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Effects of drying methods on assay and antioxidant activity of xanthones in mangosteen rind

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ABSTRACT

Rind of mangosteen is one of the best natural sources of xanthones, which have been reported to have high antioxidant activity. In many cases mangosteen rind must be dried prior to extraction of the active compounds. However, information on the effects of different drying methods and conditions on the retention of xanthones in mangosteen rind is still very limited. This work was therefore aimed at studying the effects of selected drying methods and conditions on the changes of the contents as well as the antioxidant activity of xanthones in mangosteen rind. Mangosteen rind was subject to hot-air drying, vacuum drying or low-pressure superheated steam drying (LPSSD) at 60, 75 and 90 °C and in the case of subatmospheric drying methods at an absolute pressure of 7 kPa. The xanthones contents were analysed by HPLC, while their antioxidant activity was assessed by DPPH radical scavenging capacity and ABTS assays. The results showed that the drying methods significantly affected degradation of xanthones (i.e., α-mangostin and 8-desoxygartanin) and their antioxidant activity. Either hot-air drying or LPSSD at 75 °C is proposed as an appropriate drying technique and condition to preserve xanthones in mangosteen rind.

1. Introduction

Mangosteen (*Garcinia mangostana* Linn.) or "Mang Khut" in Thai is a tropical fruit and is known as the "Queen of fruits" in Asia. When mangosteen is ripe its rind becomes dark purple to red purple, while the flesh is white, soft, juicy and sweet. Besides the edible flesh mangosteen rind has been used to prepare traditional medicines for treatment of diarrhea, skin infection, among other diseases, for years (Ji, Avula, & Khan, 2007; Zadernowski, Czaplicki, & Naczk, 2009).

Mangosteen rind is known as one of the best natural sources of xanthones, which are secondary plant metabolites (Deachathai, Mahabusarakam, Phongpaichit, & Taylor, 2005; Jung, Su, Keller, Mehta, & Kinghorn, 2006). Xanthones belong to a class of polyphenolic compounds commonly found in higher plant families (Peres, Nagem, & Oliveira, 2000; Zadernowski et al., 2009). Xanthones and their derivatives have been reported to have high antioxidant activity (Jung et al., 2006; Okonogi, Duangrat, Anuchpreeda, Tachakittirungrod, & Chowwanapoonpohn, 2007; Tachakittirungrod, Okonogi, & Chowwanapoonpohn, 2007), anti-inflammatory activity (Chen, Yang, & Wang, 2008; Park et al., 2006b), antibacterial activity (Fang, Ye, Chen, & Zhao, 2008), anti-atherosclerotic activity (Park et al., 2006b) and anti-malarial activities (Hay et al., 2004). Therefore, xanthones from mangosteen rind have also recently been used to produce various dietary supplement products, fortified beverages as well as antiseptic goods, e.g., soap and plaster, in many countries. Ji et al. (2007) and Walker (2007) reported the use of high-performance liquid chromatography (HPLC) with photodiode array detector to detect and quantify xanthones in mangosteen rind. These investigators reported the existence of six xanthones, which are α-mangostin, β-mangostin, 9-hydroxycalabaxanthone, 3-isomangostin, gartanin, and 8-desoxygartanin, in mangosteen rind.

In many cases mangosteen rind must be dried prior to extraction of active compounds or even storage to extend its shelf life. Although methods and conditions of drying are known to affect differently the quality and quantity of various bioactive compounds in fruits and vegetables, there is very little information on the evolution of xanthones during drying. Only the work of Carnat et al. (2005) is available on the study of the influences of drying methods on the amounts of xanthones in root of wild gentian (*Gentiana lutea* Linn.). The results showed that the amounts of xanthones were independent of the drying methods (i.e., ambient air drying in shade and hot-air drying at 40 °C for 5 days). However, in that study, the ranges of the tested conditions were limited; the antioxidant activity of xanthones was also not investigated.

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Many research studies have been devoted to polyphenols in fruits and vegetables and their benefits, especially their antioxidant activity. In general, the polyphenolic content of fresh plant materials is higher than that of dried plant materials due to degradation of phenols during drying. Decline in polyphenolic content after drying has been reported for plums (Caro, Piga, Pinna, Fenu, & Agabbio, 2004), persimmons (Park et al., 2006a), mulberry leaves (Katsube, Tsurunaga, Sugiyama, Furuno, & Yamasaki, 2009), apricots (Madrau et al., 2008), olive mill waste (Obied, Bedgood, Prenzier, & Robards, 2008) and ginger leaves (Chan et al., 2009). However, some recent studies have shown that dried plant materials contain higher polyphenolics as compared to fresh plant materials. For example, an increase in polyphenolic content after drying has been reported for tomatoes (Chang, Lin, Chang, & Liu, 2006) and shiitake mushroom (Choi, Lee, Chun, Lee, & Lee, 2006). Drying has also been reported to affect the antioxidant activity of fruits and vegetables differently (Chantaro, Devahastin, & Chiewchan, 2008; Choi et al., 2006; Kuljarachanan, Devahastin, & Chiewchan, 2009; Park et al., 2006a).

The objective of this study was to investigate the effects of selected drying methods, i.e., hot-air drying, vacuum drying and low-pressure superheated steam drying (LPSSD), on the amounts and antioxidant activity of xanthones in mangosteen rind. This information is needed in order to maximise the quantity and quality of xanthones in dried mangosteen rind.

2. Materials and methods

2.1. Chemicals

Xanthone standards, α-mangostin and 8-desoxygartanin, were purchased from ChromaDex Inc. (Irvine, CA). Ethanol, methanol and deionized water (HPLC grade) were purchased from Lab-Scan Analytical Sciences (Bangkok, Thailand). For antioxidant activity analyses, 2,2-diphenyl-2-picrylhydrazyl (DPPH) and 2,2′-azinobis(3-ethylbenzithiazoline-6-sulphonic acid) diammonium salt (ABTS) were obtained from Sigma–Aldrich (St. Louis, MO). Potassium persulfate ($K_2S_2O_8$) was purchased from Carlo Erba (Milan, Italy). All these chemicals were of analytical grade.

2.2. Sample preparation

Mangosteen (*G. mangostana* Linn.) at mature stage with rind colour dark purple to red purple was purchased from a local market. Mangosteen rind was separated from the fruit flesh and stored at −18 °C until further use. To perform a drying experiment frozen mangosteen rind was thawed and then gathered by trimming outer and inner skins off. The residual rind was then chopped by a chopper (Moulinex, model DPA141, Ecully, France) to obtain a particle size of about 1 mm prior to drying.

2.3. Drying of mangosteen rind

Prepared mangosteen rind was dried at temperatures of 60, 75 and 90 °C in a hot air dryer (Termaks, model TS8000, Bergen, Norway). Experiments were also conducted in a vacuum dryer and low-pressure superheated steam dryer devised and used by Devahastin, Suvarnakuta, Soponronnarit, and Mujumdar (2004); the absolute pressure in the drying chamber was fixed at 7 kPa and the drying temperatures were also 60, 75 and 90 °C. Mangosteen rind was dried until reaching the final moisture content of around 0.10 kg/kg (d.b.). The moisture content of mangosteen rind was evaluated by drying the sample at 105 °C for 24 h in a hot air oven (Memmert, model 800, Schwabach, Germany). The dried sample was packed in sealed aluminium bags and kept at −18 °C until further analysis.

2.4. Extraction of xanthones

Extraction of xanthones was performed according to the methods of Aberham, Schwaiger, Stuppner, and Ganzera (2007) and Ji et al. (2007) with some modifications. Dried mangosteen rind (0.2 g) was mixed with 3 ml of 95% (v/v) ethanol and extracted in an ultrasonic bath (Ultrawave, model U1350, Cardiff, UK), which generated the frequency of 30 kHz, for 10 min at room temperature. The mixture was then centrifuged (Hitachi, model himacCR21, Ibaraki, Japan) at 3000 rpm for 5 min. A supernatant was collected and transferred to a 10-ml volumetric flask. The extraction was repeated thrice; all extracted solutions were combined in one 10-ml volumetric flask. The ethanolic extract was then filled up to the final volume of 10 ml with 95% (v/v) ethanol and kept at −18 °C until further use.

2.5. HPLC analysis

The HPLC analysis method, which was used to detect and quantify xanthones in the ethanolic extract, was that of Walker (2007). The HPLC system consists of a pump and a controller (Waters,

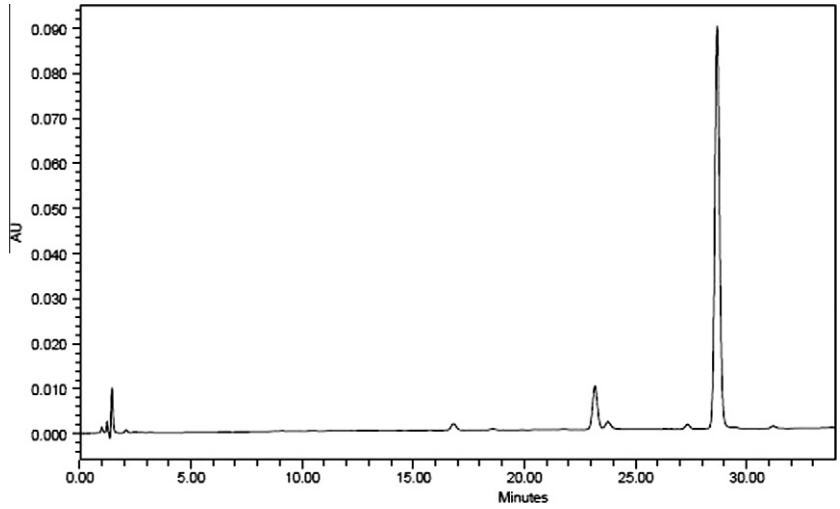

Fig. 1. Typical HPLC chromatograms of xanthones in mangosteen rind at a wavelength of 254 nm: (1) 8-desoxygartanin and (2) α-mangostin.