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Valorization of *Dacryodes rostrata* fruit through the characterization of its oil

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ABSTRACT

Dacryodes rostrata (kembayau) is an important food and oil resource for local communities in Borneo, but it is not commonly known to wider community. The objective of this work is to valorize kembayau fruit by evaluating the characteristics of the oil from the fruit. In this study, the physicochemical characteristics and the lipophilic essential nutrient; the fatty acid composition, vitamin E and beta-carotene content of oils obtained from the peel, pulp and seeds of kembayau fruits were studied. The pulp of the kembayau fruit contained highest proportion of oil, followed by peel and seed. Kembayau fruit contained vitamin E and had trace amount of beta-carotene. Besides, kembayau fruit oils were not toxic to BRL3A cells, provided hepatoprotection and reversed lipid peroxidation in paracetamol-induced toxicity. Our results suggest that kembayau can be a potential source for cooking oil as the physicochemical characteristics are comparable with commercial source such as oil palm.

1. Introduction

Dacryodes rostrata belongs to the family *Burseraceae*, and there are approximately 70 species of *Dacryodes* distributed throughout the humid tropical forests of the Americas, Africa and Southeast Asia. *Dacryodes* species are evergreen, perennial trees that bear fleshy fruits. Many species of *Dacryodes* are underutilized, but they have been used in folk medicine to treat diseases such as malaria, anemia, fever, skin diseases and headaches. In addition, *Dacryodes* species are also valued for their timber and edible, oil-rich fruits. *D. rostrata* is an indigenous fruit of Sabah, Sarawak, Borneo, Sumatra, Thailand and the Philippines. This species is commonly called "kembayau" in Malaysia (Kong et al., 2011; Tee et al., 2014). The fruit is seasonal (December-February) and is ovoid or oblong in shape, with a single seed in the centre surrounded by fleshy pulp. The unripe fruit is yellow-brown and changes to purple-black when ripe. At present, the fruits are harvested by local communities and sold in local markets. The fresh pulp of the fruit is edible and is served as a snack by local people; it is often blanched with hot water before consumption. In addition, kembayau fruits are often preserved in salt or black soy sauce and later consumed as an appetizer with rice or porridge by local communities.

Fresh kembayau fruit is highly nutritious and is rich in carbohydrates (20.7%), oils (16.1%), protein (3.4%), and antioxidants (Hoe & Siong, 1999; Kong et al., 2011). Among 16 indigenous fruit that have been studied in Malaysia, kembayau was ranked the second highest in oil content after *Canarium odontophyllum* (dabai) (Hoe & Siong, 1999). Consumption of this fruit helps to combat hunger and reduce malnutrition in rural communities (Kong et al., 2011). Plant oil is often a good source of dietary lipids because it contains high amounts of unsaturated fats as well as important dietary antioxidants (Foster, Williamson, & Lunn, 2009). The fatty acid content of plant oil and other minor components could contribute to its functionality and health-promoting properties.

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However, no data are available on the chemical quality parameters, lipophilic essential nutrient; fatty acid composition, vitamin E content, beta-carotene content, antioxidant capacity, cytotoxicity and hepatoprotective activity of kembayau oil. Hence, this paper reports physicochemical characteristics, fatty acid composition, vitamin E, beta carotene, the antioxidant capacity and hepatoprotective activity of kembayau oil. This study further evaluates the similarities of the kembayau oil with crude palm oil (CPO), refined, bleached, deodorized palm oil (RBDPO) and olive oil and demonstrates the potential for kembayau oil as new plant oil for future commercialization.

2. Materials and methods

2.1. Chemicals and reagents

Cyclohexane, *n*-hexane, 2-propanol, isooctane, absolute ethanol, hydrochloric acid, glacial acetic acid, potassium dichromate, toluene (all analytical grade), methanol, hexane, propanol, tetrahydrofuran (THF) and isopropanol (all HPLC grade), hydrochloric acid and soluble starch were purchased from Merck (Darmstadt, Germany). Ethanol (analytical grade) was obtained from Friedemann Schmidt (Parkwood, Australia). Wijs solution, potassium iodide, sodium lauryl sulfate, potassium hydroxide (KOH), sodium thiosulfate, phenolphthalein solution, Beta carotene standard, 2,2-diphenyl-1-picryl hydrazyl (DPPH), butylated-hydroxytoluene (BHT), 3-ethylbenzothiazoline-6-sulfonice acid) (ABTS), potassium peroxodisulphate, iron chloride, a standard mix of thirty-seven fatty acid methyl esters (Supelco® 37 Component FAME Mix), triethylamine (TEA), penicillin, streptomycin, amphotericin B, trypsin, ethylenediaminetetraacetic acid (EDTA), glucose, phosphate buffer solution (PBS), Dimethyl sulfoxide (DMSO), Dulbecco's Modified Eagle's medium (DMEM), fetal bovine serum (FBS), Methyl thiazolyldiphenyl-tetrazolium bromide (MTT), paracetamol, silymarin, trichloroacetic acid (TCA), thiobarbituric acid (TBA) were purchased from Sigma (St. Louis, USA). Vitamin E standard was provided by Sime Darby, Malaysia. BRL3A cells (Buffalo Rat liver cells) were procured from the National Centre for Cell Science (NCCS), Pune, India.

2.2. Sample preparation

Mature fresh fruits of *Dacryodes rostrata* (kembayau) were collected and provided by the Agricultural Research Centre, Department of Agriculture, Sarawak. The kembayau fruits were sampled from Lachau town, Sarawak, Malaysia from two different years. The fruits were transported in an icebox via airmail to Monash University Malaysia and were stored at −80 °C before sample preparation and analysis. The frozen kembayau fruits were thawed at room temperature for less than one hour, and fruits without physical damage were chosen for uniformity of shape and color. The selected fruits were then washed with distilled water and air dried. The pulp, peels and seeds of the fruits were manually separated and subjected to lyophilization. Freeze-dried samples were then ground into fine powder and sieved through 0.25 mm sieves. The sieved samples of kembayau peels, pulp and seeds were then stored in an air-tight container at −20 °C until further analysis. Commercial RBDPO and refined olive oil were purchased from a local supermarket.

2.3. Physical properties of the fruit

A total of 100 fruits were used to determine the physical parameters. The mass of the fruit was measured to an accuracy of 0.01 g. For consistency, the fruits were measured in bulk of 10, and the average mass was calculated with an accuracy of 0.01 g. The dimensions and size parameters were measured using a Vernier caliper to an accuracy of 0.01 mm. The fruits were measured in terms of length (L), width (W), thickness (T) to calculate the volume (V) of the fruit and seed, fruit geometric mean diameter (D_g), surface area of the fruit (S) and fruit sphericity (Ø), using the formula below (Pérez-Sánchez, Morales-Corts, & Gómez-Sánchez, 2013). Besides, the relative size of the seed with respect to the fruit, the weight of 100 fruits, and the mean weight of a single fruit were also measured.

$$V = \frac{4}{3}\pi r^3 \tag{2-1}$$

$$D_g = (L + W + T)^{0.333} \tag{2-2}$$

$$Ø = \frac{D_g}{L} \tag{2-3}$$

$$S = \pi D_g^2 \tag{2-4}$$

2.4. Oil extraction

Oil was extracted using a method adapted from Bhatnagar and Krishna (2013) with slight modifications. Grounded, sieved samples of peel, pulp and seed powder (20 g each) were placed in conical flasks, and hexane was added at a ratio of 1:5 (w/v). The mixture was then shaken for 1 h in a shaker (ZHWY-100D, Labwit, China) and maintained at 200 rpm at room temperature. The extracts were then vacuum-filtered. This procedure was repeated until the hexane became colorless to completely extract the oils. The solvent was evaporated in a rotary evaporator and the remaining crude oil was then weighed to calculate the oil content.

2.5. Physicochemical characteristics of the oils

The following physicochemical properties of the oils extracted from the peels, pulp and seeds were determined according to the official methods of the 'American Oil Chemist's Society (2009): the iodine value (IV), the saponification value (SV), the acid value (AV) and the peroxide value (PV). A Color Flex EZ spectrophotometer (Model 4510, Hunter Lab, Reston, VA, USA) was used to determine the color of the different oils. In this system, L is the lightness on a 0–100 scale from white to black, a is the (+) redness or (−) greenness and b is the (+) yellowness and (−) blueness. The peel, pulp and seed oil were filtered through filter paper to remove solid impurities and are subjected to the following physicochemical properties test.

2.5.1. Iodine value

The oil samples (0.2 g) were weighed into a 500 mL iodine flask. Fifteen milliliters of cyclohexane and glacial acetic acid (1:1 v/v) was added to the samples and swirled to ensure the samples dissolved completely. Twenty-five milliliters of Wijs solution was dispensed into the flasks and stored in the dark for 1 h; then, 20 mL of 10% KI solution followed by 100 mL distilled water were added. The solution was then titrated with 0.1 M sodium thiosulfate solution until the yellow color had almost disappeared, and 1–2 mL starch solution was added. The titration was continued until the blue color disappeared. One blank determination without the sample was conducted simultaneously. The iodine value was calculated using the following formula:

$$\textit{Iodine value}\left(\frac{\text{g}}{100\text{g}}\right) = \frac{(B - S) \times M \times 12.69}{\textit{mass of test portion, g}} \tag{2-5}$$