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Identification of nutrients and phytochemicals of raja banana (*Musa acuminata*) peels extracted with ethanol and acetone solvents and its potential as an anti-obesity agent

Identifikasi nutrisi dan fitokimia kulit pisang raja (Musa acuminata) yang diekstraksi dengan pelarut etanol dan aseton serta potensinya sebagai agen anti-obesitas

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Abstract

Banana peel is a waste that has the potential as an anti-obesity agent due to its nutritional and phytochemical content. This study aims to analyze and compare the content of macronutrients, micronutrients, and phytochemical compounds in raja banana peel extracts. The maceration method was performed during the preparation of extracts by using ethanol and acetone solvents. The nutritional and phytochemical contents of the extracts were compared to determine which solvent produced the optimum anti-obesity properties. The ethanol extract consists of water (17,68%), minerals (22,76%), protein (3,50%), carbohydrates (47,98%), and vitamin C (0,82%). The phytochemical content includes flavonoids (73,38 mgQE/g), tannins (0,32%), and chrysin (1,16 mg/L). In conclusion, the ethanol extract of Raja banana peel contains higher nutrients and phytochemicals than the acetone extract, showing greater potential as an anti-obesity agent. Further research is needed to test its bioactivity *in vivo* or *in vitro*.

Keywords: Raja banana peel, Ethanol, Acetone, Phytochemicals, Anti-obesity

Abstrak

Kulit pisang merupakan limbah yang berpotensi sebagai agen anti-obesitas karena kandungan nutrisi dan fitokimianya. Penelitian ini bertujuan untuk menganalisis dan membandingkan kandungan zat gizi makro dan mikro serta senyawa fitokimia pada kulit pisang raja. Metode maserasi dilakukan saat penyiapan ekstrak dengan menggunakan pelarut etanol dan aseton. Kandungan nutrisi dan fitokimia ekstrak dibandingkan untuk menentukan pelarut mana yang menghasilkan sifat anti-obesitas yang optimal. Ekstrak etanol mengandung kadar air sebesar 17,68%, mineral 22,76%, protein 3,50%, karbohidrat 47,98%, dan vitamin C 0,82%. Kandungan fitokimia meliputi flavonoid sebesar 73,38 mgQE/g, tanin sebesar 0,32%, dan krisin sebesar 1,16 mg/L. Sebagai kesimpulan, ekstrak etanol kulit pisang raja mengandung nutrisi dan fitokimia yang lebih tinggi daripada ekstrak aseton, menunjukkan potensi yang lebih besar sebagai agen anti-obesitas. Penelitian lebih lanjut diperlukan untuk menguji bioaktivitasnya secara *in vivo* atau *in vitro.*

Kata Kunci: Kulit pisang raja, Etanol, Aseton, Fitokimia, Anti-Obesitas

Introduction

The rapid development of digital technology has influenced people's lifestyles, including reduced physical activity and increased consumption of foods containing high levels of fat, sugar, and salt; thus contributing to the rising prevalence of obesity (Woessner et al., 2021). By 2030, it is estimated that around 50% of the global adult population will be overweight or obese (World Obesity Federation, 2025), including Indonesia, where the obesity rate among adults is 23,4% (Kemenkes RI, 2023). This condition not only poses serious health risks but also increases the economic burden on countries, projected to rise by 3,2% by 2060 if current trends continue (Okunogbe et al., 2022).

Obesity management typically involves lifestyle changes, pharmacological treatments, or surgical procedures (Brown, 2023). However, the long-term effectiveness of these strategies is often limited by low motivation and lack of consistency. Therefore, there is a need for safe and practical alternatives, such as the use of natural ingredients containing bioactive compounds with anti-obesity potential through several mechanisms; i.e., enhanced lipolysis, increased energy expenditure, and reduced food intake (Pakpahan et al., 2024).

The use of agricultural by-products as a source of functional ingredients, especially those derived from food crops, has received considerable attention. Bananas are a common food crop worldwide, but their peels, like other agricultural by-products, are often discarded (Masuku, 2021). Banana peels have the potential to be transformed into functional foods because they have historically been consumed as food and medicine in several regions of the world. Many studies have reported the bioactive chemical content of banana peels and their associated biological activities, which seem to provide a rationale for the proposed use of banana peels in several food industries (Zaini et al., 2022). Banana peels show great potential to be developed into functional foods and beneficial nutraceuticals (Zaini et al., 2022). Functional foods are foods that are consumed as part of a normal diet and contain active components that have the potential to improve health or reduce the risk of acquiring particular diseases (Wahyuni et al., 2023).

Banana peels contain nutrients and phytochemicals that are beneficial in obesity management. Our previous research (Devina et al., 2023-2025) reported that raja banana peel contains carbohydrates, fat, protein, crude fiber, minerals, and water. We also detected quercetin, a phytochemical compound with a positive effect on weight management. However, the chrysin compound, which is thought to also play a role in obesity, was not detected and may play a role in reducing body weight in obese mouse models.

Isolation of active substances in banana peels involves the solvent extraction method by separating the chemical components of a mixture using a solvent or assay solution (Cegledi et al., 2024). Therefore, the use of the appropriate solvent significantly affects the yield of extracts. Chrysin and quercetin are flavonoid compounds. Previous research shows that an effective solvent for dissolving flavonoid compounds is ethanol with a concentration of 50-80% (Hakim & Saputri, 2020). Another solvent that can dissolve flavonoid compounds is acetone. A previous study reported that extraction with 80% acetone solvent with 5x re-maceration resulted in a higher yield compared to extraction with n-hexane and ethyl acetate solvents (Zirconia et al., 2015).

The selection of extraction methods must consider the nature and characteristics of the compounds being sought because the extraction method affects both physical properties and the stability of the resulting products. One simple extraction method is the cold extraction method, namely maceration (Nurmawati et al., 2022). Maceration is a process of extracting bioactive compounds from plant materials by soaking them in a suitable solvent at room temperature, usually with occasional stirring over a certain period (Zhang et al., 2018).

Due to the high prevalence of obesity and the limited research on the use of agricultural by-products for obesity treatment, this preliminary study aimed at evaluating potential anti-obesity properties in ethanol and acetone extracts of raja banana peels. A solvent that facilitates the optimum yield of nutrients and phytochemicals will be used in a subsequent study to investigate the effect of banana peel extract on obese rats.

Methods

This study used ripened raja banana peels obtained from a fruit seller in Klaten City, Central Java, Indonesia. Ethanol and acetone solvents were purchased from a local supplier (CV De Access). Standard chrysin (Sigma

Aldrich-C80105) and quercetin (TCI-P0042) were used for identifying the bioactive compounds in ethanol and acetone extracts of raja banana peels.

The flour from raja banana peels from our previous study (Devina et al., 2023-2025) was used during extract preparation for this present study. The extraction process itself was slightly different from the method used by Devina et al. (2023). The modifications include the use of ethanol and acetone solvents as suggested by Aboul-Enein et al. (2016), as well as an increase in the number of repeated macerations to five times, while our previous study used methanol and performed only two macerations. The extraction process was carried out at the Phytochemical Laboratory, Universitas Setia Budi, Surakarta. In brief, 800g of banana peel flour was soaked in 8L of 80% ethanol or acetone with a 1:10 ratio for three days. After that, the filtrates were re-dissolved 4 times in the same solvent with 1:8, 1:6, 1:4, and 1:2 ratios for two days to obtain a clear extract. The use of a gradual solvent ratio starting from 1:10 to 1:2 was due to efficiency and optimization of solvent use as well as to avoid solvent saturation. In the early stages, more solvents were used to extract very soluble compounds. Then, in the next stage with less solvent, we targeted the remaining active compounds that may not have been fully extracted. This solvent usage ratio is modified from Devina et al. (2023), which uses solvent ratios of 1:10, 1:5, and 1:3, and from Silmi et al. (2023), which uses solvent ratios of 1:8 and 1:6. The first to the fifth filtrates were mixed and concentrated using a rotary evaporator at 80 rpm and 80^{0}C. Finally, the extract was dried using an oven at 45-50^{0}C, resulting in a thick extract. The extracts were stored in the refrigerator at 4^{0}C before further analysis.

There are several analytical methods used to measure the nutritional and phytochemical content of the extracts. The analysis method used to determine the water content is thermogravimetry. Mineral content is analyzed by the dry method. The Kjeldahl method was used to analyze protein content, while the Soxhlet method was used to analyze fat content. The different methods are used to determine the carbohydrate content. For measuring the levels of vitamin C, flavonoid, and tannin in the extracts, we use the spectrophotometric method with wavelengths of 271 nm, 415 nm, and 725 nm, respectively. The Folin-Ciocalteau method was performed to analyze phenol content. Anthocyanin content was analyzed by pH differential and the DPPH method was used to analyze antioxidant content. The method used to determine the content of quercetin and chrysin in banana peel extracts was High Performance Liquid Chromatography (HPLC) which refers to the previous research by Devina et al. (2023). The HPLC system consists of a cylindrical reverse-phase C18 column with dimensions of 250 mm × 4,6 mm and a particle size of 5 micrometers. The sample injection volume was 20 microliters, with a mobile phase flow rate of 1 mL/min. The mobile phase used was a mixture of acetonitrile and methanol with a ratio of 65:35 (v/v). Detection of chrysin and quercetin was carried out by using wavelengths of 369 nm and 268 nm, respectively. Each test was performed in duplicate.

The levels of nutrients and phytochemicals were reported as mean values and standard deviations. The data obtained from HPLC were presented as chromatograms and the concentrations of chrysin and quercetin were reported in mg/L. This present study has been approved by the Research Ethics Committee of the Faculty of Medicine, Sebelas Maret University (No. 247/UN27.06.11/KEP/EC/2024).

Result and Discussion

Table 1. Nutrients and phytochemicals of ethanol and acetone extracts of raja banana peels

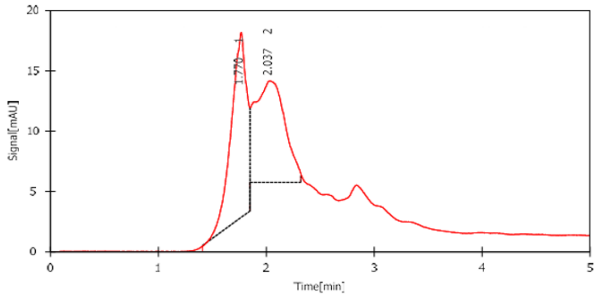
Parameter	Results	
	Ethanol extract	Acetone extract
Carbohydrate (%)	47,9 ± 0,6	25,8 ± 0,5
Protein (%)	3,5 ± 0,0	0,7 ± 0,0
Fat (%)	8,0 ± 0,4	69,6 ± 0,5
Crude fiber (%)	0,6 ± 0,0	1,5 ± 0,3
Mineral (%)	22,7 ± 0,1	0,9 ± 0,0
Water (%)	17,6 ± 0,2	2,8 ± 0,0
Vitamin C (%)	0,8 ± 0,0	0,0 ± 0,0
Flavonoids (mgQE/g)	73,3 ± 0,6	72,5 ± 0,1
Chrysin (mg/mL)	1,1 ± 0,3	0,4 ± 0,1
Phenol (%)	0,8 ± 0,0	0,9 ± 0,0
Tannin (%)	0,3 ± 0,0	0,1 ± 0,0
Anthocyanin (ppm)	474,7 ± 36,0	2019,0 ± 14,8
Antioxidant (% inhibition)	81,3 ± 1,6	88,8 ± 0,5

The extraction of raja banana peel yielded 34,2% ethanol extract and 26,8% acetone extract. The results of nutritional and phytochemical analyses are presented in Table 1. It can be seen

that the ethanol extract contains higher levels of carbohydrates, protein, minerals, water, vitamin C, flavonoids, and tannin compared to the acetone extract. In contrast, the acetone extract has higher levels of fat, crude fiber, phenol, anthocyanin, and antioxidant compared to the ethanol extract.

Figure 1, shows the results of HPLC analysis of chrysin in ethanol and acetone extracts of raja banana peels compared to the standard chrysin chromatogram. In the ethanol and acetone extracts of raja banana peel, there were several chromatogram peaks and the chrysin peaks appeared at a retention time of 2,037 in Figure 1a and 2,063 in Figure 1b. Those peaks were close to the retention time of the chrysin standard peak; i.e., 2,067 minutes (Figure 1c). The concentration of chrysin in the extracts is calculated using the linear regression formula generated from the standard curve; i.e, y = 89,9x + 35,1 (Figure 1d), with y representing the area undercurve and x representing the concentration of chrysin. By using this formula, it can be determined that ethanol and acetone extracts of raja banana peels contain 1,1 mg/mL and 0,4 mg/mL of chrysin, respectively.

The results from HPLC did not show any peak indicating the presence of quercetin in the ethanol or acetone extracts of raja banana peel (Figure 2a and 2b). Figure 2c shows that there is a chromatogram peak in the standard quercetin with a retention time of 3,283 minutes. Thus, the levels of quercetin in both extracts were not calculated.



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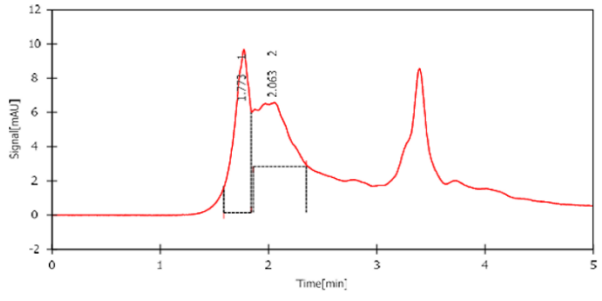

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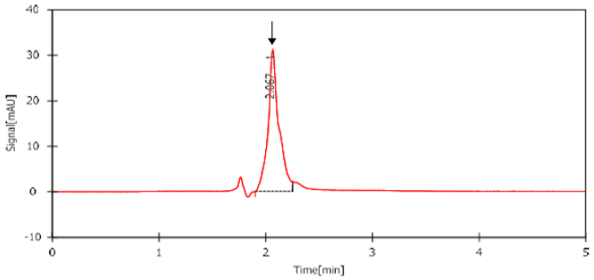

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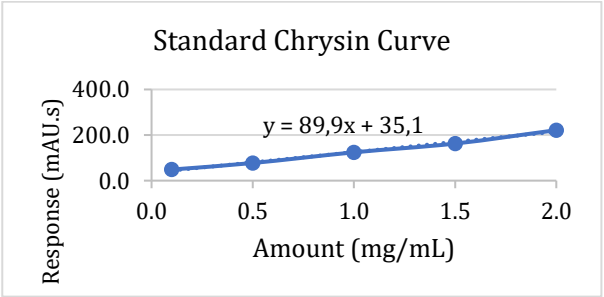

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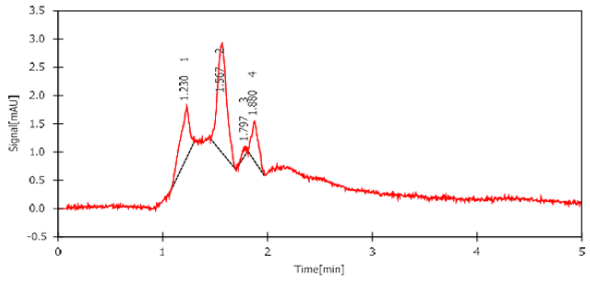
Figure 1. Chrysin chromatogram of (a) the ethanol extract and (b) the acetone extract of raja banana peel, (c) chromatogram of standard chrysin, and (d) chrysin standard curve.



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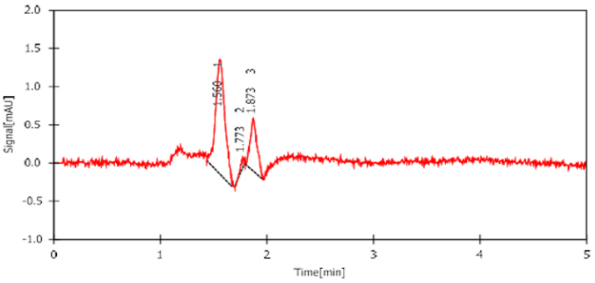

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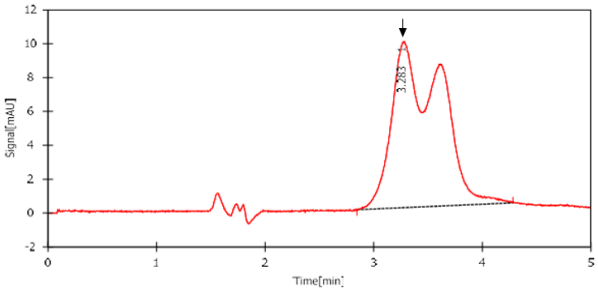

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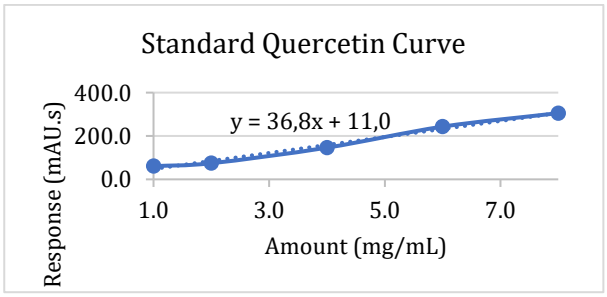

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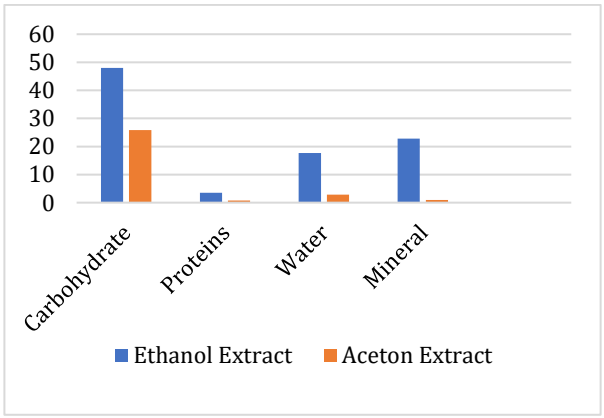
Figure 2. Chromatograms of ethanol (a) and acetone (b) extracts of raja banana peels did not show quercetin peaks, chromatogram of standard quercetin (c), and quercetin standard curve (d).

Overall, the nutritional and phytochemical contents were higher in the ethanol extract than that in the acetone extract (Figure 3). In the present study, the yield of ethanol and acetone extracts of raja banana peels is higher than that in previous research using the same method and solvents; i.e., 34,2% and 26,8% *vs* 24,2% and 25,7% (Gultom et al., 2020). Our present study shows that the carbohydrate content in ethanol extract was higher than that in acetone extract but lower than that in our previous study (Devina et al., 2023). Banana peels contain complex carbohydrates that have promising effects on weight loss, which may be associated with improving host metabolism by regulating gut flora (Fu et al., 2021). The protein content in the ethanol extract is higher than that in the acetone extract and also higher than that in the previous study (Devina et al., 2023).

Another previous study reported that banana peels contain all essential amino acids, such as lysine (7,2%), isoleucine (6,9%), leucine (5,9%), and threonine (5,8%), which play an important role in supporting muscle growth, increasing metabolism, and controlling body weight (Angelis, 2025). Banana peels show a protein content that is not high but of good quality in terms of essential amino acids (Angelis, 2025). The fat content in acetone extract is higher than that in the ethanol extract and higher than that in the methanol extract (Devina et al., 2023). The high level of fat in the acetone extract in this present study is attributable to acetone which is a non-polar solvent; thus, it can dissolve lipids optimally. A previous review reported that banana peels have >40% of total fatty acids derived from polyunsaturated fatty acids, such as α-linolenic acid and linoleic acid (Wani & Dhanya, 2025). Linoleic acid can increase metabolism and reduce fat levels in the liver and linolenic acid can reduce inflammation in obesity (Wani & Dhanya, 2025). The limitation of our study is that there is no supporting data for specific fat in the acetone extract.



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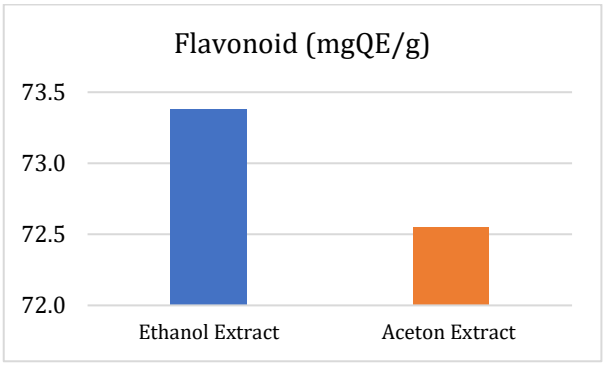

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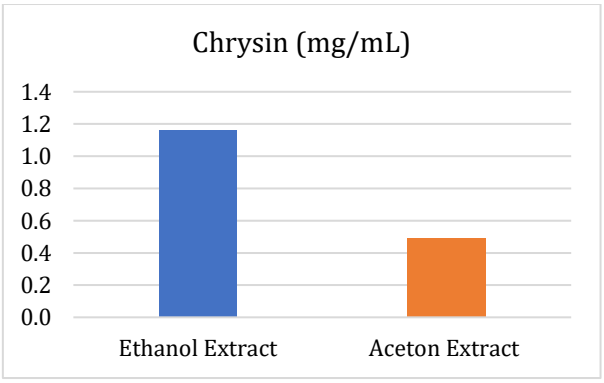

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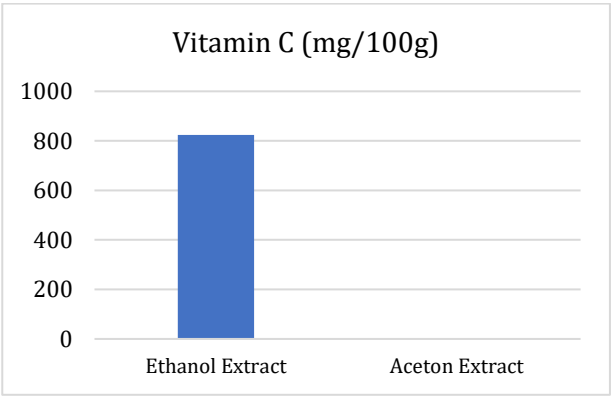

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Figure 3. Comparison of nutrients and phytochemicals of raja banana peel extracts: (a) nutritional content (%), (b) flavonoid (mg QE/g), (c) chrysin (mg/L), and (d) vitamin C (mg/100g).

The crude fiber in the acetone extract is higher than that in the ethanol extract and higher than that in the methanol extract (Devina et al., 2023). Banana peels contain high dietary fiber (40–50%). This fiber consists of insoluble fiber (30–45%), such as cellulose and lignin, which helps increase stool volume and speed up bowel movements, and soluble fiber (5–10%), such as pectin, which plays a role in stabilizing blood sugar levels and lowering cholesterol levels (Wani & Dhanya, 2025).

The level of minerals in the ethanol extract is higher than that in the acetone extract and methanol extract (Devina et al., 2023). Banana peels contain minerals such as potassium (1485 mg/100g) and magnesium (179 mg/100g) (Amini Khoozani et al., 2019). The level of water in the ethanol extract is higher than that in the acetone extract but is lower than Devina et al. (2023) study. The level of vitamin C in the ethanol extract is higher than that in the acetone extract and is higher than that in previous research using the same method and solvents (Gultom et al., 2020). The previous research reported the levels of vitamin C in ethanol and acetone extracts of white sweet potato leaf are 189,4 mg and 228,3 mg, respectively (Gultom et al., 2020). Vitamin C from fruits and vegetables can protect healthy cells from oxidative damage and act as a free radical scavenger in the body (Ji & Qiu, 2022). A previous study reported that people living with obesity have lower levels of vitamin C (Jampilek & Kralova, 2020). Antioxidants in vitamin C can reduce body weight in obese mice (Pandiangan et al., 2022). In adipocytes of obese mice, vitamin C causes a significant increase in glycerol outflow (Imessaoudene et al., 2022).

The level of flavonoid in this present study is higher than that in the Sirih Cina ethanol extract (Pratiwi et al., 2023). Flavonoids in bananas, such as quercetin, kaempferol, myricetin, and cyanidin, act as scavengers of free radicals and reactive nitrogen species (Wani & Dhanya, 2025) and show lipoxygenase inhibition which can help reduce inflammation and improve fat metabolism (Al-Khayri et al., 2022). In this study, the phenol content in the acetone extract of raja banana peel was higher (0,9%) compared to that in the ethanol extract (0,8%). Our research results are in line with the research of Aboul-Enein et al. (2016) where the phenol content in the acetone extract was higher than that in the ethanol extract. Phenol can reduce levels of inflammatory cytokines such as TNF-α, IL-6, and CRP, as well as increase the production of anti-inflammatory compounds that help reduce inflammation in obese individuals (Randenia et al., 2024).

The level of tannin in the ethanol extract was higher (0,3%) compared to that in the acetone extract (0,1%). The difference in tannin content in the ethanol and acetone extracts can be influenced by the polarity of the solvent used in the extraction process. The ethanol solvent is more effective in extracting tannins because its polarity is moderate and its solubility is good for polar compounds such as tannins. The results of this study differ from the study of Gultom et al. (2020) where the level of tannin in the ethanol extract was lower (0,7%) compared to the acetone extract (1,3%). This difference is due to the difference in samples used and the number of macerations during extraction. A review article concluded that tannins play a role in lipid metabolism by inhibiting fat accumulation, increasing fatty acid oxidation, and suppressing lipid synthesis (Marrone et al., 2024). In addition, tannins also have the potential to prevent obesity through antioxidant mechanisms.

The level of anthocyanin was higher in the acetone extract (2019,0 ppm) compared to that in the ethanol extract (474,7 ppm). The results of this study differ from another study which reported that the anthocyanin content in hibiscus flower extracted with 80% ethanol solvent is 1853,8 ppm (Agustin & Ismiyati, 2015). In addition, another study by Mulyana et al. (2024) reported that the anthocyanin content in Jawer Kotok Daun Ungu plants extracted with 80% acetone solvent is 3,6 ppm. Anthocyanin can inhibit glucose absorption, have high antioxidant activity and have a mechanism for inhibiting the α-glucosidase enzyme in the small intestine (Hardono et al., 2024). The antioxidant level in this present study is higher than that in the previous research using the same method and solvents, which reported the levels of antioxidant in ethanol and acetone extracts of white sweet potato leaf are 47,2% and 64,2% (Gultom et al., 2020). Research shows that antioxidants increase the activity of the superoxide dismutase enzyme and reduce malondialdehyde levels in the livers of hypercholesterolemic rat models by protecting cells from oxidative stress and reducing lipid peroxidation levels (Ulfa et al., 2020).

The ethanol extract contains chrysin of 1,1 mg/mL and the acetone extract contains chrysin

of 0,4 mg/mL, while the quercetin compound was not detected in both extracts. The concentration of these two compounds is different from the results of our previous study which showed that no chrysin compound was detected in the methanol extract of banana peel (Devina et al., 2025). This difference is due to the difference in solvents used and the number of macerations. Chrysin has higher solubility in ethanol and acetone solvents compared to methanol (Dong et al., 2021). In this study, 80% of ethanol and acetone solvents were used. The results of this study are in line with the study conducted by Parappa et al. (2023), which reported that ethanol is the best solvent used for the extraction of chrysin from propolis which produced the highest chrysin content of 0,085% of the sample weight. The concentration of chrysin in our study was lower than the previous study due to the differences in the types of plants and the extraction method. Chrysin inhibits adipogenesis by modulating the key adipogenic transcription factor PPARγ. Increased adipogenesis leads to obesity and targeting adipogenesis has the potential to regulate adipose tissue development (John & Arockiasamy, 2021).

Quercetin was not detected in both ethanol and acetone extracts of this present study even though our previous study had detected a quercetin compound in the methanol extract of raja banana peels with a concentration of 0,3 mg/dL (Devina et al,, 2025). The levels of quercetin content in plantain vary from 32,3 to 125,0 µg/g which is influenced by the type of solvent and the number of macerations during the extraction process (Maheshwari et al., 2022). This research is in line with the previous research by Shofia et al. (2024) which reported that the concentration of quercetin was higher in methanol extract (0,78 ppm) than in the ethanol extract (0,76 ppm) of red dragon fruit peels. Our study used 80% ethanol as a solvent, but the balance of ethanol-water polarity greatly influences the results of quercetin extraction. Research by Dwiwina et al. (2023) shows that 50% ethanol solvent was more effective in extracting quercetin from guava fruit than 70% ethanol (54,7 mg/kg *vs* 28,8 mg/kg) (Dwiwina et al., 2023).

It has been reported that quercetin helps reduce fat accumulation by inhibiting lipid synthesis and increasing fat breakdown, reducing the production of pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α, inhibiting inflammatory signaling pathways such as MAPK and NF-κB, increasing insulin sensitivity by inhibiting insulin resistance caused by inflammation, and regulating signaling pathways related to glucose metabolism, such as PPARγ and GLUT4, thereby lowering blood glucose levels. In addition, quercetin can affect the balance of intestinal microflora, which plays a role in lipid metabolism and weight regulation (Wang et al., 2024). Our previous research found that there was a decrease in body weight and body fat percentage in obese mice, which is thought to be due to the quercetin content in banana peel extract which inhibits pancreatic lipase and lipogenesis (Devina et al., 2024).

Ethanol is a more efficient solvent than acetone, yielding higher levels of nutrients and phytochemicals. The limitation of this study is that it can only calculate the concentration of chrysin, but it has not been able to calculate the concentration of quercetin. This is due to the difference in the type of solvent needed to extract the two compounds. Methanol solvents are only able to extract quercetin compounds, while ethanol and acetone solvents are more effective in extracting chrysin compounds. Therefore, further research is recommended to use each solvent separately to obtain both compounds optimally and test the effects of raja banana peel extract in vivo or in vitro.

Conclusion

The ethanol extract of raja banana peels contains higher carbohydrates, protein, minerals, water, vitamin C, flavonoids, chrysin and tannin than the acetone extract. Therefore, the ethanol extract of raja banana peel has the potential to be developed as a nutraceutical for obesity treatment.

Further research is needed to determine the specific carbohydrate, protein, fat, and mineral contents and to analyze the specific active compounds in the ethanol extract of raja banana peel that serve as anti-obesity properties. Raja banana peel extract can be an herbal plant that has potential as an alternative therapy for obesity by inhibiting pancreatic lipase. Future research is directed to investigate the use of other solvents for isolating the pure compounds of quercetin and chrysin contained in raja banana peel extract and test them *in vitro* and *in vivo*.

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