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Isolation and Optical Properties of Natural Pigments from Purple Mangosteen Peels

Isolation and Optical Properties of Natural Pigments from Purple Mangosteen Peels

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Abstract. Purple mangosteen (*Garcinia mangostana*) has several biological applications such as anticancer, antitubercular and antioxidant agents. In this work, we isolated and studied the optical properties of the natural pigments from the purple mangosteen peels. To isolate the natural pigments, the mangosteen peels were macerated using distilled water, ethanol, or acetone for 24 h. The extracts were filtrated and characterized using spectrophotometers of Fourier transform infrared (FTIR), ultraviolet-visible (UV-Vis), and spectrofluorometer. The extracts gave the FTIR vibration peaks of O-H, C-H sp^3, C=O, C=C, and C-O functional groups, while absorption peaks at 210–374 nm were observed in the UV-Vis spectra of the extracts due to the presence of mangostins, anthocyanins, and phenolic acids. The three-dimensional fluorescence spectra showed that the excitation and emission peaks of the mangosteen peels extracted with ethanol were found at 444 and 498 nm, respectively, while that extracted with distilled water gave no significant fluorescence peaks. On the other hand, the mangosteen peels extracted with acetone gave the strongest emission intensity at 472 and 502 nm due to the most intense color intensity. This study provided useful information about the optical properties of natural pigments extracted from purple mangosteen peels through a simple isolation technique.

1. Introduction

Purple mangosteen (*Garcinia mangostana*) is a widely abundant tropical fruit in tropical countries. In general, it can be found in the Malay Archipelago especially in Indonesia. Purple mangosteen has been well recognized due to its excellent biological activities [1], therefore purple mangosteen is well-known as the queen of fruits [2]. Orozco *et al.* and Palawakong *et al.* reported that the biological activities of purple mangosteen are generated by xanthones, phenolic acids, anthocyanins, flavonoids, tannins, and carotenoids [3, 4]. Xanthones especially their prenylated and oxygenated compounds exhibit excellent antimicrobial activity against *Mycobacterium tuberculosis*, *Staphylococcus aureus*, *Candida albicans*, *Plasmodium falciparum*, *etc*. Because of that, mangosteen has been thoroughly investigated and employed as antitubercular and antimalarial agents [5, 6]. Furthermore, the anticancer, antioxidant, anti-inflammatory, anti-tumorigenic and anti-obesogenic activities of purple mangosteen have been also evaluated either in *in vitro* or *in vivo* studies [7–9].

In contrast to the excellent biological activities of the purple mangosteen flesh, the purple mangosteen peels were rarely utilized and thrown as the waste. Some researchers are putting effort to minimize the waste and utilize them for other potential applications [10–12]. Therefore, in the present

work, the natural pigments from purple mangosteen peels were extracted through a maceration method and their optical properties were studied for a possible application as photonic and dye-sensitized materials. Distilled water, ethanol and acetone were employed as the media for natural pigments extraction process and the obtained extracts were characterized using spectrophotometers of Fourier transform infrared (FTIR), ultraviolet-visible (UV-Vis), and spectrofluorometer.

2. Experimental Section

Purple mangosteen fruits were bought from a supermarket in Malang, East Java. On the other hand, ethanol and acetone were obtained in EMPLURA grade from Merck. At first, as much as 1 kg of purple mangosteen fruit was cleaned with distilled water to remove the soil and other impurities. The peel of purple mangosteen was separated from its flesh, chopped and dried at 25 °C for 20 h. Then, 5 g of purple mangosteen peel was macerated with 50 mL of either distilled water or ethanol or acetone separately for 24 h. Afterwards the extract was characterized with a Fourier transform infrared (FTIR) spectrophotometer (JASCO FTIR-6800), an ultraviolet-visible (UV-Vis) spectrophotometer (JASCO V-760), and a spectrofluorometer (JASCO FP-8500).

3. Results and Discussion

In the present work, the natural pigments were extracted from purple mangosteen peels and their optical properties were investigated. Through a simple maceration method, three extracts of the purple mangosteen peels were successfully obtained and their photograph is shown in Figure 1. Figure 1 shows that the yellow color intensity was increased in the order of using distilled water, ethanol and acetone solvents. From the naked eye investigation, it could be predicted that the concentration of the natural pigments in acetone was higher than ethanol and was also higher than distilled water extract.

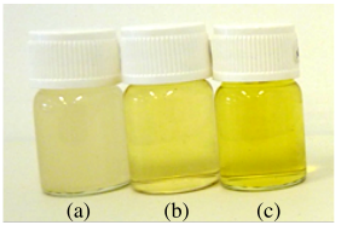

Figure 1. The photograph images of the purple mangosteen peel extract in (a) distilled water, (b) ethanol and (c) acetone.

To identify the functional groups of the extracted natural pigments, the FTIR spectra of the extract was measured by attenuated total reflectance (ATR) method. Before spectrum recording, the extract was treated using nitrogen gas flow to remove the used solvents. The FTIR spectra of the extracts are shown in Figure 2. The FTIR spectrum of the distilled water extract (Figure 2(a)) gave six main absorption peaks at 3319, 2972, 2872, 1735, 1375, and 1054 cm^{-1}. The presence of alkyl groups (R-CH_2-R') was indicated by the presence of C-H sp^3 stretching (2972 and 2872 cm^{-1}) and -CH_3 bending (1375 cm^{-1}) peaks, while the presence of carbonyl ester and hydroxyl groups was confirmed by the presence of C=O stretching (1735 cm^{-1}), C-O stretching (1054 cm^{-1}) and O-H stretching (3319 cm^{-1}), respectively.

The FTIR spectrum of the ethanolic extract (Figure 2(b)) gave eight main absorption peaks at 3440, 2938, 2828, 1686, 1419, 1363, 1207 and 1052 cm^{-1}. The presence of alkyl groups was shown by the presence of C-H sp^3 stretching (2938 and 2828 cm^{-1}), -CH_2- bending (1419 cm^{-1}), and -CH_3 bending (1363 cm^{-1}) peaks, while the presence of the carboxylic acid functional group was confirmed by the presence of O-H stretching (3440 cm^{-1}), C=O stretching (1686 cm^{-1}), and C-O ester (1027 cm^{-1}). On the other hand, the FTIR spectrum of the acetone extract (Figure 2(c)) gave five main absorption peaks

at 2969, 1738, 1365, 1215 and 1052 cm^{-1}. The presence of alkyl groups was shown by the presence of C-H sp^3 stretching (2969 cm^{-1}), and $-CH_3$ bending (1365 cm^{-1}) peaks, while the presence of the ester functional group was confirmed by the presence of C=O stretching (1738 cm^{-1}), and either C-O ether (1215 cm^{-1}) or C-O ester (1052 cm^{-1}) functional groups.

From the FTIR spectra, both distilled water and ethanolic extracts showed that they contained polar natural pigments as the carboxylic acid and/or alcohol groups were detected. However, due to the low polarity of acetone as a non-polar solvent, the non-polar natural pigments were extracted as confirmed by its FTIR spectrum. This is in agreement with "like dissolve like" principle in which polar solvent gave higher possibility and suitability to extract polar natural pigments and vice versa [13].

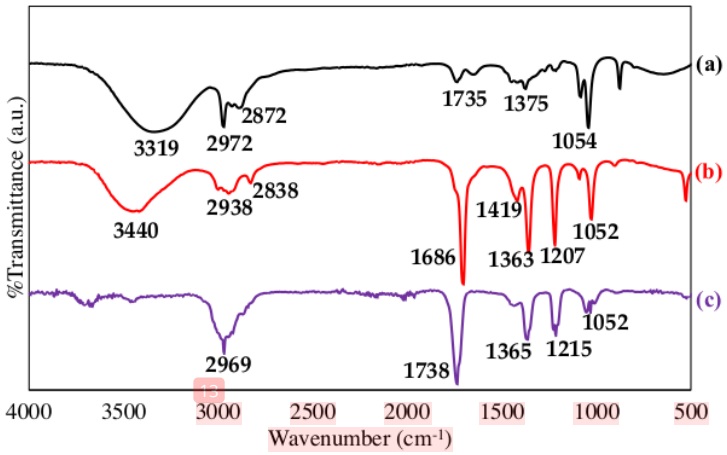

Figure 2. The FTIR spectra of the purple mangosteen peel extract in (a) distilled water, (b) ethanol and (c) acetone.

The optical properties of each extract were studied by UV-Vis and fluorescence measurements. The UV-Vis spectra of the extracts of purple mangosteen peels are shown in Figure 3 (a), (b) and (c) when using distilled water, ethanol and acetone as the media, respectively. The UV-Vis spectrum of the distilled water extract gave weak absorption peaks at 210, 283 and 374 nm (Figure 3 (a)), while the ethanolic extract gave a little bit stronger absorption peaks at 240, 256, 320 and 360 nm (Figure 3 (b)). Among the media, acetone extract gave the strongest absorption intensity. The absorption peaks were observed at 248, 258, 312, and 354 nm (Figure 3 (c)), in which agreed with the color appearance of the extract. The UV-Vis spectrum of the distilled water extract showed the absorption peaks at 210 and 374 nm, corresponding to the presence of the mangostin compounds (including α-mangostin, β-mangostin, γ-mangostin, gartanin and garcinone E), while the absorption peak at 283 nm corresponding to the presence of anthocyanin pigments (including cyanidin-3-sophoroside and cyanidin-3-glucoside) [14–16]. On the other hand, the characteristic absorption peak of cinnamic acid (256 nm), sinapinic acid (240 and 320 nm) and syringaldehyde (240 and 360 nm) were found at the ethanolic extract [17–19]. Similar to the ethanolic extract, the acetone extract also contained these pigments. However, their absorption peaks, *i.e.* cinnamic acid (258 nm), sinapinic acid (248 and 312 nm) and syringaldehyde (248 and 354 nm) were shifted due to the solvatochromic effect. The chemical structures of these compounds are shown in Figure 4, while further investigation is still required to confirm these natural pigments either by liquid chromatography-mass spectrometry (LC-MS) or nuclear magnetic resonance (NMR) analysis.

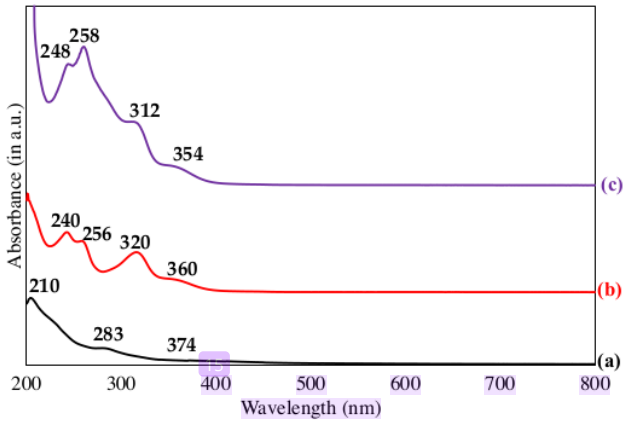

Figure 3. UV-Vis spectra of the purple mangosteen peel extract in (a) distilled water, (b) ethanol and (c) acetone.

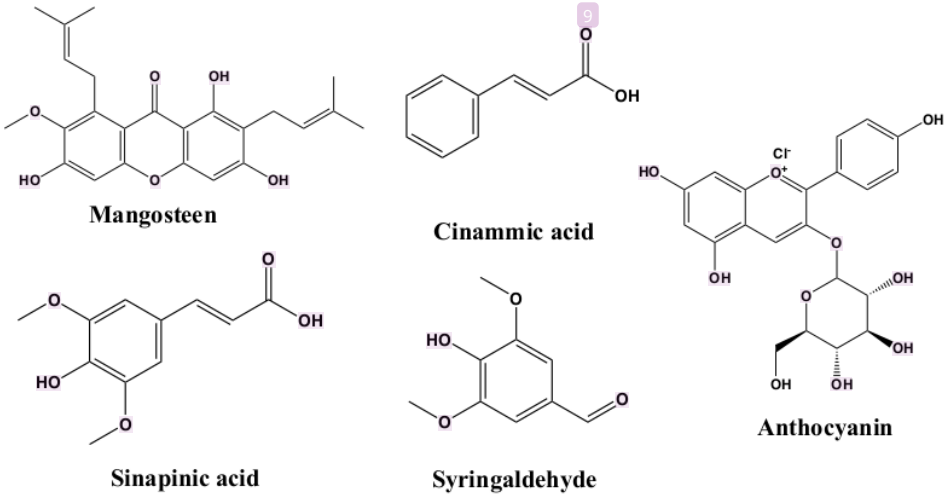

Figure 4. Chemical structures of the natural pigments found in the extracts of purple mangosteen peel.

The three-dimensional fluorescence spectra of the extracts are shown in Figure 5. The x-axis of the three-dimensional fluorescence spectrum shows the emission wavelength and the y-axis shows the excitation wavelength. Meanwhile, the z-axis shows the fluorescence intensity from 0 (black color) to 200 (red color) units. The three-dimensional fluorescence spectrum of the distilled water extract gave a very low fluorescence intensity, while ethanolic and acetone extract gave a stronger fluorescence spectrum as indicated by the color appearance.

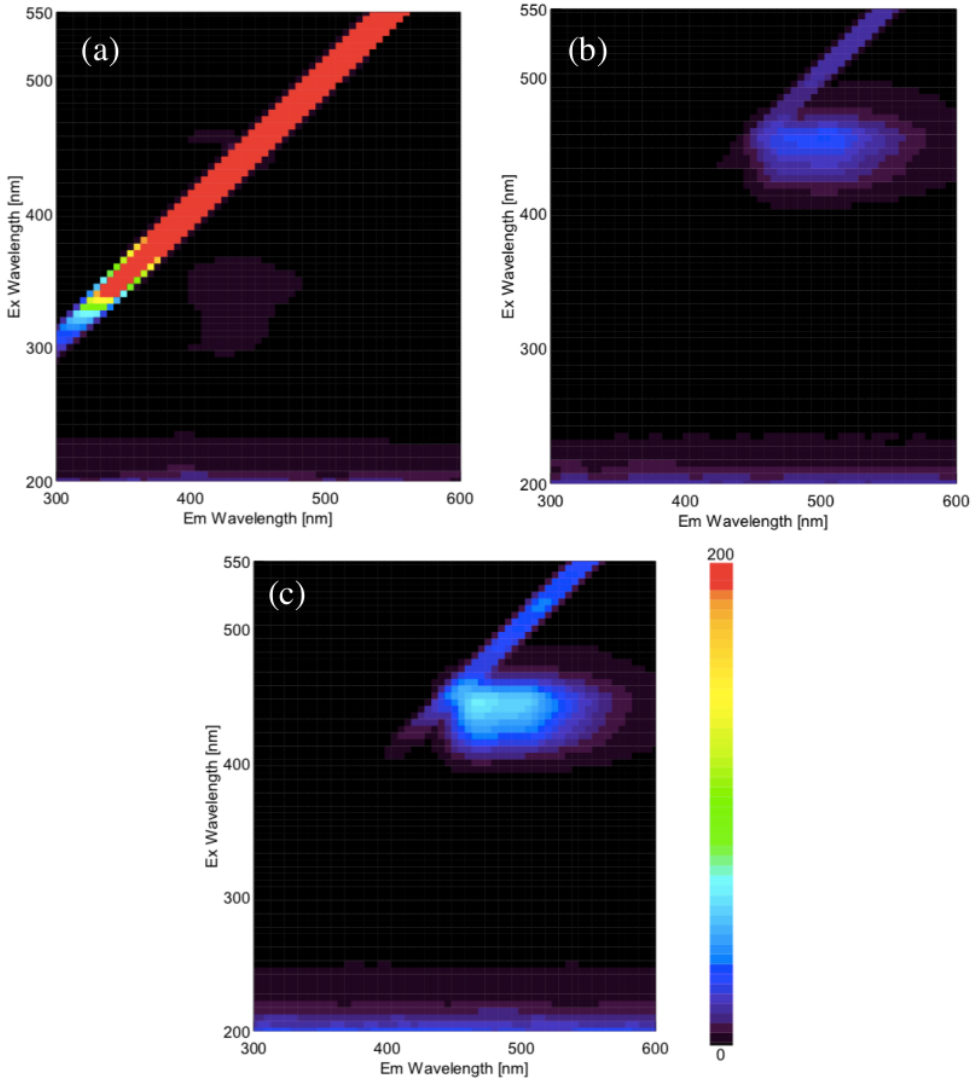

Figure 5. Three-dimensional fluorescence spectra of the purple mangosteen peel extract in (a) distilled water, (b) ethanol and (c) acetone.

In good agreement to the three-dimensional fluorescence spectra, the two-dimensional fluorescence spectrum of distilled water extract showed no significant absorption peak. The two-dimensional fluorescence spectra of ethanolic and acetone extracts are shown in Figure 6 (a) and (b), respectively. Corresponding to its three-dimensional spectrum, the ethanolic extract gave the main excitation and emission signals at 444 and 498 nm. Meanwhile, the acetone extract gave a single excitation signal at 452 nm and three emission signals at 472, 502 and 667 nm. According to their UV-Vis spectra shown in Figure 3 (b) and (c), the ethanolic and acetone extracts contained cinnamic acid, sinapinic acid and

syringaldehyde compounds. However, these major compounds did not seem to be the emissive ones. It was found that the ethanolic extract gave a similar fluorescence spectrum to that of the anthocyanin compounds [20], while the acetone extract showed similar fluorescence spectra to those of the anthocyanin and chlorophyll compounds [21].

The intensity of either excitation or emission signals of acetone extract was higher than those of the ethanolic extract, which was in good agreement with the naked-eye observation as well as their UV-Vis spectrum. These experiments serve a useful preliminary data for the optical properties of the isolated natural pigments from purple mangosteen peels. Since both ethanolic and acetone extracts show a remarkable fluorescence intensity, they are promising to be used as the photonic material and/or dye-sensitizer agents in the near future.

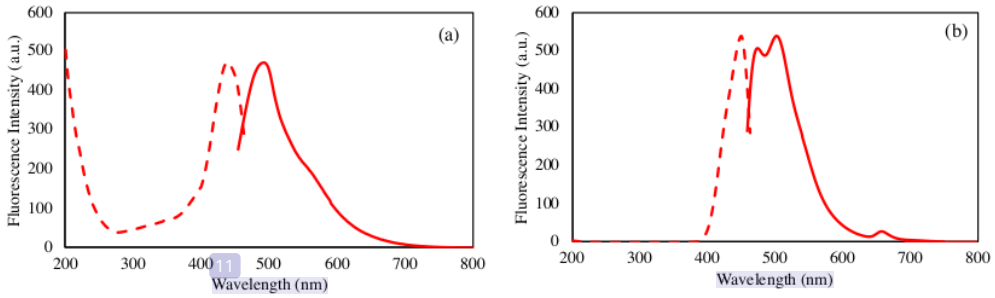

Figure 6. The two-dimensional fluorescence spectra of the purple mangosteen peel extract in (a) ethanol and (b) acetone. Dash line: excitation spectrum. Solid line: emission spectrum.

4. Conclusions

Isolation of the natural pigments from purple mangosteen peels has been successfully carried out through a maceration technique employing distilled water, ethanol, and acetone as the solvents. From the FTIR spectra, both distilled water and ethanolic extracts contained polar natural pigments, yielding a pale yellow color, while the acetone extract contained non-polar natural pigments, giving stronger yellow color intensity than those of the distilled water and ethanolic extracts. The UV-Vis spectra of the extracts revealed that the isolated natural pigments were dominated by mangosteen, anthocyanin and phenolic acid compounds. While the distilled water extract gave no remarkable fluorescence signal, the acetone extract gave the highest fluorescence intensity in which agreed well with the naked-eye observation and UV-Vis spectrum analysis.

Acknowledgement

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