.3.9. Fatty acid composition

The fatty acid methyl ester (FAME) composition was determined by converting the oil to fatty acid methyl esters by adding 1 ml of n-hexane to 40 mg of oil followed by 200 μl of sodium methoxide (2 M). The mixture is heated in the bath at 50 °C for few seconds followed by adding 200 μl HCl (2N). The top layer (1 μl) was injected into a GC (Agilent 6890N, California, USA) equipped with a flame ionization detector (FID) and a polar capillary column (HP-Innowax polyethylene glycol, 0.25 mm internal diameter, 30 m length and 0.25 μm film in thickness) to obtain individual peaks of fatty acid methyl esters. The detector temperature was 275 °C and the column temperature was 150 °C held for 1 min and increased at the rate of 15 °C/min to 200 °C and the rate of 2 °C/min to 250 °C and held for 4 min. The run time was 45 min. The fatty acid methyl esters peaks were identified comparing their retention times with individual standard FAME (approximately 99% pure purchased from Supelco, USA) of lauric ($C_{12:0}$), myristic ($C_{14:0}$), palmitic ($C_{16:0}$), palmitoleic ($C_{16:1}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arachidic ($C_{20:0}$), eicosenoic ($C_{20:1}$), behenic ($C_{22:0}$), lignoceric ($C_{24:0}$) acids and analysed with the Agilent Technologies Chemstation A09.01 Software. The relative percentage of the fatty acid was calculated on the basis of the peak area of a fatty acid species to the total peak area of all the fatty acids in the oil sample. Fatty acid methyl esters peak identification was confirmed by GC–MS (NIST 2002 database) operating under similar conditions as used for the GC–FID.

2.3.10. Triacylglycerol composition

The triacylglycerols (TAGs) profile was obtained by a reverse phase high performance liquid chromatography (HPLC) (Agilent 1100, CA, USA) equipped with a G1354 quaternary pump, a G1313A standard auto sampler, and a G1362A refractive index detector. The chromatogram was carried out using Agilent Technology Chemstation software. The TAGs were separated using a commercially packed Hypersil ODS column (125 mm × 4 mm) with a particle size of 3 μm and were eluted from the column with a mixture of acetonitrile/acetone (65/35) at a flow rate of 0.5 ml/min; the TAG was detected with a refractive index detector. Ten microliters of 0.05 g oil diluted in 1 ml (chloroform/acetone 50/50, v/v) was injected into the HPLC. The total run time was 45 min. Due to the limitation of commercially available TAGs standard; the identified TAGs of *A.*