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Rambutan seed as a new promising unconventional source of specialty fat for cosmetics

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ABSTRACT

Rambutan is commercialized for fresh consumption and industrially processed leaving seed as a major residue. *Rambutan* seed from the industry is worthy of attention for certain industrial applications and feasibility. Extractive yields and fatty acid compositions of *rambutan* seed fat obtained under different extraction conditions were studied to assess possible applications on an industrial scale. Maceration in *n*-hexane for 1 h was shown to be feasible for *rambutan* seed fat extraction (30.12 ± 0.04%). Re-use of the solvent gave non-significantly different extractive yields ($p > 0.05$). Oleic and arachidic acids were exhibited as the major fatty acids (31.08 ± 0.75% and 28.65 ± 0.72%) followed by gondoic, palmitic, stearic, isooleic, behenic, linoleic and palmitoleic acids. The physicochemical properties of the fat feasible for an industrial practice were determined, including acid (4.35 ± 0.00 mg KOH/g), iodine (44.17 ± 0.30 g I_2/100 g), peroxide (1.00 ± 0.00 g/g), saponification (246.73 ± 0.10 mg KOH/g) and unsaponified (0.10 ± 0.00%) values. This bio-fat with a moisture content of 1.77 ± 0.12% was melted at 46.05 ± 0.05 °C. Stable bar and liquid soaps containing *rambutan* seed fat were developed. Such application demonstrates the potential of *rambutan* seed fat as a raw material for the cosmetic and personal care industries. The extraction method was modified to meet requirements for industrial feasibility. This unconventional bio-fat with a specification in terms of fatty acid profiles and physicochemical properties is proposed. Furthermore, the fat is comparable with other vegetable oils and cosmetic ingredients, and is compatible with other cosmetic ingredients.

1. Introduction

Rambutan (*Nephelium lappaceum*) is an important fruit tree in Thailand—particularly the cultivar 'Rongrien'. The cultivated crop is commercialized for fresh consumption and is industrially processed in cans, juice, jam and jellies. The seed is a major residue of this industry (Sirisompong et al., 2011). The challenge is, therefore, to transform the seed waste of the processed crop product into ecological friendly or sustainable material suitable for industrial purposes; in particular, for personal health products that are in high demand (Santana-Méridas et al., 2012), including cosmetics, to replace synthetic raw materials (Górnaś et al., 2013).

Rambutan seed is reported to contain a relatively high amount of edible fat with a bitter taste that could be suitable as a cocoa butter substitute in the food industry and also for candle making (Tindall, 1994). Accordingly, studies of potential *rambutan* seed fat applications in the food (Solís-Fuentes et al., 2010) and bioenergy (Winayanuwattakun et al., 2008) industries have been undertaken. Given the increasing demand for vegetable fat and oils for industrial proposes in medicinal and cosmetic products (Solís-Fuentes et al., 2010; Sirisompong et al., 2011), processing of *rambutan* seed residue from the processed food industry for certain industrial applications is worthy of attention. Furthermore, extraction of *rambutan* seed fat using different extraction methods and solvents yields different fatty acids and physicochemical properties (Manaf et al., 2013; Sonwai and Ponprachanuvut, 2012). In this context, therefore, yields and fatty acid compositions of *rambutan* seed fat under different extraction conditions were studied to assess possible applications on an industrial scale. The physicochemical properties of the fat feasible for an industrial application (Lourith et al., 2014; Ribeiro et al., 2006) were determined. Cosmetic products containing *rambutan* seed fat were developed accordingly.

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2. Materials and methods

2.1. Materials

Seeds of *rambutan* 'Rongrien' were kindly provided by Malee Sampran Public Company Limited (Nakornpathom, Thailand). The kernels were removed from the seeds manually, washed with tap water and dried in a hot-air oven at 50 °C for 5 h.

2.2. Seed fat extraction

The dried kernels of the *rambutan* seeds were ground to a fine powder (Retsch, Germany) with a particle diameter of less than 0.1 mm. The extraction was preliminary undertaken by maceration in industrial-grade *n*-hexane (Zenpoint, Thailand) with orbital shaking at 150 rpm for 6, 12 and 24 h, with or without heat at 60 °C, separately. The extracts were filtered and the solvent was evaporated in a vacuum rotary evaporator at 40 °C to dryness. Three replicate extractions under each condition were performed. The maceration was additionally conducted, individually, under an ambient condition for 1 and 3 h. Furthermore, the feasibility of re-use of the solvent was assessed. The distillated *n*-hexane recovered from the rotary evaporator was used as the maceration solvent. In addition, the residue remaining from the first maceration was re-macerated an additional two times. All of the extractions were performed in triplicates, and extractive yields were compared.

2.3. Fatty acid composition analysis

All of the reagents and chemicals used in the study were of analytical grade.

2.3.1. Preparation of fatty acid methyl esters (FAMEs)

Mild esterification of fatty acids with a quantitative yield was prepared by mixing *rambutan* seed fat with toluene (J.T. Baker, USA), MeOH (Merck, Germany), and 8% HCl (VWR, USA). The mixture was incubated at 45 °C for 24 h. The solution was partitioned with *n*-hexane (Merck, Germany), dried over $MgSO_4$ anhydrous (Panreac, Spain) and concentrated to dryness in vacuo (Lourith et al., 2014).

2.3.2. GC/MS analysis

An aliquot (1 μl) of the sample diluted (1:1, v/v) with CH_2Cl_2 (VWR) was injected (220 °C) in the splitless mode into a gas chromatograph (Agilent, 6890N, USA) equipped with a HP-5MS capillary column (Agilent, 30 m × 250 μm, 0.25 μm film thickness) and mass spectrophotometer (Agilent, 5973N). The analysis was conducted using helium as the carrier gas (1.0 ml/min). Separation was successively performed with the oven program starting at 50 °C (5 min), rising to 65 °C at a rate of 2 °C/min, and then 200 °C (5 °C/min, 5 min), and 250 °C (10 °C/min) and held for 10 min. The reference mass spectrum was obtained from the MS-Willey7n.1 database (Lourith et al., 2014). The FAMEs in the *rambutan* seed fat were analyzed in triplicate.

2.4. Physicochemical properties

The acid, iodine, peroxide, saponification, and unsaponification values were determined in accordance with official methods (AOCS, 1997). Melting point was monitored using a melting point apparatus (B-540, Büchi, Switzerland) and color was matched with the Munsell color system. Moisture content was determined using a moisture analyzer (MB45, Ohaus, Switzerland).

2.5. Formulation of rambutan seed fat soaps

All ingredients used in the formulation of soaps were of cosmetic grade.

Bar and liquid soaps containing *rambutan* seed fat and vegetable oils were developed by means of saponification with NaOH and KOH, respectively. The soaps were further assessed on pH and foam ability (Ghaim and Volz, 2001; Kuntom and Kifli, 1998).

2.5.1. pH

The formulated soap solution (10%) in DI water was pH determined (Mettler Toledo, s20, USA) in triplicates.

2.5.2. Foamability

Foamability was studied by means of a shaking test (Tegewa, 2007) modified for a simple and generally applicable method (Lunkenheimer and Malysa, 2003). Soap (1.0 g) was added to a 100 ml glass measuring cylinder (Duran, Germany) containing 50 ml DI water and vigorously shaken for 2 min to generate foam. The height of the foam generated was determined immediately and after 10 min. The foamability test was repeated three times.

2.6. Statistical analysis

Data are presented as means ± SD. Differences among means were evaluated using SPSS version 11.5 (SPSS, USA). The level of significance applied was $p < 0.05$.

3. Results and discussion

3.1. Rambutan seed fat extraction

Vegetable fats and oils that are used as raw materials in the food, medicine and cosmetics industries (Górnaś et al., 2013) can be prepared by several methods, namely compression, reflux (Gunawan et al., 2006; Lourith and Kanlayavattanakul, 2013), soxhlet (Lourith et al., 2014) and maceration. Fat from *rambutan* seed previously was reported to be soxhleted with *n*-hexane (Sirisompong et al., 2011) for 6 h (Solís-Fuentes et al., 2010; Sonwai and Ponprachanuvut, 2012) or 7 h (Winayanuwattakun et al., 2008). In addition to *n*-hexane, petroleum ether has been used for *rambutan* fat extraction with a soxhlet extractor for 8 h (Augustin and Chua, 1988; Manaf et al., 2013). However, commercialized vegetable fats and oils are mainly prepared by means of maceration in *n*-hexane because of its recovery efficiency and because it can be re-used more frequently than petroleum ether (Dacera, 2003; Ribeiro et al., 2006).

In this context, maceration of *rambutan* seed in commercial-grade *n*-hexane was therefore conducted. First, the seeds were incubated at 60 °C, which was close to the solvent/s boiling point conducted in soxhlet extraction (Sirisompong et al., 2011; Sonwai and Ponprachanuvut, 2012), with shaking for 6, 12 and 24 h. Extractions at room temperature were conducted in parallel. Fat with a soft touch consistency and a slightly pale yellow color was obtained under all of the extraction conditions.

The extractive yields differed non-significantly ($p > 0.05$) (Fig. 1). Thus, extraction at room temperature for 1 h was shown to be an efficient method to extract fat from the *rambutan* seed. Furthermore, the extractive yield of this maceration (32.60 ± 0.54%) was close to that of material soxhleted for 6 and 9.2 h, which generated yields of 33.4% and 37.5%, respectively (Solís-Fuentes et al., 2010; Sirisompong et al., 2011). Accordingly, the extraction was repeated for 1 and 3 h at ambient temperature (Fig. 2A). The resulting extractive yields were comparable ($p > 0.05$). Maceration in *n*-hexane for 1 h was shown to be feasible for *rambutan* seed fat extraction. Therefore, the possible frequency of re-using the commercial-grade *n*-hexane was examined to assess the feasibility