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Unveiling the Mineral Composition: Potassium and Magnesium Levels in Musa Paradisiaca L. Varieties from Medan's Traditional Markets Using Atomic Absorption Spectrophotometry

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ABSTRACT

Bananas are rich in nutrients, particularly vitamin C, starch, sugar, fiber, and serve as an affordable source of vitamins, minerals, and energy for the community. The mineral content in fresh bananas includes zinc, selenium, phosphorus, manganese, iron, copper, and calcium. Consuming bananas for magnesium intake is particularly important. A single fresh banana contains 27 mg of magnesium. This study was conducted in the laboratory of the Faculty of Pharmacy using the Atomic Absorption Spectrophotometry (AAS) method, which is relatively fast and capable of measuring metal concentrations at low and specific levels for each element without requiring separation. The analysis results of potassium and magnesium in Ambon Bananas, Banten Bananas, Barangan Bananas, Kepok Bananas, Lilin Bananas, Mas Bananas, Raja Bananas, and Horn Bananas showed potassium levels of (367.1354 ± 1.4227) mg/100g; (412.7505 ± 0.9358) mg/100g; (386.6516 ± 0.6478) mg/100g; (413.2283 ± 0.6933) mg/100g; (405.5700 ± 0.7744) mg/100g; (417.1851 ± 0.5417) mg/100g; (374.8651 ± 0.6505) mg/100g; and (340.4262 ± 0.7292) mg/100g, respectively. The magnesium levels were found to be (44.2010 ± 0.1073) mg/100g; (57.9526 ± 0.0986) mg/100g; (45.9309 ± 0.0907) mg/100g; (82.8869 ± 0.2170) mg/100g; (79.2840 ± 0.0987) mg/100g; (59.1938 ± 0.0792) mg/100g; (76.8133 ± 0.0939) mg/100g; and (55.1193 ± 0.0734) mg/100g, respectively. The high potassium and magnesium levels found in this quantitative analysis indicate that bananas are highly beneficial for individuals with hypertension.

Keywords: Banana, Potassium, Magnesium, Atomic Absorption Spectrophotometry

ABSTRAK

Pisang memiliki nilai gizi tinggi terutama vitamin C, pati, serat gula dan merupakan sumber vitamin, mineral dan energi bagi masyarakat dengan harga relatif murah. Kandungan mineral dalam pisang segar yang terkandung di dalamnya antara lain seng (zinc), selenium, fosfor (phosphorus), mangan (manganese), besi (iron), tembaga (copper), dan kalsium. Mengonsumsi buah pisang sebagai asupan magnesium sangat penting dalam satu buah pisang segar mengandung magnesium sebanyak 27 mg. Penelitian ini dilakukan di laboratorium fakultas farmasi dengan menggunakan metode Spektrofotometri Serapan Atom (teknik AAS) karena pelaksanaannya relatif cepat dan alat ini mampu mengukur kadar logam dalam konsentrasi rendah dan spesifik untuk setiap unsur tanpa diperlukan pemisahan. Hasil analisis kalium dan magnesium pada Pisang Ambon, Pisang Banten, Pisang Barangan, Pisang Kepok, Pisang

Lilin, Pisang Mas, Pisang Raja, dan Pisang Tanduk menunjukkan kadar kalium sebesar (367,1354 ± 1,4227) mg/100g; (412,7505 ± 0,9358) mg/100g; (386,6516 ± 0,6478) mg/100g; (413,2283 ± 0,6933) mg/100g; (405,5700 ± 0,7744) mg/100g; (417,1851 ± 0,5417) mg/100g; (374, 8651 ± 0,6505) mg/100g; (340,4262 ± 0,7292) mg/100g. Kadar magnesium sebesar (44,2010 ± 0,1073) mg/100g; (57,9526 ± 0,0986) mg/100g; (45,9309 ± 0,0907) mg/100g; (82,8869 ± 0,2170) mg/100g; (79,2840 ± 0,0987) mg/100g; (59,1938 ± 0,0792) mg/100g; (76,8133 ± 0,0939) mg/100g; (55,1193 ± 0,0734) mg/100g. Dengan tingginya kadar kalium dan magnesium yang diperoleh dari analisis kuantitatif yang dilakukan menunjukkan bahwa pisang sangat baik diberikan bagi penderita hipertensi.
Kata Kunci: Pisang, Kalium, Magnesium, Spektrofotometri Serapan Atom

1. Introduction

Bananas are a vital food source for humans. A single banana can contain 11 mg of calcium, 35 mg of phosphorus, 1 mg of iron (Fe), 503 mg of potassium, 1 mg of niacin, 260 IU of vitamin A, and 14 mg of vitamin C [6]. Fresh bananas are among the tropical fruits rich in calories and contain the right amounts of minerals and vitamins, making them particularly beneficial for health. The mineral content in fresh bananas plays a crucial role in supporting the body's immune system, helping to prevent illness. Among these minerals, phosphorus and magnesium are the most abundant [11]. Minerals are essential elements for the proper functioning of certain enzymes and are critical in regulating the composition of body fluids, which make up 65% of body weight. The minerals required by humans are classified into two groups: macro minerals and micro minerals. Macro minerals are those present in relatively high quantities (more than 0.05% of body weight) in body tissues, while micro minerals, also known as trace elements, are present in quantities less than 0.05% of body weight [2].

Potassium, an electrolyte present in bananas, has several interconnected functions within the body. It plays a crucial role in supporting mineral functions involved in the body's metabolic processes [11]. Given that bananas are readily available in Indonesia, they are an effective source of potassium, which offers numerous health benefits. Potassium, in particular, is vital for the proper functioning of nerve and muscle cells, especially those in the heart. Consequently, individuals with hypokalemia (a condition characterized by low potassium levels in the blood) are often advised by doctors to consume bananas. Higher levels of potassium in the body can significantly reduce the risk of heart attacks and strokes by balancing the effects of sodium. Regular consumption of bananas can decrease the risk of stroke by up to 40% [6].

Increasing potassium (K) intake can help lower high blood pressure. Epidemiological studies indicate a negative relationship between potassium consumption and hypertension in both individuals with normal and high blood pressure. It is also suggested that a higher K/Na ratio may play a more significant role in reducing hypertension. Foods rich in potassium, such as bananas and melons, are recommended [7]. The human body contains approximately 2.6 mg of potassium per kilogram of lean body mass, primarily found in nerve and muscle cells, with smaller amounts present in extracellular fluid. Within intracellular fluid, potassium is an essential cation, similar to sodium, playing a key role in pH balance and osmolarity [9].

Magnesium is the second most abundant cation in intracellular fluid after sodium and is involved in numerous metabolic processes. About 60% of the 20-28 mg of magnesium in the body is stored in bones and teeth, 26% in muscles, and the remaining portion in other soft tissues and body fluids [1]. Some experts suggest that magnesium is more crucial than calcium, as it aids in controlling heart and muscle contractions and relaxation, maintaining normal nerve function, regulating blood sugar levels, supporting protein and energy production, ensuring strong bones, and contributing to a healthy immune system. Magnesium content is particularly important for heart health [11] [13].

The average daily magnesium requirement in Indonesia is approximately 4.5 mg per kilogram of body weight. For adult men, this equates to around 280 mg per day, and for adult women, about 250 mg per day. Under normal bodily conditions, it is estimated that the body contains approximately 0.5 grams of magnesium per kilogram of lean tissue, with around 60% of this stored in bone tissue. It is believed that one-third of the magnesium in the body combines with phosphate, while the remaining amount is free, attached to the surface of mineral structures. The magnesium that attaches to bone surfaces is typically easily exchangeable with small amounts of magnesium present in the extracellular fluid [9].

Given the relationship between potassium and magnesium, the author is interested in studying the levels of these minerals in various types of bananas available in Medan City markets, specifically Ambon bananas, Banten bananas, Barangan bananas, Kepok bananas, Wax bananas, Mas bananas, Raja bananas, and Horn bananas.

2. Method

2.1. Research Design

Sampling was conducted in several markets across Medan City, including Aksara Market, Setia Budi Morning Market, Petisah Market, Peringgan Market, Sei Sikambing Market, and Sukarame Market. The sampling method used is purposive sampling, also known as judgmental sampling. In this approach, samples are selected based on the consideration that the population is homogeneous, ensuring that the samples not chosen share the same characteristics as those being studied [10].

2.2. Research Location and Time

The study was carried out at the Research Laboratory of the Faculty of Pharmacy, University of North Sumatra.

2.3 Tools

The equipment utilized in this study included an atomic absorption spectrophotometer with an air-acetylene flame and a potassium and magnesium cathode lamp, along with hot plates, an analytical balance, a blender, Whatman no. 42 filter paper, evaporating dishes, a stainless steel knife, a spatula, glass bottles, and various glassware.

2.4. Reactor

The materials used in this research were of pro-analysis quality from E. Merck, including 65% w/v nitric acid, demineralized water, a 1000 µg/mL potassium standard solution, and a 1000 µg/mL magnesium standard solution.

2.5. Sample Preparation

The sample used was fresh bananas with the peel removed. A total of 400 grams was weighed, and then the sample was blended until it became smooth.

2.6. Research procedure

2.6.1. Wet Digestion Process

The mashed banana sample was weighed to 25 grams and placed into an Erlenmeyer flask, followed by the addition of 25 ml of 65% w/v HNO3. The mixture was then left for 24 hours to accelerate the digestion process. After 24 hours, the sample was heated on a hot plate until the solution became a clear light yellow color. The solution was then transferred into a 100 ml volumetric flask, and the Erlenmeyer flask was rinsed with demineralized water. The rinse water was added to the volumetric flask, and the volume was adjusted to the mark with demineralized water. The solution was then filtered using Whatman filter paper no. 42, discarding the first 5 ml of the filtrate. The final digested solution was used for the quantitative analysis of potassium and magnesium using an atomic absorption spectrophotometer.

2.6.2. Preparation of Potassium Calibration Curve

5 ml of the potassium standard solution (1000 ppm) as LIB I was pipetted, put into a 100 ml volumetric flask, then added with aqua demineralisata to the mark line (50 ppm concentration) as LIB II. From the LIB II solution (50 ppm) pipette 1.0 ml each; 2.00 ml; 3.0 ml; 4.00 ml; 5.0 ml was put into a 25 ml volumetric flask, then filled with aqua demineralisata to the mark line to obtain a solution with a concentration of 2.0 µg/mL; 4.0 µg/mL; 6.0 µg/mL; 8.0 µg/mL; 10 µg/mL. Then the potassium calibration curve was measured at a wavelength of 766.5 nm with an air-acetylene flame type [4].

2.6.3. Preparation of Magnesium Calibration Curve

The standard solution of magnesium (1000 ppm) as LIB I was pipetted in 5 mL, put into a 100 mL volumetric flask, then added with aqua demineralisata until the mark line (concentration 50 ppm) was used as LIB II. From the LIB II solution (50 ppm) pipette 0.5 mL each; 1.0 mL; 1.5 mL; 2.0 mL and 2.5 mL, then put into a 50 mL volumetric flask then add enough aqua demineralisata to the mark line to obtain a solution with a concentration of 0.5 μg/mL; 1.0 μg/mL; 1.5 μg/mL; 2.0 μg/mL and 2.5 μg/mL. Then the magnesium calibration curve was measured at a wavelength of 285.2 nm with an air-acetylene flame type [4].

2.6.4. Determination of Potassium and Magnesium Levels

0.5 ml of the digestion solution was put into a 100 ml volumetric flask and diluted with aqua demineralisata to the mark line (Dilution Factor = 100 ml/0.5 ml = 200 times) for measuring potassium and magnesium levels. The absorbance of the solution was measured using an atomic absorption spectrophotometer at a wavelength of 766.5 nm for potassium and 285.2 nm for magnesium.

2.6.5. Calculation of Potassium and Magnesium Levels in Samples

Potassium and magnesium levels in the sample can be calculated in the following way:

$$\text{Level } (\mu g/g) = \frac{C \times V \times Fp}{W}$$

Information:

C = Metal concentration in sample solution (μg/mL)
V = Volume of sample solution (mL)
Fp = Dilution factor
W = Sample weight (g)

2.7. Statistical Data Analysis

According to Gandjar, the levels obtained from the measurement results of each sample solution were analyzed statistically by calculating the standard deviation using the following formula:

$$SD = \sqrt{\frac{\sum (Xi - \bar{X})^2}{n-1}}$$

Information:

Xi = Sample concentration
$\bar{X}$ = Sample average concentration
n = Number of repetitions

The levels obtained from the measurement results of each of the six sample solutions were tested statistically using the t test.

To find out whether data is rejected or accepted, the t test can be calculated using the formula:

$$t_{hitung} = \frac{|Xi - \bar{X}|}{\frac{SD}{\sqrt{n}}}$$

The test results or tcount values obtained are reviewed against the t distribution table, if t count > t table then the data is rejected.

According to Sudjana, to determine the level of a substance in a sample with a 99% confidence interval, α = 0.01, dk = n-1, the formula can be used:

$$\mu = \bar{X} \pm t_{\left(\frac{1}{2}\alpha, dk\right)} \frac{SD}{\sqrt{n}}$$

Information:

μ = metal content
$\bar{X}$ = average concentration of the sample
t = price t table corresponds to dk = n-1
α = level of trust
SD = standard deviation
n = number of repetitions

2.8. Validation of Analysis Methods

2.8.1. Recoverability Test

The recovery test is carried out by determining the metal content in the sample, then determining the metal content in the sample after adding a known amount of standard solution. The standard solution added was 2 ml of potassium standard solution (concentration 1000 ppm) for the potassium recovery test and 2 ml of magnesium standard solution (1000 ppm concentration) for the magnesium recovery test. Repeated 6 (six) times.

Then the percentage of recovery test is calculated using the formula:

% Recovery =

$$\frac{\text{kadar zat setelah ditambahkan standar} - \text{kadar zat dalam sampel}}{\text{kadar standar yang ditambahkan dalam sampel}} \times 100\%$$

2.8.2. Accuracy Test (Precision)

Test accuracy or precision is measured as relative standard deviation or coefficient of variation. Accuracy or precision is a measure that shows the degree of agreement between individual test results when a method is carried out repeatedly for homogeneous samples. Relative standard deviation values that meet the requirements indicate the thoroughness of the method used [5].

According to Harmita, the formula for calculating relative standard deviation is:

$$\text{RSD} = \frac{\text{SD}}{\bar{\text{X}}} \times 100\%$$

Information :

$\bar{x}$: Average concentration of the sample
SD : Standard Deviation
RSD : Relative Standard Deviation

2.8.3. Determination of Limit of Detection (LOD) and Limit of Quantitation (LOQ)

The limit of detection or Limit of Detection (LOD) is the smallest amount of analyte in a sample that can be detected which still provides a significant response, while the limit of quantitation (LOQ) is the smallest quantity of analyte in a sample which can still meet the careful and thorough criteria.

The detection limit can be calculated based on the Standard Deviation (SD), response and standard linearity slope with the formula:

Standard Deviation (SD) : $\sqrt{\frac{\sum(\text{Y}-\text{Yi})^2}{\text{n}-2}}$

Limit of Detection (LOD) : $\frac{3 \times \text{SD}}{\text{Slope}}$

Limit Quantitative (LOQ) : $\frac{10 \times \text{SB}}{\text{Slope}}$ [5].

2.8.4 Testing the Difference in Average Values

According to Sudjana, the samples being compared are independent and the number of observations each is smaller than 30 and the variance (σ) is unknown so an F test is carried out to find out whether the variances of the two populations are the same (σ1 = σ 2) or different (σ1 ≠ σ 2) by using the formula:

$$\text{Fo} = \frac{S1^2}{S2^2}$$

Information :

Fo = Difference in calculated values
S1 = Sample standard deviation (mg/100 g)
S2 = Sample standard deviation (mg/100 g)

If the results obtained Fo do not exceed the critical value F then continue the test with the t distribution with the formula:

$$\text{to} = \frac{(\bar{\text{X}}1 - \bar{\text{X}}2}{\text{Sp}\sqrt{\frac{1}{\text{n}1}+\frac{1}{\text{n}2}}}$$

$$\text{Sp} = \sqrt{\frac{(\text{n}1-1)\text{S}1^2 + (\text{n}2-1)\text{S}2^2}{\text{n}1+\text{n}2-2}}$$

Information :

X1 = average concentration of sample (mg/100 g)
X2 = average concentration of sample (mg/100 g)
Sp = standard deviation (mg/100 g)
n1 = number of sample repetitions
n2 = number of sample repetitions
S1 = Sample standard deviation (mg/100 g)
S2 = Sample standard deviation (mg/100 g)

And if Fo passes the critical value F then continue testing with the t distribution with the formula:

$$to = \frac{(\overline{X1} - \overline{X2})}{Sp\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

Information :

X1 = Average concentration of sample (mg/100 g)
X2 = Average concentration of sample (mg/100 g)
Sp = Standard deviation (mg/100 g)
n2 = Number of sample repetitions
S1 = Sample standard deviation (mg/100 g)
S2 = Sample standard deviation (mg/100 g)

The two samples are declared different if the t obtained exceeds the critical value t, and vice versa.

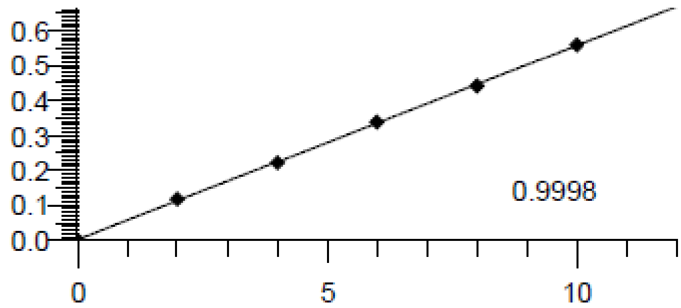
3. Results and Discussion

3.1. Potassium and Magnesium Calibration Curves

Calibration curves for potassium and magnesium were obtained by measuring the absorbance and standard solutions at a wavelength of 766.5 nm for potassium and 285.2 nm for magnesium. The potassium and magnesium calibration curves can be seen in Figure 1 and Figure 2 below.

a. Y = 0.055512857

Absorbance

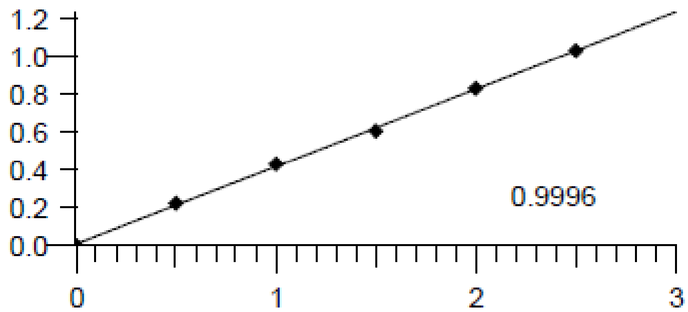


Concentration (ppm)

Figure 1. Potassium Calibration Curve

b. Y = 0.409708571

Absorbance



Concentration (ppm)

Figure 2. Magnesium Calibration Curve

Based on the curve above, a linear relationship is obtained between concentration and absorbance with a correlation coefficient (r) of 0.9998 for potassium and 0.9996 for magnesium. The best r value is close to 1, this shows a positive correlation between concentration and absorbance [4].

3.2. Determination of Potassium and Magnesium Levels

Examination of potassium and magnesium levels was carried out using atomic absorption spectrophotometry at a wavelength of 766.5 nm for potassium and 285.2 nm for magnesium. Potassium and magnesium levels were obtained from the regression line equation of the standard solution.

Table 1. Results of quantitative analysis of potassium and magnesium

Sample	Potassium Level (mg/100 g)	Magnesium Levels (mg/100g)
Ambon banana	367.1355 ± 1.4228	44.2011 ± 0.1074
Bantam Banana	412.7506 ± 0.9359	57.9527 ± 0.0987
Banana Barangan	386.6517 ± 0.6478	45.9309 ± 0.0908
Banana Kepok	413.2283 ± 0.6933	82.8869 ± 0.2170
Banana Wax	405.5700 ± 0.7744	79.2841 ± 0.0987
Banana Mas	417.1852 ± 0.5418	59.1938 ± 0.0792
Plantain	374.8652 ± 0.6505	76.8134 ± 0.0939
Banana Horn	340.4262 ± 0.7293	55.1194 ± 0.0735

Table 1. Above, it can be seen that bananas contain large amounts of potassium and magnesium. These results indicate that there are significant differences in potassium and magnesium levels in the banana samples studied. With the high levels of potassium and magnesium obtained from the quantitative analysis carried out, it shows that bananas are very good for people with hypertension.

3.3. Recoverability Test

Table 2. Percent of Potassium and Magnesium Recovery Tests

Sample	Metal	Recovery (%)
Plantain	Potassium	98.43 %
	Magnesium	100.71 %

Table 2. Above, it can be seen that the average recovery test results for potassium and magnesium in bananas are 98.43% and 100.71%. This percent recovery shows good work accuracy when examining potassium and magnesium levels in samples. The results of this recovery test meet the predetermined accuracy requirements, the average recovery results are in the range of 80-120% [3].

Precision Test

From calculations carried out on data from measurements of potassium and magnesium levels in bananas, standard deviation (SD) values were obtained of 1.92 for potassium and 1.04 for magnesium. And the relative standard deviation (RSD) value is 1.95% for potassium and 1.03% for magnesium. According to Harmita, the relative standard deviation (RSD) value for analytes with parts per million (ppm) levels is no more than 16% and for analytes with parts per billion (ppb) levels the RSD is no more than 32%. The results obtained show that the method used has good precision.

Detection Limit (Limit of Detection) and Limit of Quantitation (Limit of Quantitation)

Based on the potassium and magnesium calibration curve data, the detection limit (LOD) and quantitation limit (LOQ) were obtained. From the calculation results, it was obtained that the LOD for measuring potassium was 0.2183 µg and for magnesium it was 0.0916 µg, while the LOQ was 0.7278 µg for potassium and 0.3055 µg/ml for magnesium. From the calculation results it can be seen that all the results obtained from sample measurements are above the detection limit and quantitation limit./ml/ml/ml

4. Conclusion

From the research results, the public can be informed about the differences in potassium and magnesium mineral levels in the types of bananas circulating in the city of Medan, so that the public can know which type of banana is best to consume as a source of potassium and magnesium minerals which can lower blood pressure. It is recommended for people to consume bananas as additional food because they contain high levels of potassium and magnesium minerals which are good for people who have hypertension problems. Significant results were obtained from the differences in potassium and magnesium levels found in the banana samples studied.

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