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The intervention of banana peel smoothies products to lower blood pressure in prehypertensive patients

Intervensi produk smoothies kulit pisang untuk menurunkan tekanan darah pada penderita prehipertensi

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Abstract

The incidence of hypertension in Indonesia is increasing, affecting not only the elderly population but also young adults aged 18–39 years. Prehypertension is an early indicator of hypertension; however, the application of fruit-based interventions remains limited. Bananas, particularly their peels, are abundant in nutrients and bioactive compounds that may mitigate hypertension. This study aimed to assess the impact of banana peel smoothing on blood pressure in individuals with prehypertension. A quasi-experimental pre-post-test design was employed. Thirty-two participants were screened and equally divided into two groups: one receiving banana fruit smoothies, and the other receiving banana peel smoothies. The study was conducted from February to March 2024 at the Faculty of Agriculture, Siliwangi University, Tasikmalaya, West Java. Blood pressure measurements were obtained before and after the intervention, and the data were analyzed using a paired t-test. Both banana fruit and banana peel smoothies significantly reduced blood pressure (p= 0,000) in both interventions. In conclusion, banana peel smoothies exhibited greater efficacy in lowering blood pressure in prehypertensive individuals than banana fruit. Banana peel smoothies represent an effective intervention for reducing blood pressure in prehypertensive individuals, offering a promising and nutrient-rich approach for hypertension management.

Keywords: Banana smoothies, banana peel smoothies, prehypertension

Abstrak

Prevalensi hipertensi di Indonesia meningkat, termasuk pada dewasa muda (18-39 tahun). Prehipertensi merupakann indicator awal hipertensi, namun penggunaan buah sebagai pencegahan masih terbatas. Pisang kaya akan nutrisi dan senyawa bioaktif yang berpotensi menurunkan tekanan darah. Penelitian ini bertujuan untuk mengevaluasi efek intervensi smoothie kulit pisang dalam menurunkan tekanan darah pada penderita prehipertensi. Desain penelitian ini menggunakan kuasi-eksperimen pre-post-test untuk mengevaluasi pengaruh smoothie kulit pisang. Terdapat 32 subjek dibagi menjadi dua kelompok, masing-masing 16 orang menerima smoothie buah pisang dan 16 lainnya smoothie kulit pisang. Penelitian dilakukan di Fakultas Pertanian, Universitas Siliwangi, Kota Tasikmalaya, Jawa Barat, pada Februari hingga Maret 2024. Tekanan darah diukur sebelum dan sesudah intervensi, dianalisis menggunakan uji T berpasangan. Hasil menunjukkan kedua smoothie menurunkan tekanan darah secara signifikan (p= 0,000), namun smoothie kulit pisang lebih efektif dalam menurunkan tekanan darah pada prehipertensi. Kesimpulan, soothie kulit pisang merupakan intervensi yang efektif untuk menurunkan tekanan darah pada individu prehipertensi, sehingga menawarkan pendekatan yang menjanjikan dan kaya nutrisi untuk pengelolaan hipertensi.

Kata Kunci: Smoothies pisang, smoothies kulit pisang, prehipertensi

Introduction

Hypertension, defined as a systolic blood pressure > 140 mmHg and diastolic blood pressure > 90 mmHg, affects approximately 22% of the global population, with over 1,28 billion cases primarily in the low- and middle-income groups (Andriani et al., 2023). Hypertension is classified into two types: primary hypertension, which has no identifiable cause; and secondary hypertension, which results from an underlying condition. In children, 5-10% experience hypertension, with primary hypertension linked to obesity, while secondary hypertension is often due to conditions such as aortic coarctation or kidney disease (Bassareo et al., 2023).

If hypertension is not treated properly, it can cause various complications such as damage to the kidneys (kidney failure), heart (heart disease), and brain (causing stroke) (Kokubo et al., 2015). Hypertensive complications cause approximately 9,4 million deaths worldwide every year (Kifle et al., 2022). Hypertension is a significant health issue that requires serious attention in order to minimize the risk of its onset and progression. It is increasingly being identified as a health concern among young adults aged 18–39 years. Hypertension is a primary risk factor for cardiovascular disease and contributes substantially to the global burden of morbidity and mortality (Zahra & Siregar, 2023).

Prehypertension is associated with an increased risk of cerebrovascular and cardiovascular diseases, chronic kidney disease, insulin resistance, and atherosclerosis (Zahra & Siregar, 2023). The main causes of prehypertension and hypertension are still not clearly known, but there are several risk factors that can increase the occurrence of prehypertension and hypertension, namely risk factors that cannot be modified and risk factors that can be modified. Risk factors that cannot be modified include age, sex, and genetics, whereas risk factors that can be modified include lifestyle such as high salt consumption, low fruit and vegetable consumption, lack of rest, lack of physical activity, smoking, and stress. People with prehypertension are three times more likely to develop hypertension than those with normal blood pressure (Moussouni et al., 2022). In Indonesia, a recent study revealed a prevalence of 32,5% among adults aged over 40 years, with obesity and age over 60 years being significant contributors (Lydia et al., 2021).

Hypertension complications necessitate blood pressure control through both pharmacological and non-pharmacological approaches. Non-pharmacological methods, such as weight loss, sodium reduction, increased physical activity, and a potassium-rich diet, have been shown to effectively manage hypertension (Dhungana et al., 2022; Tjahjono & Pramudya, 2023). These approaches are particularly recommended for prehypertensive individuals as a preventive measure to lower future risks without the need for medication (Ojangba et al., 2023). Non-pharmacological treatments are favored in Indonesia and globally owing to their affordability and minimal side effects (Ballut et al., 2023).

One promising non-pharmacological approach is dietary intervention, particularly the inclusion of potassium-rich foods, such as bananas. Bananas are affordable and not only affordable but also packed with essential nutrients, including potassium, vitamins, and bioactive compounds, making them an ideal option for controlling blood pressure. Potassium plays a significant role in reducing hypertension by promoting vasodilation and preventing arterial wall thickening (Staruschenko, 2018). Moreover, bananas contain phenolics and carotenoids that offer antioxidant benefits, as well as angiotensin-converting enzyme (ACE) inhibitory properties, which help prevent blood vessel constriction and regulate blood pressure (Afzal et al., 2022; Fitri et al., 2022; Olivia & Suryana, 2018).

This study further supports the role of bananas in the management of BP. For instance, consuming Ambon bananas has been shown to significantly reduce systolic and diastolic blood pressures in patients with hypertension. A study reported an average decrease in systolic blood pressure of 13 mmHg after 14 days of consuming three bananas daily (Efendi et al., 2023). Another study involving elderly hypertensive patients found that incorporating bananas into their diet effectively lowered blood pressure, demonstrating its potential as a non-pharmacological treatment (Zaini et al., 2022). These findings highlight the benefits of integrating bananas with dietary interventions for hypertension management.

Banana peels are rich in potassium and phenolic compounds, which can help lower the blood pressure and provide health benefits. Research has shown that the phenolic content of banana peels, including compounds such as

gallocatechin, is significantly higher than that of the fruit (Adetuyi et al., 2022). Additionally, banana peels contain potent antioxidants such as myricetin and quercetin, which contribute to cardiovascular health (Afzal et al., 2022). Therefore, banana peel may be a valuable natural approach for the management of prehypertension and hypertension.

Smoothies are a popular and nutritious snack option in Indonesia, offering a convenient way to retain the nutritional content of the fruits. In the context of hypertension management, smoothie therapy provides a natural approach to improve blood vessel function without the harmful side effects often associated with blood pressure medications. Banana peels were chosen as the main ingredients for this study because of their unique nutritional profile and bioactive compounds, which are often discarded despite their health potential.

Studies have demonstrated that extracts derived from banana peel extracts have a greater antihypertensive effect than other fruit-based ingredients because of their higher bioavailability of active compounds (Efendi et al., 2023). Furthermore, the use of banana peels aligns with sustainable food practices by reducing waste and maximizing the nutritional value of the fruit. Incorporating banana peels into smoothies not only enhances the therapeutic benefits for prehypertensive individuals but also presents an innovative approach to leverage the underutilization of natural resources for health interventions. This study aimed to explore the potential of banana peel smoothies as an alternative treatment to lower blood pressure in individuals with prehypertension.

Methods

This study employed a quasi-experimental pre-post-test design to evaluate the effect of banana peel smoothing on lowering blood pressure in individuals with prehypertension. Blood pressure measurements were conducted at two points: a pre-test (baseline) before the intervention and a post-test after a 10-day intervention period. The participants consumed smoothies daily with dosage and timing standardized to ensure consistency. Control variables, such as participants' diet, physical activity, and other lifestyle factors, were monitored to minimize external influences on blood pressure changes, ensuring that the observed effects were attributable to smoothing smoothies. This study was conducted from February to March 2024 in the Faculty of Agriculture, Siliwangi University, Tasikmalaya City, West Java. This location was chosen because of its proximity to a readily available pool of participants with prehypertension, access to supporting laboratory facilities for product analysis, and controlled environment suitable for monitoring and implementing the intervention.

The ingredients used in this study were 150 g of banana, 50 g of banana peel, 50 mL of low-fat liquid milk, and 50 mL of plain yogurt. The tools used consisted of tools for making products and blood pressure-measuring devices. The tools used in this study included a food scale, blender, glass, and an Omron HEM-7120 digital sphygmomanometer. Specific procedures were performed to ensure the accuracy of blood pressure measurements, specific procedures were followed. The participants were instructed to sit in a relaxed position for at least five minutes before each measurement. Blood pressure was measured three times for each participant, with a one-minute interval between measurements, and the average of the three readings was used for analysis. These procedures minimized variability and ensured reliable results.

Making banana smoothies refers to a modified experiment in which ingredients such as bananas, banana peels, low-fat liquid milk, and plain yogurt are placed in a blender, and all ingredients are blended until homogeneous (Pratiwi et al., 2018). Group 1 was given the banana smoothie intervention without the peel, whereas group 2 was given the banana smoothie intervention with the peel. The banana peel smoothie intervention was performed for 10 d. The participants were prehypertensive sufferers who had hypertension at Siliwangi University in Tasikmalaya City. Banana peel smoothies were administered once a day, namely in the morning at approximately 07.30 WIB.

This study included young adults with and without prehypertension. The subject screening stage began by using blood pressure measurement data, BH and BW measurements, and filling out a questionnaire. If these criteria are met, they can be used as a study subject. The inclusion criteria in this study were that the subject was willing to become a study

respondent by providing informed consent, had a blood pressure of 120-139/80-89 mmHg, was 18-39 years old, did not consume more than 200 ml of coffee per day, and was willing to consume banana smoothies for 10 days. The exclusion criteria were subjects who took blood pressure-lowering drugs, were pregnant women, and had non-communicable diseases such as diabetes mellitus, and kidney and heart failure.

This study was approved by the Health Study Ethical Clearance Commission of the Faculty of Dental Medicine at Airlangga University (approval number: 0607/HRECC). FODM/VI/2024). Ethical principles were strictly maintained throughout the study. All participants provided written informed consent after being briefed on the study's purpose, procedures, and rights, including the freedom to withdraw at any time without consequences. The confidentiality of the respondents' data was ensured by anonymizing all personal identifiers, securely storing data in password-protected digital files, and locked physical storage accessible only to the research team. Respondents received compensation in the form of free health checkups, including blood pressure measurements and dietary assessments, as well as guidance on maintaining healthy blood pressure levels.

The number of study participants was determined by calculating the estimated sample size for each group. The sample calculation formula uses the Lemeshow formula, as follows:

$$n = \frac{2\,(Z_\alpha + Z_\beta)^2 \times S^2}{(\mu_1 + \mu_2)^2}$$

$$= \frac{2\,(1{,}96 + 0{,}84)^2 \times 19^2}{(135{,}25 + 156{,}63)^2}$$

$$= 12{,}38 = 13$$

Information:

- n : Number of samples for each group
- Zα : Standard normal distribution value, which is the same as the 95% significance, namely 1,96
- Zβ : Is the standard normal distribution value, which is equal to a power of 80 (0,84), that is, 0,84.
- S : Standard deviation estimate based on a study by Fitri et al. (2022)
- (μ_1-μ_2) : The difference in mean blood pressure measured before and after the intervention, based on the study by Fitri et al. (2022).

Based on the formula obtained, the minimum number of samples in each group was 13. The estimated sample dropout rate was 20%; therefore, the were number 16 samples in each group of samples in each group was 16. The study respondents were divided into two groups: 16 people in the group given banana smoothies without peel, and 16 people in the group given banana smoothies with peel.

The data collected in this study included baseline and endline data obtained through screening, interviews, basic data measurements, and laboratory analyses. Food consumption data were obtained using a combination of accuracy and validation methods. A 2 × 24-h2×24-h recall form was administered on both weekdays and holidays to capture day-to-day variations in dietary intake. To ensure the accuracy and reliability of the data, the respondents were guided through 24-hour recall forms during face-to-face interviews conducted by trained researchers. During these sessions, respondents were asked follow-up questions to clarify the portion sizes, preparation methods, and frequency of consumption. Data on respondents' nutritional status were determined based on their body mass index (BMI), which was calculated using the ratio of body weight (BW) in kilograms to the square of body height (BH) in meters. Blood pressure measurements, including systolic (mmHg) and diastolic (mmHg) blood pressure, were conducted using a digital sphygmomanometer, following standardized procedures to ensure accuracy and reliability.

Primary data were collected through direct observation and interviews using a questionnaire. Primary data collection was conducted after the respondents agreed to provide informed consent. The students filled out a questionnaire using a direct interview method. Data were collected before and after the intervention to assess the effect of banana peel smoothing on blood pressure. Univariate, bivariate, and multivariate analyses were performed. Univariate analysis used descriptive statistics to determine individual characteristics.

Bivariate analysis, namely, a statistical test to determine the effect of banana peel smoothing on blood pressure, was carried out in several stages. The first stage was the data normality test. If the data are normally distributed, data analysis can be performed using a parametric data test (paired t-test). Next, a difference test was carried out for the data before and after the intervention, followed by Duncan's Multiple Range Test, if there was significant treatment between groups. Multivariate analysis was performed using a linear regression test to analyze confounding variables.

Result and Discussion

Table 1. Characteristics of respondents

Characteristics	n	%
Gender		
Man	18	56.25
Woman	14	43,75
Age		
21 – 23 years	32	100
Nutritional status		
Normal	26	81,25
Overweight	1	3,12
Obesity	5	15,63

There were 32 respondents who met the criteria in this study and were divided into two groups: 16 people who were given banana smoothies with the peel and 16 other people who were given banana smoothies without the peel. The respondents in the study consisted of 18 men (56,25%) and 14 women (43,75%), aged between 21 and 23 years. Most respondents had a normal nutritional status (81,25%), with a few classified as overweight (3,12%) and some as obese (15,63%).

This suggests a relatively young and generally healthy sample, with a small proportion of participants experiencing weight-related health issues. Younger individuals often have optimal vascular elasticity and minimal comorbidities, which makes them a valuable group for observing the direct effects of dietary interventions. This study highlights the potential benefits of banana peel smoothies in maintaining cardiovascular health in young adults, and offers a foundation for exploring their effects in other populations.

Table 2. Nutritional comparison analysis

Parameter	Banana Fruit Smoothies	Banana Peel Smoothies	Unit	Test Method
Water Content	83,33	81,27	%	Gravimetry
Ash Content	0,81	0,69	%	Gravimetry
Proteins	1,86	3,28	%	Kjeldahl
Fat	3,50	4,29	%	Soxhlet
Carbohydrate	10,50	10,47	%	By Difference
Sodium	1,107,89	1,262,80	mg	AAS
Potassium	0,27	0,34	%	AAS
Total Phenol	0,037	0,035	%	Spectrophotometry

Table 2 highlights that banana peel smoothies contain higher levels of potassium (compared to banana fruit smoothies (0,27%), while bota has a relatively low sodium content (1,262,80 mg vs, 1,107,89 mg, respectively). Table 2 highlights that banana peel smoothies contain higher levels of potassium (0,34%) compared to banana fruit smoothies (0,27%), while both have relatively low sodium content (1,262,80 mg vs. 1,107,89 mg, respectively).

Potassium plays a vital role in regulating blood pressure by promoting vasodilation, reducing vascular resistance, and counteracting the fluid retention effects of sodium (McLean & Wang, 2021; Su et al., 2020). This balance between potassium and sodium is critical for cardiovascular health, as excessive sodium can lead to fluid retention and increased blood volume and pressure on blood vessel walls. The higher potassium levels in banana peel smoothies likely contributed to their superior effectiveness in lowering blood pressure, as reflected by the greater reduction in systolic blood pressure (15,87 mmHg) compared to banana fruit smoothies (13,29 mmHg). This aligns with evidence suggesting that even modest increases in potassium intake can significantly improve blood pressure regulation, particularly in individuals with prehypertension (Suchitra & Parthasarathy, 2021).

The low sodium content in both types of smoothies also supports their suitability as interventions for blood pressure management. While sodium intake above the recommended levels is strongly associated with hypertension and cardiovascular risks (Mozaffarian et al., 2014), the levels in these smoothies are within a range unlikely to exacerbate blood pressure issues. The combination of low sodium and high potassium in banana peel smoothies creates a synergistic effect, enhancing their antihypertensive properties. These findings emphasize the importance of potassium as a dietary component to neutralize the adverse effects of sodium, which is particularly beneficial in the context of the prehypertensive participants in this study. The greater impact of

banana peel smoothies underscores the value of utilizing underappreciated food components, such as banana peels, as part of a comprehensive dietary strategy for preventing and managing hypertension.

The sodium content in banana fruit smoothies (1,107,89 mg) and banana peel smoothies (1,262,80 mg) was relatively low, minimizing the risk of sodium-induced blood pressure increases. Despite the slightly higher sodium content in banana peel smoothies, the higher potassium content (0,34% vs. 0,27% in banana fruit smoothies) likely played a more dominant role in reducing blood pressure, as potassium helps counteract the effects of sodium by promoting vasodilation and fluid balance (McLean & Wang, 2021; Su et al., 2020). The higher potassium levels in banana peel smoothies contributed to a more significant reduction in blood pressure (15,87 mmHg) compared to banana fruit smoothies (13,29 mmHg). This finding aligns with the well-established relationship between potassium intake and improved blood pressure regulation, where potassium offsets sodium-induced fluid retention and relaxes blood vessel walls, ultimately lowering the risk of hypertension (Suchitra & Parthasarathy, 2021). Thus, the potassium content in banana peel smoothies likely amplifies their antihypertensive effects, underscoring their potential as a dietary intervention for managing blood pressure.

The phenol content in banana fruit smoothies (0,037%) and banana peel smoothies (0,035%) was relatively low, indicating that phenols alone may not have a strong antihypertensive effect in a short period. However, their antioxidant properties contribute to the reduction in oxidative stress, which supports endothelial function and blood pressure regulation (Lutz et al., 2019; Yousefian et al., 2019). The higher potassium content in banana peel smoothies (0,34% vs. 0,27%) likely plays a more significant role in reducing blood pressure, as potassium promotes vasodilation and reduces vascular resistance (Staruschenko, 2018). This effect is further complemented by proteins, carbohydrates, and other micronutrients, which collectively enhance cardiovascular health. For sustained antihypertensive benefits, regular, long-term consumption of banana peel smoothies is recommended as phenolic compounds have cumulative effects over time (Pereira & Maraschin, 2015; Vu et al., 2019).

Table 3 presents an analysis using paired t-tests to compare the initial and final blood pressure measurements within each group (banana peel smoothies and banana fruit smoothies). Additionally, ANOVA was conducted to assess the differences between the two intervention groups.

Table 3. Changes in blood pressure before and after intervention

Group	Initial Blood Pressure (mmHg)	Final Blood Pressure (mmHg)	Difference (mmHg)	Max/Min (mmHg)	Initial Std. Dev.	Final Std. Dev.	Std. Dev. of Difference	p-value
Banana Peel Smoothies	138,31	122,44	15,87	122/78	17,138	7,857	9,280	0,000*
Banana Fruit Smoothies	133,88	120,59	13,29	123/84	8,565	8,055	0,510	0,000*
ANOVA								0,017*

*Significant at p < 0,05.

Table 3 shows significant reductions in systolic blood pressure within both groups (p= 0,000) for both interventions, indicating a high level of statistical significance (p < 0,05). Specifically, the banana peel smoothie group exhibited a greater reduction in mean systolic blood pressure (15,87 mmHg) than the banana fruit smoothie group (13,29 mmHg). The ANOVA test further confirmed that the difference in effectiveness between the two interventions was statistically significant (p = 0,017), suggesting that banana peel smoothies were more effective in lowering blood pressure than banana fruit smoothies. This aligns with the finding that a functional beverage made from fruit effectively reduces systolic and diastolic blood pressure in prehypertensive women compared to increased urinary potassium concentrations, which is crucial in counteracting sodium and regulating blood pressure (Zheng et al., 2017).

A p-value less than 0,05 indicates that the likelihood of the observed differences occurring by chance is less than 5%. This reinforces the clinical relevance of the interventions. The greater reduction in blood pressure in the banana peel group suggests that the bioactive compounds in banana peels, such as phenolics and potassium, may have contributed to the additional antihypertensive effects compared to the banana fruit alone. This highlights the potential of banana peel smoothing as a viable, natural, and affordable dietary intervention for managing prehypertension, particularly in resource-limited settings.

As stated in many studies, bananas are rich in various nutrients that are beneficial for health. Bananas are rich in carbohydrates, proteins, dietary fibers, vitamins, minerals, and various bioactive compounds (Afzal et al., 2022; Sidhu & Zafar, 2018; Singh et al., 2016). Specific nutrients, such as phenolics and potassium, play key roles in reducing blood pressure. While both banana fruit and banana peel smoothies contain similar levels of phenolic compounds (0,037% and 0,035%, respectively), the higher potassium content in banana peel smoothies (0,34% compared to 0,27% in banana fruit smoothies) likely explains their stronger antihypertensive effect. Potassium is known to promote vasodilation, reduce vascular resistance, and support endothelial function, all of which are critical mechanisms for lowering blood pressure (Staruschenko, 2018).

The results of this study showed that banana peel smoothies reduced blood pressure by 15,87 mmHg, whereas banana fruit smoothies reduced blood reduction by 13,29 mmHg. This greater reduction is likely attributable to the higher potassium levels in banana peel smoothies, as potassium is a key mineral in the management of hypertension. Additionally, the presence of phenolic compounds in both smoothies likely contributes to their overall effectiveness by reducing oxidative stress and improving endothelial health. Thus, it can be stated that intervention with banana peel smoothies is more effective in lowering blood pressure.

This study has some limitations that should be acknowledged to provide context for the findings. The relatively small sample size of 32 participants may have limited the statistical power and reduced the generalizability of the results to a wider population. Additionally, the narrow age range of the participants (18–28 years) restricts the applicability of the findings to older age groups, who may exhibit different physiological responses to dietary interventions. The short duration of the intervention (10 days) may not fully capture the long-term effects of banana peel smoothie consumption on blood pressure. Furthermore, while efforts were made to monitor the participants' dietary habits and physical activity, potential uncontrolled variables may have introduced bias. These limitations underscore the need for future studies with larger, more diverse samples and extended intervention periods to validate and expand upon these findings.

Conclusion

Banana peel smoothies effectively lowered blood pressure in prehypertensive individuals (15.87 mmHg) and outperformed banana smoothies (13.29 mmHg). Their high potassium and phenolic content contribute to their superior antihypertensive effects through vasodilation, antioxidant, and anti-inflammatory actions.

Consuming one banana peel smoothie daily, preferably in the morning, is recommended as a low-cost and sustainable intervention. This approach may be integrated into public health programs and clinical lifestyle strategies for the management of prehypertension. Further research is required to confirm the long-term benefits across populations.

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