IJPST
Indonesian Journal of Pharmaceutical Science and Technology

Research Article
Vol. 13 No. 1 (2026): 17-24
https://doi.org/10.24198/ijpst.v13i1.63013

Formulation and Anti-Hypertensive Activity of Ambon Banana Peel Foam Mat Drying Granules as a Nutraceutical

Ibrahim Arifin[1], Khoirul Anwar[1], Danang N Wibowo[2], Ayu Shabrina[2*], Muhammad S Amirudin[3], Wahyu Kumalasari[3], Anastasya Angelita[3], Sri Mastuti[4], and Dian Inayati[4]

[1]Department of Chemical Pharmacy, Faculty of Pharmacy, Universitas Wahid Hasyim, Semarang, Indonesia
[2]Department of Pharmaceutics and Pharmaceutical Technology, Faculty of Pharmacy, Universitas Wahid Hasyim, Semarang, Indonesia
[3]Undergraduate Program Study, Faculty of Pharmacy, Universitas Wahid Hasyim, Semarang, Indonesia
[4]Faculty of Medicine, Universitas Wahid Hasyim, Semarang, Indonesia

Abstract

Ambon banana peel (ABP) is rich in phenolic compounds yet unstable to light and heat. Foam-mat drying (FMD) protects bioactive components and facilitates the development of nutraceutical products. This study aimed to formulate and evaluate FMD granules containing ABP for their antioxidant and antihypertensive activities. Granules were prepared with ABP at 1% (F1), 2.5% (F2), and 5% (F3) w/w, combined with 6% Tween-80 and 15% maltodextrin, dried at 40 °C for 60 min, and blended with excipients. Physical characteristics, pH, flowability, and antioxidant activity (ABTS assay) were assessed. Antihypertensive effects were tested in Wistar rats induced with 2% NaCl and treated orally for 14 days; captopril (5 mg/kg BW) served as a positive control. Data were analyzed by one-way ANOVA. All formulations produced free-flowing granules with a moisture content <2% and a dissolution time <5 min. Antioxidant inhibition increased with ABP content, with F3 showing the highest activity (71.3 ± 1.4%). F3 also achieved the greatest reductions in systolic (≈31%) and diastolic (≈39%) blood pressure, approaching the effect of captopril. Moreover, F3 exhibits strong antioxidant activity and significant antihypertensive effects, indicating potential as a sustainable nutraceutical for the management of hypertension. Further studies on product stability and clinical efficacy are warranted.

Keywords: anti-hypertension, antioxidant, banana peel, foam mat-drying, nutraceutical

Article History:
Submitted 24 April 2025
Revised 23 September 2025
Accepted 12 November 2025
Published 28 February 2026

*Corresponding author:
shabrina@unwahas.ac.id

Citation:
Arifin I, Anwar K, Wibowo DN, Shabrina A, Amirudin MS, Kumalasari W, et al. Formulation and Anti-Hypertension Activity of Ambon Banana Peel Foam Mat Drying Granules as a Nutraceutical. Indonesian Journal of Pharmaceutical Science and Technology. 2026: 13 (1), 17-24.

Formulasi dan Uji Aktivitas Anti-Hipertensi Granul *Foam Mat Drying* Kulit Pisang Ambon sebagai Nutrasetikal

Abstrak

Kulit pisang Ambon (ABP) mengandung senyawa fenolik yang tidak stabil terhadap cahaya dan panas tinggi, sehingga perlu dilakukan proteksi terhadap kandungannya menggunakan metode foam-mat drying (FMD). Studi ini bertujuan untuk menentukan potensi granul FMD yang mengandung ABP sebagai nutraseutikal antihipertensi. Persiapan ABPFMD dibuat dengan variasi ABP dengan konsentrasi 1% (F1), 2,5% (F2), dan 5% (F3) dalam rasio 1:1 dengan aquades dan dicampur dengan 6% Tween-80 dan 15% maltodekstrin. Campuran dikeringkan dalam oven pada suhu 40°C selama 2 jam. Sediaan diuji secara organoleptik, aktivitas antioksidan dengan metode ABTS, dan aktivitas antihipertensi diuji secara in vivo. Hewan-hewan dibagi menjadi kelompok kontrol sehat (HC), kontrol positif (PC; captopril 5mg/kg BB), kontrol negatif (NC; tanpa perlakuan), dan perlakuan F1-F3. Data yang diperoleh dianalisis secara statistik menggunakan one-way ANOVA. Hasil uji organoleptik menunjukkan bahwa semua ABPFMD memenuhi kriteria granul yang baik. Lebih lanjut, F3 menunjukkan aktivitas antioksidan tertinggi sebesar skor inhibisi 71,30 ± 1,40%. Hasil uji in vivo menunjukkan F3 dengan persentase penurunan sistol tertinggi sebesar 31,04 ± 2,34% dan diastol sebesar 38,87 ± 2,23%. Secara keseluruhan, ABPFMD berpotensi untuk dikembangkan lebih lanjut sebagai nutraseutikal antihipertensi.

Kata Kunci: anti-hipertensi, antioksidan, *foam-mat drying*, kulit pisang ambon, nutrasetikal

1. Introduction

The World Health Organization (WHO) predicts that the prevalence of hypertension will reach 1 billion individuals globally by 2021, with approximately 67% residing in developing countries.[1] The WHO forecasts indicate that by 2025, hypertension will rise to 29% among adults. According to the 2018 Riskesdas data, the prevalence of hypertension among individuals over 18 years in Indonesia rose to 34.1%, resulting in an annual mortality count of 427,218, affecting a total of 63,309,620 individuals in the country.[2]

Hypertension is regarded as a silent killer because of its potential to induce abrupt death while being identified gradually. The examination results indicated that 13.3% of individuals were undiagnosed, 23.4% were unaware of their hypertension, 35.72% of those with hypertension experienced hypercholesterolaemia, resulting in strokes, and 32.3-45.5% of patients were either non-compliant or irregular in their medication adherence, complicating the attainment of normal blood pressure.[3] Treatment for hypertension is essential to avert elevated blood pressure and consequences, including hypercholesterolaemia, renal impairment, and coronary artery disease.[4] Drug therapy in hypertensive patients has multiple challenges, including patient noncompliance with medication and the emergence of side effects affecting the kidneys and liver.[5] Offering nutraceutical forms may improve adherence of patients and the general populace in hypertension prevention.[6]

The component of ambon banana peel can be utilized as nutraceutical. The Ambon banana peel methanol extract exhibits significant antioxidant activity, with an IC_{50} ranging from 56 to 108 ppm.[7] Ambon banana peel extract has been utilized in dietary therapy for individuals with hypertension and hypercholesterolaemia, demonstrating a significant reduction in blood pressure and body weight.[8] Ambon banana peel extract is recognised as non-toxic and offers protection to the liver and proximal renal tubules.[9] Ambon banana peel extract comprises flavonoids and proteins that can markedly lower blood sugar levels for a duration of 24 days of dosing.[10] The methanol extract of banana peel may serve as a gastroprotective agent for the stomach.[11] The ethanol extract and banana peel nanoemulsion exhibit multiple deficiencies, including the necessity for an extended extraction duration, reliance on organic solvents, the requirement for specialised equipment in nanoemulsion formation, and the instability of extract results due to oxidation, necessitating a protective process for the flavonoids in banana peels.[12]

Foam mat drying (FMD) is a process employed to safeguard color pigments and antioxidants derived from plants.[13] The FMD process involves incorporating a foaming agent into the material designated for drying. FMD drying has numerous advantages, such as operating at low temperatures, below the freezing point, and under vacuum conditions, hence preventing the rapid degradation of bioactive components that are very susceptible to elevated temperatures and oxidation.[13] FMD can produce finished products, particularly nutraceutical drinks with desirable attributes, including colour, flavour, and aroma, akin to fresh vegetables, along with a porous structure, low moisture content, and elevated water activity.[14] Previous study indicated that the moderate drying temperature in the FMD process can reduce scent evaporation and enhance colour preservation in powder.[15]

The use of ethanol and methanol extracts incurs significant expenses and generates hazardous waste.[12] Dry extracts from banana peels are prone to oxidation and challenging to include into food or beverages.[16] The preparation of foam mat–dried banana peel requires a relatively short time.[17] The purpose of this study was to obtain an Ambon banana peel FMD granule that can be developed into a nutraceutical beverage for a hypertension complementary therapy. The availability of nutraceutical goods can enhance patient adherence to medication compared to treatment with solely synthetic pharmaceuticals.

2. Materials and Method

2.1. Tools

The instruments employed include a pH meter, a granule flow rate tester, a tap densitometer, a particle size analyser (Electrolab), a UV-Vis spectrophotometer (Shimadzu), and Kent Scientific CODA.

2.2. Materials

The materials utilized were Ambon banana peels sourced from Dusun Ngareanak, Singorojo District of Boja, Kendal Regency, Central Java. Plant identification was carried out by the Laboratory of Ecology and Biostatistics, Faculty of Biology, Diponegoro University (110325), with the result of the species *Musa paradisiaca* L.

Additional ingredients utilized in the production of foam mat drying (FMD) with pharmaceutical grade were Tween 80, maltodextrin, sucrose, avicel PH 101, magnesium stearate, and aerosil. The reagents utilized for the antioxidant test were ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), ethanol 96% and potassium persulfate obtained from PT Kairos Indonesia.

2.3. Methods

2.3.1. Production of Foam Mat Drying (FMD) Containing of Ambon Banana Peel (ABP)

Ambon Banana Peel (ABP) is combined with water in a 1:1 ratio (100 g ABP: 100 ml water) and blended. Thirty gram of blended ABP was mixed with 6% Tween 80 foaming agent and stirred for eight minutes. Fifteen percent maltodextrin was incorporated into the mixture and swirled for three minutes. ABP was positioned on a baking pan lined with 1 mm thick aluminum foil and dehydrated in a tray dryer at a temperature of 40°C for 60 minutes. Weight measurements are recorded every 30 minutes until stability is achieved.

The FMD granules were obtained and then added with other excipients as displayed in Table 1.

2.3.2. Physical Test of ABP-FMD

Physical test was conducted including physical appearance, including homogeneity, foaming capacity, pH, and granule flow rate and angle of repose.[18]

2.3.3. Antioxidant Activity of ABP-FMD

Antioxidant activity was assessed utilizing the ABTS technique.[19,20] An amount of 2.5 mM potassium persulfate and 7.6 mM ABTS diammonium salt was made into aqueous solutions. The two solutions were combined and diluted using analytical-grade ethanol. The finished solution was incubated for 6 hours in darkness at ambient temperature. Absorption was quantified with a spectrophotometer (Shimadzu UV-1800) at a wavelength of 734 nm. The inhibition percentage of ABTS was determined using the formula: [(A0 − As) / A0] × 100%, where A0 represents the absorbance of the blank solution.

2.3.4. In vivo Antihypertensive Activity

This study received ethical approval from the Health Polytechnic of the Ministry of Health, Number 1358/EA/F.XXIII.38/2024. The animals used were Wistar rats aged 2–3 months and weighing 150–250 grams. The rats were obtained from Faculty of Veterinary, Universitas Gadjah Mada. The acclimatized Wistar rats were categorized into seven groups, each comprising eight rats: Group 1-3 were given ABP FMD of 1% (F1), 2.5% (F2), and 5%(F3) respectively; Group 4 was given Captopril 5mg/kgBB; Group 5 was given with 1% CMC Na solution and Group 6 were healthy rats without any induction or treatment. Induction was performed by providing a 2% NaCl solution for a duration of 7 days for Group 1-5. Nutraceutical therapy using ABP FMD was administered for a duration of 14 days. Blood pressure measurement was conducted using the CODA Mouse Tail-Cuff® both prior to and following treatment. Testing was conducted prior to induction, seven days following 2% NaCl induction, and fourteen days after product administration. Blood pressure findings were examined and compared with negative controls, positive controls, and baseline controls.[21]

2.3.5. Data Analysis

Physicochemical stability data were examined utilizing a linear regression analysis. Blood pressure data were analyzed using a t-test to assure the antihypertensive modeling. One-way ANOVA was used to analyze the blood pressure before and after treatment in all formulas, as well as the percentage of reduction in blood pressure.

3. Result

3.1. The physical characteristic result of ABP-FMD

Figure 1 illustrates the outcomes of ABP-FMD. Table 2 displays the physical characteristics of ABP FMD granules.

The physical characteristics data can be seen in Table 1. The FMD banana peel is a light yellow, dry powder that flows effortlessly. The drying results using the FMD process indicated a powder yield of 109 grams and a recovery percentage of 109%.

3.2. The result of antioxidant activity test of ABP FMD Granules

Table 3 shows the result of the antioxidant activity of banana peel FMD granules. The antioxidant activity test results for banana peel FMD granules showed

Table 1. The formula of ABP-FMD nutraceutical granules

Formula	Percentatage (% w/w)		
	F1	F2	F3
ABP FMD	1	2.5	5
Aerosil	2	2	2
Mg Stearate	1	1	1
Avicel PH 101	add to 100%		

Table 2. The result of the physical characteristics of ABP-FMD granules

Parameter	Formula		
	F1 (1%)	F2 (2.5%)	F3 (5%)
Loss on drying (%)	1.29± 0.20	1.32 ±0.12	1.28 ±0.32
Flowability time (s)	5.25 ± 0.45	5.21 ± 0.25	5.36± 0.30
Angle of repose (°)	26.25 ± 1.15	27.30 ±0.78	29.42 ± 0.82
Solubility (seconds)	148 ± 15	178 ± 21	185 ± 25
pH	5.35 ± 0.28	5.41 ± 0.25	5.27 ± 0.38

Data displayed n= 3±Standard deviation

that all formulations achieved inhibition percentages exceeding 50%. The statistical test findings indicated that all formulas were significantly different (p = 0.042). This results from variations in concentration among the formulations. Elevating the concentration of banana peel FMD can enhance the inhibition percentage.

3.3. The result of in vivo antihypertensive activity of ABPFMD.

Table 4 and Figure 2 show the result of the antihypertensive activity of ABPFMD. The formulation with a 2.5% concentration demonstrated a reduction in systolic blood pressure of up to 31.04% and diastolic blood pressure of up to 38.87%. These results suggest that FMD granules may contribute to blood pressure reduction.

4. Discussion

The results for the physical characteristics of ABP-FMD align with recent research indicating that the foaming approach can increase granule volume and mass, thereby improving recovery.[13,22] The nutraceutical granules of ABP FMD were white to yellowish and free-flowing. The results of the loss-on-drying test indicated that all formulations had a moisture content of less than 2%. This aligns with prior research indicating that a water content below 5% yields a porous dry powder that readily dissolves in water.[23] The granules generated by the FMD process exhibited ideal physical properties, with a moisture content of less than 2%, a dissolution time of under 5 minutes, and a pH of below 7. These measurements demonstrate that the granules possess excellent physicochemical stability and are suitable for use as instant beverages.

The FMD procedure, which utilizes foaming additives such as maltodextrin and Tween 80, is responsible for the granules' low water content (<2%). The decrease in water content is crucial for enhancing products' shelf life. Granules with less water content are less susceptible to chemical breakdown, oxidation, or microbial proliferation. The findings align with the study of Singh et al.[24] which demonstrated that the FMD method yields powder with minimal water content, hence preserving the stability of bioactive chemicals.

FMD banana peel granules dissolved within less than five minutes. This indicates that these granules possess a porous structure and readily disperse in water. The brief disintegration period is a benefit of granules for use in instant beverages. In the pharmaceutical sector, granules with rapid dissolution rates are valued for

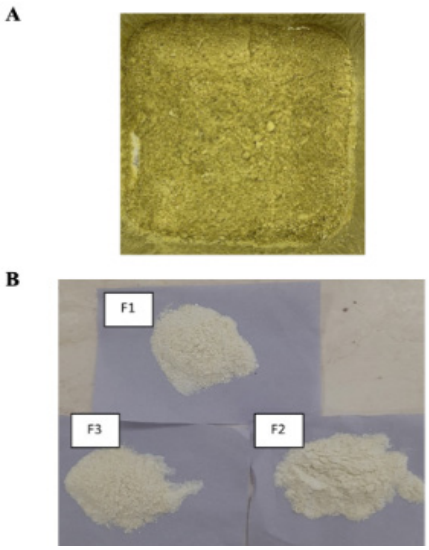

Figure 1. The result of (A) ABP FMD, and (B) Nutraceutical granules containing ABP-FMD (F1-F3).

Table 3. The result of antioxidant activity of banana peel FMD granules

Formula	Percentage of Inhibition (%)	R^2
F1	58.45 ± 1.47[b,c]	
F2	65.78 ± 1.22[a,c]	0.9982
F3	71.30 ± 1.40[a,b]	

Data displayed n = 3±Standard Deviation. a: significantly different with F1; b: significantly different with F2; c: significantly different with F3

improving consumer use. The flowability of the granules was assessed using the angle of repose, yielding a value between 26° and 29°. This range signifies that the granules fall inside the easy-to-flow group. This attribute is crucial in large-scale production processes, particularly for ensuring consistent filling of packaging or containers. These results align with flowability time and angle of repose, indicating that FMD granules are good and easily flowable.[18]

The outcomes of the physical assessment of FMD banana peel granules correspond to a granule solubility time of under 5 minutes. FMD granules and effervescent granules are typically advised to dissolve within 10 minutes. According to these findings, FMD banana peel granules are classified as readily soluble. The pH test results indicated that all pH values were below 7, indicating that the FMD results were acidic. This is affected by the composition of banana peels, specifically by protein and beta-carotene, as well as by the timing of harvest.[25] The pH of the granules, below 7, indicates acidity. The acidity is affected by the levels of protein, beta-carotene, and phenolic compounds in banana peels. This characteristic is beneficial as items with an acidic pH generally exhibit greater stability against chemical deterioration during storage. Furthermore, an acidic pH enhances the product's appeal as a nutraceutical beverage, giving it a refreshing flavor.

Based on the linear regression results, the R-squared value is 0.9982, indicating that ABP concentration affects antioxidant activity. Antioxidant activity assessed by the ABTS assay indicated that banana peel FMD granules exhibited an inhibitory percentage of over 50%. This value is substantial, particularly for items derived from natural substances. The increase in antioxidant activity at higher formula concentrations corroborates the significance of flavonoid content in the granules in neutralizing free radicals. This aligns with previous study indicating that an increase in banana peel ethanol extract enhances antioxidant activity.[26] The rise may be attributed to the phenolic component of banana peel, which acts as an antioxidant.[27] Banana peels include minerals like iron, magnesium, calcium, and potassium.[28] Banana peels are recognized for their content of phenolic and flavonoid chemicals, which are the primary contributors to antioxidant action. Flavonoids contribute by donating electrons to free radicals, thereby interrupting the oxidation chain reaction. Research conducted by Ida et al. corroborates this conclusion, demonstrating that the ethanol extract of banana peels exhibited substantial antioxidant activity alongside elevated flavonoid contents.[29]

A key feature of the FMD method is its ability to preserve the stability of bioactive chemicals, such as flavonoids and phenolic compounds, which are typically prone to oxidation during conventional drying methods. This technique also preserves the product's color and fragrance, which are crucial for consumer approval. Compared with commercial antioxidant products such

Table 4. The result of *in vivo* antihypertensive test of ABP FMD

Formula	Before Induction (mmHg)		Day 7 (after Induction) (mmHg)		Day 21 (After 14 days of treatment) (mmHg)	
	Systole	Diastole	Systole	Diastole	Systole	Diastole
F1	117.00±2.12	81.80 ±2.05	177.00 ± 2.24*	137.60 ± 5.59*	136.00 ± 5.43*#[c,d,e,f]	124.40 ± 3.36* [c,d,e,f]
F2	110.00 ± 5.80	81.00 ± 2.20	178.40 ± 5.20*	145.80 ± 4.20*	135.00 ± 4.60 #[c,d,e,f]	116.00± 5.60* [c,d,e,f]
F3	119.20 ± 2.77	81.20 ± 2.84	182.20 ± 4.49*	138.80 ± 5.26*	125.60 ± 3.36*#[a,b,d,e,f]	84.80 ± 3.27* [a,b,d,e,f]
Captopril	108.60 ± 3.13	83.40 ± 3.36	183.0 ± 5.07*	144.20 ± 5.15*	111.20 ± 4.49*#[a,b,c,e]	83.80 ± 3.83* [a,b,c,e]
CMC Na	111.40 ± 2.61	82.60 ± 4.56	184.20 ± 4.82*	147.80 ± 4.87*	180.40 ± 4.56 [a,b,c,d,f]	140.20 ± 3.96 [a,b,c,d,f]
Normal	112.20 ± 1.44	81.72 ± 2.46			113.41 ± 3.71 [a,b,c,e]	80.41 ± 2.12 [a,b,c,e]

Data displayed n = 8 ± standard deviation
* significantly different with the blood pressure data before induction
\# significantly different with the blood pressure data after induction (Day 14)
a. significantly different with F1
b. significantly different with F2
c. significantly different with F3
d. significantly different with Captopril
e. significantly different with CMC Na
f. significantly different with normal group

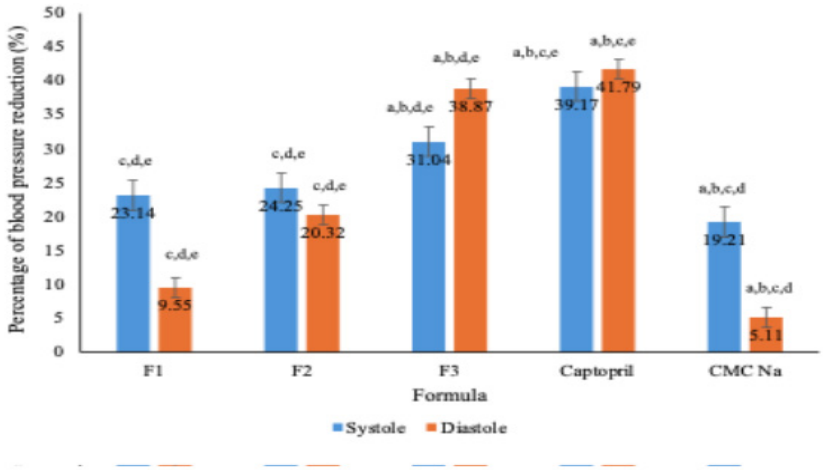

Figure 2. The result of the percentage of blood pressure reduction (%). a: significantly different with F1; b: significantly different with F2; c: significantly different with F3; significantly different with Captopril; significantly different with CMC Na

as vitamin C, the study's results indicated that banana peel granules showed competitive activity. The 71.30% inhibition rate for the formula with the highest concentration suggests that these granules may serve as an alternative to natural antioxidants, particularly for individuals seeking to avoid synthetic compounds.

In this study, captopril was used as the positive control. This is due to the similar effects of banana peel constituents, such as flavonoids and phenolic compounds. The flavonoid structure that enhances ACEI activity comprises the following components: (a) the catechol moiety in the B-ring, (b) the double bond between C2 and C3 in the C-ring, and (c) the ketone group at C4 in the C-ring.[30] The antihypertensive mechanism is likely due to the concentration of phenolic compounds in banana peels, which helps lower blood pressure by mitigating the effects of salt in the body.[30]

Captopril, used as a positive control, reduced systolic and diastolic blood pressure by 39.17% and 41.79%, respectively. Although the granules do not fully match captopril, the 8% discrepancy indicates significant potential for FMD granules as an adjunctive therapy.

Polyphenols extracted from banana peels have been shown to effectively lower systolic and diastolic blood pressure.[31] Experimental studies in hypertensive rats showed that banana peel polyphenols at 150 mg/kg/day reduced systolic arterial pressure (SAP) by 16% and diastolic arterial pressure (DAP) by 18%, comparable to the antihypertensive drug captopril at 5 mg/kg/day. [32] These are the primary active ingredients responsible for the antihypertensive effects.

Protocatechuic aldehyde is one of the key polyphenolic compounds isolated from banana peels. [32] The banana peel mechanism, as an antihypertensive, increases nitric oxide (NO) production, a potent vasodilator that relaxes blood vessels. [33] The potassium contained in banana peel also helps to reduce blood pressure.[34,35]

FMD-based products offer benefits for packing and storage due to their stability, flowability, and readily soluble properties.[36] This process is more environmentally sustainable because it avoids using organic solvents that generate harmful waste. Using banana peel waste as a raw material may create added economic value.

This study was limited by the relatively small animal sample size and short intervention period, which may not fully capture long-term antihypertensive effects. The active compounds (flavonoids, phenolics, and potassium) were inferred from prior literature but not quantified in the formulated granules, so their direct correlation with bioactivity remains to be established. Moreover, only one drying condition and formulation matrix were tested; optimization of temperature, foaming agents, and excipient composition could further enhance stability and palatability. Future research should therefore quantify the key bioactive constituents in each formulation and conduct stability testing under various storage and packaging conditions.

5. Conclusion

The FMD nutraceutical granules with 5% ABP showed the highest antioxidant activity and the greatest reduction in blood pressure compared with the negative controls, F1 (1%) and F2 (2.5%). This approach may contribute to the valorization of banana peel wast while generating high-value products. It is recommended to determine the product's stability in storage and in various types of packaging.

Acknowledgement

The authors would like to thank Yayasan Wahid Hasyim Semarang for funding this research through DIPA Universitas Wahid Hasyim.

Conflict of Interest

The authors declare no conflicts of interest.

Reference

1. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. Hypertension. 2020;75(6):1334–57.
2. Riskesdas. National Research Report of Indonesia 2023. Lembaga Penerbit Balitbangkes. 2023. p. hal 156.
3. Alkhusari, Anggita KD, Satrio A. Pengaruh Pendidikan Kesehatan Dalam Pelayanan Home Care Terhadap Perubahan Perilaku Gaya Hidup Penderita Hipertensi. J 'Aisyiyah Med. 2023;8(2):42–51.
4. Almeida CS de, Miccoli LS, Andhini NF, Aranha S, Oliveira LC de, Artigo CE, et al. Clinical Guideline for the Management of Hypertension [Internet]. Vol. 5, Revista Brasileira de Linguística Aplicada. 2016. 1689–1699 p.
5. Al Saffar HBS, Al Khazragy AH, Ali MAK. Hypertension Prevention, Diagnosis, and Treatment. Prim Healthc Proj. 2013;0–43.
6. Ardhany SD. Tingkat Kepatuhan Minum Obat Pasien Hipertensi JKN di Poli Penyakit Dalam RSUD Dr. Doris Sylvanus Palangka Raya. J Surya Med. 2016;1(2):10–7.
7. Tullah MH, Marliana E, Erwin. Uji Aktivitas Antioksidan Ekstrak Metanol Kulit Buah Pisang Ambon (Musa paradisiaca var. sapientum (L.) Kunt.) dengan Metode DPPH. J At. 2023;08(2):54–9.
8. Tangkilisan LR, Sonny K, Gresty M. Pengaruh Terapi Diet Pisang Ambon (Musa paradisiaca Var. Sapientum Linn) Terhadap Penurunan Tekanan Darah Pada Klien Hipertensi Di Kota Bitung. J Kepeawatan Samratulangi. 2022;1(1):6.
9. Prasetya H, Isradji I, Hardec A, Fahryzal M, Azizah LD, Ferwina D, et al. Perbandingan Aktivitas Antioksidan dan Toksisitas antara Drop Vitamin A dari Karotenoid Kulit Pisang Ambon dan ß-Karoten Antioxidant Activity and Toxicity of Vitamin A Drop from Ambon Peel Carotenoid and Pure ß-carotene. 2015;49(1):1–7.
10. Larasati D, Putri FMS. Skrining Fitokimia dan Penentuan Kadar Flavonoid Ekstrak Etanol Limbah Kulit Pisang (Musa acuminata Colla). J Mandala Pharmacon Indones. 2023;9(1):125–31.
11. Noviardi H, Masaenah E, Indraswari K. Antioxidant And Sun Protection Factor Potency Of Ambon Banana White (Musa acuminata AAA) Peel Extract Potensi Antioksidan Dan Tabir Surya Ekstrak Kulit Buah Pisang Ambon Putih (Musa acuminata AAA). J Ilm Farm Bahari [Internet]. 2020;11(2):180–8.
12. Al-Hakim NA, Fidrianny I, Anggadiredja K, Mauludin R. Effect of Banana (Musa sp.) Peels Extract in Nanoemulsion Dosage Forms for the Improvement of Memory: In Vitro & In Vivo Studies . Pharm Nanotechnol. 2022;10(4):299–309.
13. Shivani S, Verma AK, Sharma P, Gupta A, Kaushal M. Effect of Foaming Agent on Quality and Yield of Foam Mat Dried Papaya Powder. Int J Curr Microbiol Appl Sci. 2019;8(12):2821–35.
14. Mareta DT. Hedonic Test Method for Measuring Instant Pindang Seasoning Powder Preferences. J Sci Appl Technol. 2019;3(1):34.
15. Widarti W, Hartati I, Harianingsih H, Maharani F. Pembuatan Bubuk Bayam Dengan Metode Foam Mat Drying. J Inov Tek Kim. 2021;6(1):46–9.
16. Hidayati DN, Arifin I, Antika Y, Ardian NK. Pengujian Aktivitas Antioksidan Ekstrak Dan Fraksi Jantung Pisang Mas (Musa acuminata Colla) Menggunakan Metode DPPH Antioxidant. Pharm J Farm Indones. 2017;549(01):40–2.
17. Kalambe S. Sustainable Food Technology review of process parameters , product quality , and Sustainable Prospect. 2026;133–52.
18. United State Pharmacopeia. Powder Flow. In: US Pharmacopeia. 2016. p. 1–7.
19. ERTEKİN FİLİZ B. Bioactive compounds of hawthorn powders produced by convectional and lyophilized foam mat drying method. Int J Agric Environ Food Sci. 2023;7(1):197–205.
20. Sari BP, Kustiawan PM. Antioxidant Activity Of Extract Combination From Averrhoa bilimbi L. Leaves And Stingless Bee Honey. Indones J Pharm Sci Technol. 2023;1(1):28–34.
21. Anas Y, Hatimah NA. Efek Antihipertensi Ekstrak Etanol Kombinasi Rambut dan Biji Jagung (Zea mays L.) pada Tikus Hipertensi yang Diinduksi Monosodium Glutamat. JIFFK J Ilmu Farm dan Farm Klin. 2018;15(01):29.
22. Kaba B, Yıkılkan Y, Pashazadeh H, Ali Redha A, Koca I. Production of cornelian cherry (Cornus mas L.) pulp powder by foam-mat drying: analysis of physicochemical and antioxidant properties. Biomass Convers Biorefinery [Internet]. 2023;(0123456789).
23. Purbasari D. Aplikasi Metode Foam-Mat Drying Dalam Pembuatan Bubuk Susu Kedelai Instan. J Agroteknologi. 2019;13(01):52.
24. Brar AS, Kaur P, Kaur G, Subramanian J, Kumar D, Singh A. Optimization of Process Parameters for Foam-Mat Drying of Peaches. Int J Fruit Sci [Internet]. 2020;20(S3):S1495–518.
25. Nisaa NRK, Malik A, Handayani V. Analisis Kadar Total Flavonoid Ekstrak Etanol Kulit Pisang Cavendish (Musa paradisiaca var. Sapientum) Menggunakan Metode Spektrofotometri Uv-Vis. J Sains dan Kesehat. 2023;5(2):212–7.
26. Rahmi A, Hardi N, Hevira L. Aktivitas Antioksidan Ekstrak Kulit Pisang Kepok, Pisang Mas Dan Pisang Nangka Menggunakan Metode DPPH. J Ilmu Farm dan Farm Klin. 2021;18(2):77–84.
27. Islam MR, Kamal MM, Kabir MR, Hasan MM, Haque AR, Hasan SMK. Phenolic compounds and antioxidants activity of banana peel extracts: Testing and optimization of enzyme-assisted conditions. Meas Food.2023.
28. Hikal WM, Said-Al Ahl HAH, Bratovcic A, Tkachenko KG, Sharifi-Rad J, Kačániová M, et al. Banana Peels: A Waste Treasure for Human Being. Evidence-based Complement Altern Med. 2022;2022.
29. Adhayanti I, Abdullah T, Romantika R. Uji Kandungan Total Polifenol Dan Flavonoid Ekstrak Etil Asetat Kulit

Pisang Raja (Musa paradisiaca var. sapientum). Media Farm. 2018;14(1):39.
30. Guerrero L, Castillo J, Quiñones M, Garcia-Vallvé S, Arola L, Pujadas G, et al. Inhibition of Angiotensin-Converting Enzyme Activity by Flavonoids: Structure-Activity Relationship Studies. PLoS One. 2012;7(11):1–11.
31. Medina-Remon A, Estruch R, Tresserra-Rimbau A, Vallverdu-Queralt A, Lamuela-Raventos RM. The Effect of Polyphenol Consumption on Blood Pressure. Mini-Reviews Med Chem. 2013;13(8):1137–49.
32. Avram I, Gatea F, Vamanu E. Functional Compounds from Banana Peel Used to Decrease Oxidative Stress Effects. Processes. 2022;10(2):4–11.
33. Prameswari AS, Rahayu KP, Pranadita EN, Puspa D. The Effectiveness of Ambon Banana Peel Extract (Musa sapientum) as Atherosclerosis Prevention through Inhibition of NF-κβ and Increased eNOS Expression in Atherogenic Rat Model. 2017;114–20.
34. Syukriani L, Febjislami S, Lubis DS, Hidayati R, Asben A, Suliansyah I, et al. Physicochemical characterization of peel, flesh and banana fruit cv. raja [Musa paradisiaca]. IOP Conf Ser Earth Environ Sci. 2021;741(1).
35. Oyeyinka BO, Afolayan AJ. Comparative evaluation of the nutritive, mineral, and antinutritive composition of musa sinensis l. (banana) and musa paradisiaca l. (plantain) fruit compartments. Plants. 2019;8(12).
36. Gomes JVP, de Oliveira LA, Pereira SMS, da Conceição AR, Anunciação PC, de Souza ECG, et al. Comparison of bioactive compounds and nutrient contents in whey protein concentrate admixture of turmeric extract produced by spray drying and foam mat drying. Food Chem [Internet]. 2021;345:128772.