DEVELOPMENT OF THE OBESITY NUTRACEUTICAL FROM RAJA AND KEPOK BANANA PEELS

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ABSTRACT
Patients with obesity often fail to control their body weight through diet and physical activity, while the existing anti-obesity drugs have some side effects for long-term use. Banana is Indonesia's tropical fruits with the highest production, and the banana peel has become soil waste. This study aimed to analyze nutrients and active compounds of methanol extracts of raja and kepok banana peels (ERP and EKP respectively). Macro and micro-nutrient compositions of the ERP and EKP were determined using the proximate analysis, while Thin Layer Chromatography (TLC) was used to detect the ERP and EKP active compounds. The ERP contained 0.11% crude fibers, 4.44% fat, and 58.08% carbohydrates, different from the EKP (4.25% protein, 20.95% water, and 14.45% minerals). By contrast, both the ERP and EKP contained flavonoids, phenols, tannins, alkaloids, and saponins. In conclusion, ERP is potentially developed as a nutraceutical for obesity treatment in the future. Further study is needed to measure specific fat levels and to analyze specific active compounds in the ERP which can modulate gene expression and interact with protein targets in lipid metabolism.

Keywords: active compound; nutraceutical; obesity; raja and kepok banana peels

INTRODUCTION
Lockdown during the COVID-19 pandemic has affected people's lifestyles, such as decreasing physical activity, and increasing consumption of high-calorie and high-energy foods, resulting in fat accumulation in body tissues. This has increased body weight and the prevalence of obesity worldwide (Ekström *et al*., 2023; Nour and Altintaş, 2023). The prevalence of obesity is expected to continue to increase to 42% in 2025 (Lobstein *et al*., 2023). Obesity can increase morbidity and mortality rates because obesity is associated with the occurrence of metabolic syndrome diseases such as diabetes mellitus and cardiovascular disease (Lin and Li, 2021). Obesity therapy can be done through non-pharmacological therapy and pharmacological therapy. Non-pharmacological therapies such as dietary adjustments and increased physical activity often cannot reduce weight in obese patients, so pharmacological therapy is needed (Ruban *et al*., 2019). Synthetic drugs for the treatment of obesity, which are consumed for a long time, can cause side effects such as insomnia, headaches, and gastrointestinal diseases (Tchang *et al*., 2021). Therefore, natural ingredients are needed that can be used as alternative therapies for obesity (Lin and Li, 2021).

Banana plants are one of the tropical fruits in Indonesia with the highest production level and there are 15 varieties of *Musa acuminate* and 200 local cultivars spread throughout Indonesia (Badan Pusat Statistik, 2021). The type of banana that is most widely sold and consumed by the people of Indonesia is the raja (*Musa acuminate x balbisiana* AAB Group) and kepok (*Musa acuminate x balbisiana* ABB Group) (Poerba *et al*., 2016). Banana consists of 60% flesh and 40% peel so the amount of banana peel waste is quite abundant. Banana peels are not used optimally because they are generally only used as animal feed, fertilizer, or thrown away (Acevedo *et al*., 2021). Several previous studies have stated that banana peels are useful for treating hyperlipidemia and hypercholesterolemia (Bagabaldo *et al*., 2022; Samiasih *et al*., 2019).

The content of active compounds that have the potential as anti-obesity in banana peels can be separated through extraction. Extraction is the process of separating the active compounds contained in plant parts using certain solvents. One of the extraction methods is maceration (Abubakar and Haque, 2020). The right type of solvent in maceration can produce active compounds more optimally and prevent the formation of unwanted compounds (Zhang *et al*., 2018). The reason that underlies the researchers are the increasing prevalence of obesity and no research that has detected the nutritional content and active compounds in the methanol extract of raja peel (ERP) and kepok (EKP) which can act as anti-obesity. Therefore, this study aims to analyze the nutritional content and active compounds in ERP and EKP.

METHOD

This type of research was laboratory experimental, carried out in 3 stages: banana peel extraction, phytochemical screening, and proximate analysis. The extract was made at the Phytochemical Laboratory, Universitas Setia Budi, Surakarta. Phytochemical screening was carried out at the Integrated Research and Testing Laboratory, Universitas Gadjah Mada, Yogyakarta. Proximate analysis was carried out at the Food Technology Laboratory, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta. The reagents used in this study were 80% methanol, sodium thiosulfate ($Na_2S_2O_3$), ethanol, H_2SO_4 2N, chloroform, quercetin standard, ferric chloride ($FeCl_3$), dragendorff reactor, diethyl ether, concentrated sulfuric acid, the catalyst of HgO + K_2SO_4, NaOH-thiosulfate, saturated boric acid, 0.1N HCl, MB-MR indicator (Methylene Blue + Methyl Red), H_2SO_4 0.255N, NaOH 0.313N, K_2SO_4 10%, and 95% alcohol. This study used raja and kepok peels which were ripe and yellow. Banana peels were obtained from a fruit seller in Klaten City.Banana skin that had been selected, was then washed and cut into smaller sizes. The piece was immersed in $Na_2S_2O_3$ to inhibit the oxidation process, then dried using a cabinet dryer with a temperature of 80^oC for 8 hours. The dried banana peels were then ground into flour (Maulana, 2018). Extract preparation was carried out by modifying the maceration method developed from the research of Aboul-Enein *et al* (2016). A total of 1 kg of banana peel flour was soaked in 10 liters of methanol 80% (1:10) for three days in a closed container. The banana peel solution was filtered using filter paper to obtain the filtrate. The residue was redissolved with methanol 80% (1:5) for two days, then filtered to obtain the filtrate. The residue was redissolved with methanol 80% (1:3) for two days and filtered as before. The filtrate from the first, second, and third screening was mixed and concentrated using a rotary evaporator at 80 rpm at 80^oC, then dried using an oven with a temperature of 45-50^oC until a thick extract was obtained (Aboul-Enein *et al*., 2016).

The method used for phytochemical screening was Thin Layer Chromatography (TLC). The content of flavonoids in the extract was detected using standard quercetin. $FeCl_3$ was used to detect phenolic content. Saponin content was detected using H_2SO_4 2N. Dragendorff was used to detect alkaloids. Ethanol 20% and $FeCl_3$ were used to detect tannins. Crude fiber content was analyzed using a strong acid-base hydrolysis method. Kjeldahl method was used to analyze protein content, while the Soxhlet method was used to analyze fat content. Water content was analyzed using the Thermogravimetric method. Mineral content was analyzed using the dry method. Carbohydrate levels were analyzed using the method by the difference obtained through the reduction of 100% minus protein, fat, water, and minerals levels.

RESULTS AND DISCUSSION

This study used the maceration method as an extraction method because the process was straight forward, easy, and the cheapest (Azwanida, 2015; Tambun *et al*., 2021). The extraction solvent used in this study was methanol 80%. Methanol is a polar solvent that can dissolve polar compounds such as phenol groups. Methanol has a –OH group (polar) and a -CH3 group (non-polar), so methanol is also non-polar (Mustofa *et al*., 2021). Based on previous studies, 80% methanol solvent was able to extract active compounds more optimally in banana peel extract when compared to water, ethanol 80% and acetone 80% (Aboul-Enein *et al*., 2016).

In this study, remaceration was also carried out twice with the aim of getting the remaining active compounds that were still left behind during the first screening process. The filtrate obtained was then concentrated using a rotary evaporator to separate active compounds from solvents (Tambun *et al*., 2021). The concentration results were calculated to determine the amount of extract yield. In this study, the yield of ERP was higher (39.5%) compared to EKP (36.6%). The yield produced from the maceration process was higher when compared to other extraction processes. The high yield was also caused by the length of the maceration and remaceration processes carried out. The long maceration time caused the membranes and cell walls to be damaged so that many active compounds were dissolved. In addition, remaceration caused the amount of filtrate produced to increase so that it could increase the amount of yield (Hasnaeni *et al*., 2019). ERP and EKP had a denser consistency in the form of a paste.

Table 1.
Rendement of ERP and EKP using the maceration method

Sample	Simplicia (g)	Extract (g)	Yield (%)	Consistency
ERP	1,000	395	39.5	Paste
EKP	1,000	366	36.6	Paste

All parts of natural materials such as fruit, peel, flowers, leaves, and stems, contain different active compounds. Table 2 shows ERP and EKP contained flavonoids, phenols, tannins, alkaloids, and saponins. Flavonoids are polyphenolic compounds divided into six categories: flavones, flavanones, flavonols, isoflavonoids, flavanols or catechins, and anthocyanins (Panche *et al*., 2016). Flavonoids could reduce body weight through several mechanisms such as reducing food intake, inhibiting pancreatic lipase, thereby reducing fat absorption in the intestine, could stimulate energy expenditure by inducing thermogenesis, modulating adipocyte differentiation, adipogenesis, apoptosis, and lipolysis. In addition, flavonoids could reduce the impact of intestinal microbiota dysbiosis, which could cause obesity (Rufino *et al.*, 2021; Song *et al*., 2019). Phenol is an active compound such asp-coumaric, caffeic acid, ferulic acid, cinnamic acid, ellagic, dan p-hydroxybenzoic acid, which are involved in energy metabolism, adiposity, and act as anti-obesity. Phenol has hypolipidemic, hypocholesterolemic and hypoglycemic effects. In addition, phenol can inhibit cell growth through increasing apoptosis (Sharma T and Kanwar SS, 2018). Previous studies have shown that tannins could lower cholesterol, triglyceride, LDL, and increase HDL levels in obese rats. In addition, tannins could reduce ghrelin activity, which regulates hunger to regulate food intake and reduce body weight (Manzoor *et al*., 2021; Panche *et al*., 2016). Alkaloid mechanisms in losing weight include suppressing lipogenesis, suppressing leptin expression, and sterol regulatory element-binding protein-1c (SREBP-1c). In addition, alkaloids could reduce fat mass due to decreased glucose absorption resulting in increased utilization of fat reserves in the body (Huang *et al*., 2017; Sharma T and Kanwar SS, 2018).

Saponins have been shown to have anti-obesity activity by inhibiting fat absorption in the intestine, reducing appetite, and inhibiting pancreatic lipase. In the intestine, fat will be excreted along with the feces so that the fat in the stool will increase while the fat in the blood will decrease (Bogoriani *et al*., 2019). Saponins can also reduce the expression of neuropeptide Y (NPY) in the hypothalamus so that it can reduce appetite (Marrelli *et al*., 2016).

Table 2.
Phytochemical content of ERP and EKP

Chemical compound	ERP	EKP
Flavonoids	+	+
Phenols	+	+
Tannins	+	+
Alkaloids	+	+
Saponins	+	+

+ : detected

The active compounds contained in ripe and yellow banana peels are higher when compared to unripe banana peels (Borges *et al*., 2020). The ripeness level of banana peels also affects the macro and micronutrient content. Ripe and yellow banana peels contain higher crude fiber, protein, fat, and minerals when compared to unripe or green banana peels and banana peels that are too ripe or brown (Yan *et al*., 2016). Therefore, this study used banana peels that were ripe and yellow. Table 3 shows the differences in macro and micronutrients contained in ERP and EKP. The crude fiber content in ERP was higher (0.11%) than in EKP (0.045%). Previous research said crude fiber can reduce cholesterol and LDL levels (Reynolds *et al*., 2020). The protein content in ERP was lower (3.46%) than in EKP (4.25%). The results of this study were lower when compared to the research by Acevedo *et al*. (2021), which stated that the protein content in banana peels was 4.77%. The difference in results may be due to the different types of banana peels studied. Protein comparises various amino acids, and in raja banana peel contains essential amino acids such as leucine and lysine, which can play a role in weight loss (Khawas and Deka, 2016).

The fat content was higher in ERP (4.44%) than in EKP (3.83%). The results of this study aligned with the research of Zaini *et al.* (2022), which stated that the fat content in banana peels ranges from 2.24-11.6%. Fat in banana peels consists of unsaturated fatty acids such as linoleic acid and linolenic acid, which have anti-inflammatory effects on obesity (Khawas and Deka, 2016). The carbohydrate content was higher in ERP (58.08%) than in EKP (56.52%). The results of this study were higher than those of Romelle *et al*. (2016), which showed that the carbohydrate content in banana peels was 43.40%. This difference in results was due to the different types of bananas studied. Carbohydrates in banana peel like resistant starch have been shown to reduce weight by improving the composition of gut microbiota (Johnstone *et al*., 2020). The water content in ERP is slightly lower (20.67%) than in EKP (20.95%). The results of this study are not much different from the research of Oyeyinka and Afolayan (2019), which stated that the water content in banana peels was 20.87-21.81%. Minerals in ERP were lower (13.35%) than in EKP (14.45%). Previous research said banana peels contain many minerals such as magnesium, calcium, potassium, and phosphorus. Minerals play a role in carbohydrate and fat metabolism, which can increase muscle mass and reduce fat accumulation in the body (Chu *et al*., 2023; Zou *et al*., 2022). Our limitations are no supporting data for quantification of phytochemical content.

Table 3.
Proximate composition of ERP and EKP

Components	Composition (%wb)	
	ERP	EKP
Crude fiber	0.11	0.045
Protein	3.46	4.25
Fat	4.44	3.83
Carbohydrate	58.08	56.52
Water	20.67	20.95
Mineral	13.35	14.45

wb: wet basis

CONCLUSION

ERP and EKP contain flavonoids, phenols, tannins, alkaloids, and saponins. However, ERP contains better macro and micronutrients when compared to EKP. ERP contains higher crude fiber, fat, and carbohydrates than EKP. Therefore, ERP has the potential to be developed as a nutraceutical for the treatment of obesity in the future. Further research is needed to measure specific lipid content and analyze specific active compounds in ERP that can modulate genes and interact with protein targets in lipid metabolism.

REFERENCES

Aboul-Enein, A. M., Salama, Z. A., Gaafar, A. A., Aly, H. F., Bou-Elella, F. A., & Ahmed, H. A. (2016). Identification of phenolic compounds from banana peel (Musa paradaisica L.) as antioxidant and antimicrobial agents. Journal of Chemical and Pharmaceutical Research, 8(4), 46–55. www.jocpr.com

Abubakar, A., & Haque, M. (2020). Preparation of Medicinal Plants: Basic Extraction and Fractionation Procedures for Experimental Purposes. Journal of Pharmacy and Bioallied Sciences, 12(1), 1–10. https://doi.org/10.4103/jpbs.JPBS

Acevedo, S. A., Carrillo, A. J. D., Lopez, E. F., & Grande-Tovar, C. D. (2021). Recovery of Banana Waste-Loss from Production and Processing: A Contribution to a Circular Economy. Molecules (Basel, Switzerland), 26(17), 1–32. https://doi.org/10.3390/molecules26175282

Azwanida. (2015). A Review on the Extraction Methods Use in Medicinal Plants, Principle, Strength and Limitation. Medicinal & Aromatic Plants, 04(03), 3–8. https://doi.org/10.4172/2167-0412.1000196

Badan Pusat Statistik. (2021). Produksi Tanaman Buah-buahan 2021. https://www.bps.go.id/indicator/55/62/1/produksi-tanaman-buah-buahan.html

Bagabaldo, P. A. A., Atienza, L. M., Castillo-Israel, K. A. T., Estacio, M. A. C., Gaban, P. J. V., Maniwang, J. R. C., Gapasin, R. P., Estribillo, A. G. M., & Cena-Navarro, R. B. (2022). ‘Saba’ banana (Musa acuminata x balbisiana BBB Group) peel pectin supplementation improves biomarkers of obesity and associated blood lipid disorders in obese hypercholesterolemic mice. Current Research in Food Science, 5, 251–260. https://doi.org/10.1016/j.crfs.2022.01.016

Bogoriani, N. W., Laksmiwati, A. A. I. M., Putra, A. A. B., Heltyani, W. E., Lestari, K. D. P., & Mahayani, P. A. E. (2019). Saponins role of Bali Andong leaf as antiobesity in rats. International Journal of Pharmaceutical Research, 11(2), 382–389. https://doi.org/10.31838/ijpr/2019.11.02.052

Borges, C. V., Maraschin, M., Coelho, D. S., Leonel, M., Gomez, H. A. G., Belin, M. A. F., Diamante, M. S., Amorim, E. P., Gianeti, T., Castro, G. R., & Lima, G. P. P. (2020). Nutritional value and antioxidant compounds during the ripening and after domestic cooking of bananas and plantains. Food Research International, 132(109061), 1–11. https://doi.org/10.1016/j.foodres.2020.109061

Chu, N., Chan, T. Y., Chu, Y. K., Ling, J., He, J., Leung, K., Ma, R. C. W., Chan, J. C. N., & Chow, E. (2023). Higher dietary magnesium and potassium intake are associated with lower body fat in people with impaired glucose tolerance. Frontiers in Nutrition, 10, 1–8. https://doi.org/10.3389/fnut.2023.1169705

Ekström, S., Andersson, N., Kull, I., Georgelis, A., Ljungman, P. L. S., Melen, E., & Bergstrom, A. (2023). Changes in lifestyle, adiposity, and cardiometabolic markers among young adults in Sweden during the COVID-19 pandemic. BMC Public Health, 23(1026), 1–11. https://doi.org/10.1186/s12889-023-15998-w

Hasnaeni, Wisdawati, & Usman, S. (2019). Pengaruh Metode Ekstraksi Terhadap Rendemen Dan Kadar Fenolik Ekstrak Tanaman Kayu Beta-Beta (Lunasia amara Blanco). Jurnal Farmasi Galenika (Galenika Journal of Pharmacy) (e-Journal), 5(2), 175–182. https://doi.org/10.22487/j24428744.2019.v5.i2.13149

Huang, L., Li, D., Xu, Y. S., Feng, Z. L., Meng, F. C., Zhang, Q. W., Gan, L. S., & Lin, L. G. (2017). Clausoxamine, an alkaloid possessing a 1,3-oxazine-4-one ring from the seeds of: Clausena lansium and the anti-obesity effect of lansiumamide B. RSC Advances, 7, 46900–46905. https://doi.org/10.1039/c7ra09793j

Johnstone, A. M., Kelly, J., Ryan, S., Romero-Gonzalez, R., McKinnon, H., Fyfe, C., Naslund, E., Lopez-Nicolas, R., Bosscher, D., Bonnema, A., Frontela-Saseta, C., Ros-Berruezo, G., Horgan, G., Ze, X., Harrold, J., Halford, J., Gratz, S. W., Duncan, S. H., Shirazi-Beechey, S., & Flint, H. J. (2020). Nondigestible Carbohydrates Affect Metabolic Health and Gut Microbiota in Overweight Adults after Weight Loss. The Journal of Nutrition: Nutrient Requirements and OPtimal Nutrition, 150(7), 1859–1870. https://doi.org/10.1093/jn/nxaa124

Khawas, P., & Deka, S. C. (2016). Comparative Nutritional, Functional, Morphological, and Diffractogram Study on Culinary Banana (Musa ABB) Peel at Various Stages of Development. International Journal of Food Properties, 19(12), 2832–2853. https://doi.org/10.1080/10942912.2016.1141296

Lin, X., & Li, H. (2021). Obesity: Epidemiology, Pathophysiology, and Therapeutics. Frontiers in Endocrinology, 12(September), 1–9. https://doi.org/10.3389/fendo.2021.706978

Lobstein, T., Jackson-leach, R., Powis, J., Brinsden, H., & Gray, M. (2023). World Obesity Atlas 2023. World Obesity Federation. https://data.worldobesity.org/publications/?cat=19

Manzoor, F., Nisa, M. U., Hussain, H. A., Khan, M. K., Ahmad, R. S., Ahmad, N., Imran, M., & Umbreen, H. (2021). Effect of hydrolysable tannin on nutrient intake obesity and other associated metabolic risk factors in polycystic rats. Translational Medicine Communications, 10, 1–18. https://doi.org/10.1186/s41231-021-00089-y

Marrelli, M., Conforti, F., Araniti, F., & Statti, G. A. (2016). Effects of saponins on lipid metabolism: A review of potential health benefits in the treatment of obesity. Molecules, 21(1404), 1–20. https://doi.org/10.3390/molecules21101404

Maulana, I. C. (2018). Pengolahan Tepung Limbah Kulit Pisang Raja Sebagai Bahan Alternatif Pengganti Tepung Terigu Dalam Proses Pembuatan Mi. Fkip Uns.

Mustofa, S., Utama, R. A. N. A., Syachrani, F., Rosti, N. Y., & Lenka, P. R. (2021). Efek Antidislipidemia Ekstrak Kulit Pisang Kepok Lampung (Musa paradisiaca L) Terhadap Kadar Kolesterol Total dan Trigleserida Tikus Putih Dengan Diet Tinggi Lemak Antidyslipidemic Effects of Kepok Banana Peel Extract (Musa paradisiaca L) Against Tota. Jurnal Kedokteran Universitas Lampung, 5(1), 35–44.

Nour, T. Y., & Altintaş, K. H. (2023). Effect of the COVID - 19 pandemic on obesity and it is risk factors : a systematic review. BMC Public Health, 23(1018), 1–24. https://doi.org/10.1186/s12889-023-15833-2

Oyeyinka, B. O., & Afolayan, A. J. (2019). Comparative evaluation of the nutritive, mineral, and antinutritive composition of musa sinensis l. (banana) and musa paradisiaca l. (plantain) fruit compartments. Plants, 8(598), 1–14. https://doi.org/10.3390/plants8120598

Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: An overview. Journal of Nutritional Science, 5(e47), 1–15. https://doi.org/10.1017/jns.2016.41

Poerba, Y. S., Martanti, D., Handayani, T., Herlina, & Witjaksono. (2016). Katalog Pisang - Koleksi Kebun Plasma Nutfah Pisang Pusat Penelitian Biologi Lembaga Ilmu Pengetahuan Indonesia. In Lembaga Ilmu Pengetahuan Indonesia. LIPI Press.

Reynolds, A. N., Akerman, A. P., & Mann, J. (2020). Dietary fibre and whole grains in diabetes management: Systematic review and meta-analyses. PLoS Medicine, 17(3), 1–22. https://doi.org/10.1371/journal.pmed.1003053

Romelle, F. D., P., A. R., & Manohar, R. S. (2016). Chemical Composition of Some Selected Fruit Peels. European Journal of Food Science and Technology, 4(4), 12–21. https://doi.org/10.1016/S0140-6736(13)61836-X

Ruban, A., Stoenchev, K., Ashrafian, H., & Teare, J. (2019). Current treatments for obesity Authors: Clinical Medicine, 19(3), 205–212. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6542229/pdf/clinmed-19-3-205.pdf

Rufino, A. T., Costa, V. M., Carvalho, F., & Fernandes, E. (2021). Flavonoids as antiobesity agents: A review. Medicinal Research Reviews, 41(1), 1–30. https://doi.org/10.1002/med.21740

Samiasih, A., Subagio, W. H., Dharmana, Susanto, H., Sadhana, U., Sunoko, H. R., & Santosa, B. (2019). Banana peels extract (Musa Paradisiaca Var Kepok) decreased MDA in New Zealand White Rabbit with DM hyperlipidemia. IOP Conference Series: Earth and Environmental Science, 292(1). https://doi.org/10.1088/1755-1315/292/1/012008

Sharma T, & Kanwar SS. (2018). Phytomolecules for Obesity and Body Weight Management. Journal of Biochemistry and Cell Biology, 1(1), 1–8.

Song, D., Cheng, L., Zhang, X., Wu, Z., & Zheng, X. (2019). The modulatory effect and the mechanism of flavonoids on obesity. Journal of Food Biochemistry, 43(8), 1–13. https://doi.org/10.1111/jfbc.12954

Tambun, R., Alexander, V., & Ginting, Y. (2021). Performance comparison of maceration method, soxhletation method, and microwave-assisted extraction in extracting active compounds from soursop leaves (Annona muricata): A review. IOP Conference Series: Materials Science and Engineering, 1122(1), 012095. https://doi.org/10.1088/1757-899x/1122/1/012095

Tchang, B. G., Saunders, K. H., & Igel, L. I. (2021). Best Practices in the Management of Overweight and Obesity. Medical Clinics of North America, 105(1), 149–174. https://doi.org/10.1016/j.mcna.2020.08.018

Yan, L., Fernando, W. M. A. D. B., Brennan, M., Brennan, C. S., Jayasena, V., & Coorey, R. (2016). Effect of extraction method and ripening stage on banana peel pigments. International Journal of Food Science and Technology, 51, 1449–1456. https://doi.org/10.1111/ijfs.13115

Zaini, H., Roslan, J., Saallah, S., Munsu, E., Sulaiman, N. S., & Pindi, W. (2022). Banana peels as a bioactive ingredient and its potential application in the food industry. Journal of Functional Foods, 92(105054), 1–12. https://doi.org/10.1016/j.jff.2022.105054

Zhang, Q. W., Lin, L. G., & Ye, W. C. (2018). Techniques for extraction and isolation of natural products: A comprehensive review. Chinese Medicine (United Kingdom), 13(1), 1–26. https://doi.org/10.1186/s13020-018-0177-x

Zou, F., Tan, C., Zhang, B., & Shang, N. (2022). The Valorization of Banana By-Products: Nutritional and Future Development. Foods, 11. https://doi.org/10.3390/foods11203170