ORIGINAL ARTICLE

The effect of Cavendish banana juice therapy *(Musa acuminata L.)* on blood pressure reduction in patients with hypertension

Ake Royke Calvin Langingi[1], Marjes Netro Tumurang[2], Finni Fitria Tumiwa[3], Siska Sibua[4], Suci Rahayu Ningsih[5], Christiane Prisilia Sarayar[6], Grace Irene Viodyta Watung*

[1]Department of Nursing, Gunung Maria Tomohon College of Health Sciences, Tomohon-95442 (North Sulawesi) Indonesia, [2]Department of Nursing, Poltekkes Kemenkes Manado, Manado-95263 (North Sulawesi) Indonesia, [3,6] Department of Nursing, Bethesda Tomohon College of Health Sciences Tomohon-95411 (North Sulawesi), Indonesia, [4, 5, 7] Department of Nursing, Graha Medika Institute of Health and Technology, Kotamobagu-95711 (North Sulawesi), Indonesia

Abstract

Background: Cavendish bananas are popular for treating a variety of illnesses because they contain active chemicals. *Aim and Objectives:* This study aimed to investigate the efficacy of Cavendish banana in the management of hypertension. *Material and Methods:* This was a quasi-experimental study using pre- and post-test control groups. The study sample consisted of 134 hypertensive patients aged > 40 years who were divided into treatment and control groups. The intervention group was administered 500 ml of Cavendish banana juice 2 times per day for seven days, while the control group did not receive any therapy. Blood pressure measurements were performed twice (before and after the intervention) using a digital sphygmomanometer. Data analysis was performed using the Wilcoxon and Mann-Whitney tests. *Results:* The findings showed that Cavendish banana was rich in potassium and carbohydrates, and contained active compounds such as flavonoids, tannins, polyphenols, saponins and glycosides. The reduction in blood pressure in the intervention group exceeded that of the control group. The data indicated a reduction in systolic blood pressure in the intervention group from 153.70 mmHg to 142.07 mmHg, and diastolic pressure from 96.17 mmHg to 91.00 mmHg. *Conclusion:* Consumption of Cavendish bananas can support efforts to control hypertension

Keywords: Hypertension, *Musa acuminata L.*, Blood pressure, Therapy

Introduction

Cavendish banana juice (*Musa acuminata L.*) is a popular drink among the public and contains active compounds that provide a myriad of benefits. Many types of bananas have their own nutritional content. Bananas are generally known for their phytochemical content, including polyphenols and flavonoids which are antiinflammatory and antioxidant agents [1-2]. Polyphenol and flavonoid compounds play an important role in dealing with inflammation and oxidative stress, both of which are directly involved in the pathophysiology of hypertension [3]. The active compounds in Cavendish banana have a significant impact on hypertension. Potassium is one of the important minerals contained in Cavendish banana. Potassium is an excellent antihypertensive agent. Potassium has vasodilating properties that can help lower blood pressure by reducing sodium content in the body by activating and improving endothelial function [4]. Evidence suggests that a K-rich diet may reduce the risk of hypertension and other related diseases. Previous research has found that the high potassium content in bananas may help treat hypertension [5-6].

Processing Cavendish banana as juice is also a very useful alternative. This is because with this processing, the nutritional content of Cavendish banana is not significantly reduced and can maintain its phytochemical properties and can improve the taste [7]. This is proven in previous studies which state that bananas have been shown to inhibit the activity of the angiotensin converting enzyme, an important mechanism in the management of hypertension [8]. By inhibiting this enzyme, blood vessels can relax more, resulting in a decrease in overall blood pressure.

Psychological and cultural dimensions are often benchmarks for treatments that utilize natural ingredients. Many patients consider these aspects when choosing alternative treatments because of their perception of the effectiveness and safety that they have known for generations. Previous studies have shown that herbal medicine is often considered better in curing various diseases compared to modern medicine among rural communities or remote cities [9]. This perspective emphasizes the general belief that exists in the community to use more traditional medicine, namely Cavendish banana juice as an alternative treatment for hypertension.

Supporting evidence regarding its efficacy and effectiveness is still limited and needs to be explored further. However, evidence that points to it already exists, for example a high potassium diet can lower blood pressure [4, 6]. Therefore, further research is needed to determine the accuracy and additional evidence supporting the reliability of Cavendish bananas as an antihypertensive. These findings will enrich the existing literature on the benefits of Cavendish bananas in managing hypertension. In addition, individual characteristic factors are also an important part in developing hypertension management strategies that combine them with natural ingredients [10].

This study fills an important gap in how Cavendish banana can be used to treat hypertension. This study is based on the nutritional content and phytochemical properties of Cavendish banana. The very high potassium content as well as the active compounds in Cavendish banana are known to act as anti-inflammatory agents, relieve oxidative stress, and are primarily related to the pathophysiology of hypertension.

Material and Methods

The intervention and control groups in this quasi-experimental study were divided into pre- and post-test groups. In order to observe the true effects of the intervention, the control group did not receive any therapy, while the intervention group received 500 ml of Cavendish banana juice twice a day for seven days. The juice was prepared without the use of any additional sweeteners. The preparation of Cavendish banana juice was carried out with a focus on maintaining the integrity and purity of the product, without any added sweeteners. This process involved selecting ripe Cavendish bananas, which were then peeled and cut into smaller pieces to facilitate blending. The banana pieces were then mixed with a certain volume of clean water (500 ml) to achieve the appropriate consistency. The blending process was carried out until a smooth texture was achieved, minimizing the inclusion of air to maintain the natural flavor and nutritional content of the juice. After blending, the juice was filtered. This method ensured that the participants received the banana juice in its pure form, allowing for an unadulterated assessment of its effects.

Active ingredients such as tannins, polyphenols, flavonoids, and saponins in Cavendish bananas were tested using particular protocols in each. An interference technique using ferric chloride reagent was employed to conduct the tannin test. The presence of tannins was indicated by a color change from blue to green. Alcohol was added to the magnesium chloride reagent test to conduct the flavonoid test. The color changes that took place verified the presence of flavonoids. The Folin-Ciocalteu reagent was used to do polyphenol assays. By measuring absorbance at a specific wavelength, the presence of phenol was identified. In order to perform the saponin test, the solution was extracted and the existence of foam was monitored.

The phenol-sulfate method was used to measure the total carbohydrate levels by measuring the absorbance using a spectrophotometer. To determine protein levels, the Kjeldahl method was used, which calculated nitrogen levels and then converted them to protein levels. Fiber levels were measured using the gravimetric method. The iodometric test, which is based on titration, was used to measure the vitamin C levels. Vitamin B_6 levels were measured using High Performance Liquid Chromatography (HPLC) method. Potassium levels were measured using Atomic Emission Spectroscopy (AES).

The study sample consisted of 134 hypertensive patients aged ≥ 40 years who were divided into two groups: intervention and control. Each group comprised of 67 samples. The number of samples was determined using the Slovin formula, and sampling was carried out using the purposive sampling technique based on the inclusion and exclusion criteria. The formula is: $n = N / (1 + Ne^2)$ Where n: is the required sample size, N: is the total population size, e: is the desired margin of error (expressed as a decimal). The inclusion criteria were: patients medically diagnosed with hypertension; aged 40 years and older; not having used antihypertensive drugs in the past four weeks; not experiencing severe comorbidities; providing written consent to participate in the study; and demonstrating willingness to adhere to the research protocol.

To ensure that the sample was homogeneous between the two groups, a sample homogeneity test was conducted using Levene's test. Each respondent's characteristic variable was tested for homogeneity. This was done to avoid bias in the intervention results. The results showed that all variables had value of p above 0.05. Education variable (0.921), age (0.951), sex (0.892), occupation (0.977), and degree of hypertension (0.973). These results indicated that the samples between the two groups were homogeneous.

Data on respondents' occupation, age, gender, and level of education were gathered via a questionnaire. A digital sphygmomanometer (systolic and diastolic) was used to measure the extent of intervention. The results were analyzed using the Statistical Package for the Social Sciences software. Data were gathered both before and after the therapy. Specifically, data were collected before breakfast on the first day of the intervention and again after the seventh day. This was done to identify and examine changes in the intervention's outcomes.

Education, age, sex, and occupation data were analyzed and entered into a table. Numerical data from certain variables were analyzed using the mean, median, standard deviation, and maximum and minimum values. The Wilcoxon test was used in both the control and intervention groups to test the changes in BP in one group. Meanwhile, to compare changes in blood pressure between the two groups, the Mann-Whitney test was used. The Wilcoxon signed-rank test is a non-parametric statistical method employed to evaluate the differences between paired observations-in this case, changes in Blood Pressure (BP) within each group (control and intervention). This test is suitable for assessing whether the median ranks of differences indicate a significant shift in BP over time within the same group. Conversely, the Mann-Whitney U test serves as a non-parametric approach to compare means or medians between two independent groups when the normality assumption is violated. Here, it facilitates the examination of differences in BP changes between the control and intervention groups, providing a robust analysis of potential efficacy of the intervention.

This study complied with the applicable ethical standards and had received an ethical clearance letter issued by Poltekkes Kemenkes Manado (IRB-12025-0227). The ongoing research was explained to the respondents at the beginning. This was to ensure that respondents knew their rights and obligations when they were willing to participate in the research process.

Results

In the control group, the mean pre-test systolic pressure (147.00) and diastolic pressure (93.33) with a p value (0.000), which indicates non-normal distribution of data. The post-test value decreased slightly and still showed significant non-normality ($p = 0$) In contrast, in the intervention group, the pre-test systolic pressure data (153.70) and diastolic pressure (96.17) also showed non-normality ($p = 0.021$) while the post test results showed a significant decrease in systolic pressure (142.07) and diastolic pressure (91.00), with the post-test diastolic showing non-normal distribution ($p = 0$). Table 1 shows that Cavendish banana contained carbohydrates (22.9 g / 100 g), protein (1.3 g / 100 g), fiber (2.8 g / 100 g), vitamin C (8.5 mg / 100 g), vitamin B6 (0.8 mg / 100 g), and potassium (458 mg / 100 g). Cavendish bananas also contained active compounds, such as flavonoids, tannins, polyphenols, and saponins. Table 2 shows that respondents in the two groups had a high school education (51% intervention and 45% control), were 40-55 years old (81% intervention and 82% control), were females (72% intervention and 67% control), housewives (39% intervention and 37%), and had grade 1 hypertension (49% intervention and 51% control). Prior to treatment, the intervention group's mean systolic blood pressure was higher (153.70) than the control group's (147.00) (Table 3). The mean systolic blood pressure in the intervention group, which was higher (142.07) than in the control group (146.47), was significantly decreased following treatment. This explains why the intervention group's systolic blood pressure changes were superior to those of the control group. Prior to treatment, the intervention group's mean diastolic blood pressure was higher (96.17), compared to the control group's (93.3). A significant decrease was also observed in the mean systolic blood pressure after treatment in the intervention group, which was higher (91.00) than that in the control group (93.20). This explains why the changes in diastolic blood pressure were better in the intervention group than in the control group. Table 4 shows the effect of treatment on systolic blood pressure (0.000) and diastolic (0.002) in the intervention group before and after treatment. In contrast to the intervention group, the control group did not show significant changes in systolic and diastolic blood pressure. On analysing the blood pressure in both groups, it was found that there was a significant difference between the intervention and control groups before (p<0.001) and after treatment (p<0.001).

Table 1: Nutritional content and active compounds and content in Cavendish bananas (Musa acuminata L.)

Nutritional content and active compounds	Results
Flavonoid	+
Tannin	+
Polyphenols	+
Saponins	+
Carbohydrate	22.9 g / 100 g
Protein	1.3 g / 100 g
Fiber	2.8 g / 100 g
Vitamin C	8.5 mg / 100 g
Vitamin B6	0.8 mg / 100 g
Potassium	458 mg / 100 g

Table 2: Comparison of characteristics in hypertension patients in the intervention and control groups

Variables	Intervention Number (Percentage)	Control Number (Percentage)
Education		
Junior high school	3 (4%)	4 (6%)
Senior high school	34 (51%)	30 (45%)
Bachelor	19 (28%)	23 (34%)
Master	11 (16%)	10 (15%)
Age		
40-55 Years	54 (81%)	55 (82%)
56-64 Years	10 (15%)	10 (15%)
>65 Years	3 (4%)	2 (3%)
Mean	46.85	46.85
Min-Max	40-63	40-63
Standard Deviation	6.377	6.377
Sex		
Male	19 (28%)	22 (33%)
Female	48 (72%)	45 (67%)
Work		
Farmer	6 (9%)	4 (6%)
Private sector employee	12 (18%)	12 (18%)
Government employees	13 (19%)	13 (19%)
Driver	7 (10%)	7 (10%)
Housewife	26 (39%)	25 (37%)
Teacher	3 (4%)	6 (9%)
Degree of Hypertension		
Class 1	49 (73%)	51 (76%)
Class 2	18 (27%)	16 (24%)
Standard Deviation	150.35	150.35
Min-Max	140-170	140-170

Table 3: Distribution of respondents based on blood pressure before and after treatment of intervention and control groups

Variables	Intervention	Control
Systolic pressure before		
Mean	153.7	147.0
Median	150.0	140.0
Minimum	140	140
Maximum	170	165
Standard Deviation	9.400	8.952
Diastolic pressure before		
Mean	96.17	93.33
Median	96.0	90.0
Minimum	90	90
Maximum	104	101
Standard Deviation	3.425	4.046

Variables	Intervention	Control
Systolic pressure after		
Mean	142.07	146.47
Median	140.0	140.0
Minimum	125	140
Maximum	156	165
Standard Deviation	6. 464	8.766
Diastolic pressure after		
Mean	91.0	93.2
Median	90.0	90.0
Minimum	80	90
Maximum	95	101
Standard Deviation	3.140	4.046

Table 4: Effect of intervention on systolic and diastolic blood pressure of respondents in the intervention and control groups

Group	Variables	Before/After	Mean ± SD	*p*
Control	Systolic blood pressure	Before	147.00 ± 8.597	0.086*
		After	146.47 ± 8.766	
	Diastolic blood pressure	Before	93.33 ± 4.046	0.102*
		After	93.20 ± 4.046	
Intervention	Systolic blood pressure	Before	153.70 ± 9.400	0.000*
		After	142.07 ± 6.464	
	Diastolic blood pressure	Before	96.17 ± 3.425	0.002*
		After	91.00 ± 3.140	
Intervention vs Control (Pre-test)			57.53 ± 7.234	0.000**
Intervention vs Control (Post-test)			51.06 ± 5.825	0.000**

**Wilcoxon **Mann-Whitney*

Discussion

The findings show that Cavendish banana had a very high potassium and carbohydrate content. The carbohydrate content in Cavendish banana reached 22.9 g per 100 g; therefore, it can be used as a good source of energy. In addition, the potassium content in Cavendish banana reached 458 mg per 100 g. Potassium is known to have a beneficial function in lowering blood pressure. The physiological mechanism that may explain this is the effect of potassium in dilating blood vessels and its role in reducing renin-angiotensin activity [11].

Potassium is known to increase the production of nitric oxide, which helps widen and relax blood vessels, leading to a reduction in blood pressure. Previous studies have shown that potassium intake is associated with a reduced risk of cardiovascular diseases and hypertension. This study showed a significant decrease in blood pressure in individuals with high potassium consumption [11]. The high potassium content observed in the researchers' findings may explain why the reduction in blood pressure was greater in the intervention group compared to the control group. In addition to heart and renal problems, untreated high blood pressure is a significant risk factor for developing other illnesses [12]. Hypertension treatment should be holistic and individualized [13].

Studies using randomized controlled trials have found that potassium is able to improve vascular function, as assessed by flow-mediated dilation and urinary nitrate excretion [14]. Potassium intake directly increases nitric oxide and reduces the negative effects of oxidative stress and improves endothelial health [14]. Sodium and potassium have complementary properties that may affect cardiovascular health. A higher sodium to potassium ratio in the diet is associated with increased cardiovascular morbidity and mortality [15].

In addition, the findings also show that Cavendish banana contained 2.8 g of fiber per 100 g. Fibers are an important component of digestive health and are beneficial for controlling blood sugar levels. Fibers can slow the absorption of blood sugar, and this inhibition of absorption can help reduce spikes in blood pressure due to fluctuations in blood glucose levels. Previous studies have shown that fiber can lower blood pressure because fiber can improve overall heart health [16].

The findings also show that Cavendish banana contained active compounds such as flavonoids, polyphenols, saponins and tannins. These compounds are known for their ability to reduce inflammation and oxidative stress. Oxidative stress and inflammation are two factors that often trigger the development of hypertension in an unhealthy direction [16]. Other research findings show that flavonoids can reduce capillary loss and improve endothelial function which plays a significant role in cardiovascular health [17]. Therefore, consumption of Cavendish bananas, which are proven to be rich in these compounds, can support the body's natural mechanisms in maintaining healthy blood pressure.

Other studies have shown that the antioxidant properties of flavonoids and other polyphenols in bananas are able to ward off oxidative damage which is a major problem in cardiovascular disease [18]. Since Cavendish banana has a rich flavonoid and polyphenol content, it can support the physiological mechanisms of blood pressure regulation. By consistently including this fruit in the diet, individuals can improve their body's resistance to oxidative stress and inflammation, which contributes to better cardiovascular health and reduces the risk of hypertension [19].

The findings also found that Cavendish banana contained several vitamins and minerals that are beneficial for health, including Vitamin C and Vitamin B6, which are known to improve body metabolism and strengthen the immune system [20]. The usefulness of vitamin B6 for blood pressure control is known because of its role in neurotransmitter regulation. Neurotransmitters are chemicals in the body that are useful for controlling mood and stress management which can ultimately control blood pressure [21]. The presence of this vitamin is supporting evidence that Cavendish banana can be used as an alternative treatment for hypertension.

Previous studies have shown that bananas have rich nutritional profiles. This also makes them very effective for inclusion in healthy diets. In addition, bananas are rich in fiber, which contributes to metabolic health and regulation of cholesterol levels, an important factor in controlling blood pressure [22]. Thus, Cavendish bananas are not only a source of vitamins B6 and C, but also serve as part of a nutritional strategy that supports the management of hypertension and overall heart health [23].

Prior to treatment, the intervention group's mean systolic blood pressure was higher (153.70) than the control group (147.00). The mean systolic blood pressure in the intervention group, which was higher (142.07) than in the control group (146.47), was significantly decreased following treatment. This explains why the intervention group's systolic blood pressure changes were superior to those of the control group. These findings explain the importance of Cavendish banana intervention to lower blood pressure. The mechanism of hypertension management is influenced by the content of active compounds found in bananas, such as potassium and fiber. Potassium and fiber have also been shown to regulate blood volume and cardiovascular health. The mechanism of blood pressure reduction in this intervention is influenced by bioactive components in bananas, such as potassium and fiber, which play a role in regulating blood volume and its impact on the cardiovascular system [20]. Significant changes in blood pressure in the intervention group confirm that banana consumption can be a primary choice of therapy to overcome hypertension.

Prior to treatment, the intervention group's mean diastolic blood pressure was higher (96.17), compared to the control group (93.3). The mean systolic blood pressure in the intervention group, which was higher (91.00) than in the control group (93.20), was significantly decreased following therapy. This explains why the changes in diastolic blood pressure were better in the intervention group than in the control group. The decrease in blood pressure in the intervention group showed that the treatment provided benefits for better blood pressure management. In line with previous research which explains that education-based interventions can improve patients' self-skills in controlling high blood pressure [24]. Other interventions (education and social support) also showed positive signs for overcoming hypertension [25].

Diastolic blood pressure is a useful predictor of mortality in certain populations, for example, in patients undergoing intracerebral haemorrhage [26]. The decrease in cardiovascular risk is also associated with a decrease in systolic and diastolic blood pressure. This is also evidence that better blood pressure control leads to decreased morbidity and mortality in hypertensive patients [26-27]. A more substantial approach regarding the consumption of high potassium foods may also reduce the risk of hypertension in various demographic groups [28]. The right intervention is basically able to lower blood pressure. This was revealed in another study which showed that a structured diet approach such as the Dietary Approaches to Stop Hypertension (DASH) diet was able to provide real results related to a significant decrease in systolic and diastolic blood pressure [28].

Systolic blood pressure ($p < 0.001$) and diastolic blood pressure ($p = 0.002$) in the intervention group before and after treatment were found to be impacted by treatment. Systolic blood pressure ($p = 0.086$) and diastolic blood pressure ($p = 0.102$) did not significantly alter in the control group compared to the intervention group. The difference between the two groups showed that there was a significant difference between the intervention and control groups before ($p < 0.001$) and after treatment ($p < 0.001$). This finding confirms that the active compounds in Cavendish banana are important and crucial for the management of hypertension. Previous studies support this finding by stating that the fiber, potassium and natural antioxidant content in Cavendish banana significantly contribute to lowering blood pressure [29].

The absence of significant changes in the control group also provides insight into the need for specific interventions to lower blood pressure. Previous studies have also shown that maintaining a diet without any specific modifications results in minimal effects on blood pressure control [30]. Therefore, these findings should receive more serious attention in order to improve blood pressure control outcomes. These findings emphasize the importance of a high-potassium diet in lowering blood pressure.

Limitation

We did not measure the dehydration status of the study participants, which may have influenced the results. However, none of the participants had signs of severe dehydration based on our objective observations. However, we recognize that this is important to measure in future studies to maximize the accuracy of the results.

Conclusion

Consuming Cavendish banana had a significant impact on hypertension management. Cavendish banana had high potassium (458 mg per 100 g) and carbohydrates (22.9 g per 100 g) contents. High levels of potassium and carbohydrates play an important role in cardiovascular health. The underlying mechanism is the dilation of blood vessels and the reduction of renin-angiotensin activity by these two nutrients. In addition, fiber (2.8 g per 100 g) in Cavendish banana can stabilize blood sugar, which ultimately plays a role in lowering blood pressure. Flavonoids, saponins, polyphenols, and tannins are also important phytochemical components of Cavendish banana. These substances show anti-inflammatory and antioxidant properties and can reduce oxidative stress as part of the cause of hypertension. This study confirms that high-potassium diet-based interventions can be an effective strategy to lower blood pressure compared with approaches without dietary modification. It also proves that potassium-rich foods and active compounds need to be introduced to improve the quality of life of patients with hypertension.

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Author for Correspondence:

Dr. Marjes Netro Tumurang, Department of Nursing, Poltekkes Kemenkes Manado, Manado-95263 (North Sulawesi) Indonesia

E-mail:marjesntumurang@gmail.com

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