

Evaluating the Efficacy of *Moringa oleifera* L. Tea on Fasting Blood Glucose in Diabetes Mellitus Patients Undergoing Metformin and Glimepiride Therapy

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Abstract

Background: The increasing prevalence of Diabetes Mellitus necessitates comprehensive management based on four pillars. Standard pharmacological therapy, which typically involves a combination of metformin and glimepiride, can be supplemented with complementary therapies. Herbal ingredients are one form of complementary therapy that can be consumed by individuals with Diabetes Mellitus. Moringa leaves (*Moringa oleifera* L.) have potential as a complementary therapy for controlling blood glucose levels, as they contain antioxidant compounds capable of neutralizing free radicals, thereby improving insulin sensitivity. **Methods:** This research was a cross-sectional study. Research data were taken from secondary data on diabetes mellitus sufferers at the Sidabowa Clinic, Banyumas Regency, who consumed Moringa leaf tea at a dose of 5.32 grams/day for 14 days. The subjects numbered 17 respondents. The data analysis used was the Kruskal-Wallis nonparametric test. **Key findings:** The median fasting blood glucose level in the group of respondents who regularly drink Moringa leaf tea is 130.5 (112-154) mg/dL, in those who do not regularly drink it is 129 (113-177) mg/dL, and in those who do not drink Moringa leaf tea at all is 149 (78-363) mg/dL. The results of the Kruskal-Wallis nonparametric test show a p-value of 0.772. **Conclusions:** There is no significant difference in fasting blood glucose levels among the groups who regularly drink, do not regularly drink, and do not drink Moringa leaf tea in Diabetes Mellitus sufferers at the Sidabowa Clinic, Banyumas Regency.

Keywords: diabetes mellitus, metformin, glimepiride, fasting blood glucose levels, moringa leaf tea

Introduction

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia or increased blood glucose levels due to impaired insulin secretion, insufficient production, or resistance to insulin. There are two main types of diabetes mellitus, namely type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) [1]. Diabetes mellitus is a chronic non-communicable disease [2]. The incidence of diabetes mellitus continues to increase every year, both in Indonesia and globally. Data show that in 2013 there were 382 million people with diabetes worldwide, which then increased to 415 million in 2015, 425 million in 2017, and reached 463 million in 2019. This number is projected to continue rising to 578 million by 2030 and 700 million by 2045. In Indonesia, according to the Basic Health Research (Riskesdas) data, the prevalence of diabetes mellitus in 2018 reached 8.5%, up from 6.9% in 2013. In 2019, the number of people with diabetes mellitus in Indonesia was

estimated at 10.7 million, and projected to increase to 16.6 million by 2045 [3]. In Banyumas Regency, there are 25,744 people with diabetes mellitus, with 24,600 of them, or about 95.6%, having received appropriate management [4]. The management of diabetes mellitus must be carried out comprehensively in accordance with the four pillars of diabetes management, which include education, lifestyle changes such as exercise, diet, and the use of oral antihyperglycemic drugs as the main approach. Metformin and Glimepiride are the most commonly used combination oral antihyperglycemic drugs. Metformin belongs to the biguanide group, which can lower blood sugar levels without causing hypoglycemia [5]. Metformin works by inhibiting the process of gluconeogenesis in the liver, thereby reducing glucose production and increasing insulin sensitivity to facilitate the utilization of glucose by peripheral tissues. On the other hand, glimepiride is classified as a sulfonylurea, which acts by stimulating the release of insulin from the granules of β Langerhans cells

in the pancreas [6]. Metformin and glimepiride are often used as combination therapy in diabetes patients because their mechanisms of action complement each other and are synergistic. The routine or adherence to taking metformin and glimepiride is an important factor in determining the success of therapy [7].

In addition to pharmacological therapy, there are many other natural ingredients that can be used as adjunct therapies for people with diabetes mellitus. One that is easily obtained is moringa leaves. Moringa leaves contain various bioactive components and antioxidants that function as antidiabetics, such as polyphenols [8]. All parts of the moringa plant can be utilized or consumed, but the leaves are the most commonly used part due to their high protein content and antioxidant compounds such as isothiocyanates, which have anti-carcinogenic and antibiotic properties [9]. Previous studies have also shown that moringa leaves contain a variety of nutrients and bioactive compounds such as vitamins, carotenoids, polyphenols, phenolic acids, flavonoids, alkaloids, glucosinolates, isothiocyanates, tannins, and saponins. The main flavonoids found in moringa leaves include myricetin, quercetin, and kaempferol, with quercetin being the prominent antioxidant. Studies also reveal that quercetin has potential as a hypolipidemic, hypotensive, and anti-diabetic agent, as demonstrated in trials on Zucker rats [10].

Moringa leaves are increasingly being utilized by the public in various processed forms of food or beverages that are easy to consume. One of the most common preparations of moringa leaves is in the form of tea. Moringa leaf tea is made by drying fresh moringa leaves to be brewed with boiling water into tea. The purpose of drying the moringa leaves is to preserve the active compounds within them [10]. A study revealed that respondents with hyperglycemia who were given moringa leaf tea as an intervention experienced a significant decrease in fasting blood glucose levels two hours after consumption [8]. Previous research has generally focused only on the compound content of moringa leaf tea as an antidiabetic, without considering the routine of its consumption. Based on these findings, this study aims to explore the relationship between regular consumption of moringa leaf tea among individuals with diabetes mellitus and their fasting blood glucose levels.

Rofianti and Septiani (2022) conducted research on the impact of moringa leaf tea consumption on blood glucose levels in patients with type 2 diabetes mellitus in the working area of the Cakung Community Health Center, East Jakarta. One of the inclusion criteria in this study was DM patients who used metformin as a blood sugar-lowering medication. The results showed that patients who consumed moringa leaf tea along with metformin experienced a more significant decrease in blood glucose

levels than those who only took metformin. This indirectly demonstrates that the antidiabetic compounds in moringa leaf tea enhance the hypoglycemic effect of metformin when taken together [10]. The main antidiabetic compound believed to strengthen the hypoglycemic effect in DM patients is quercetin, a type of flavonoid compound [11]. However, research on the relationship between moringa leaf tea and blood glucose levels in diabetes patients undergoing therapy with metformin and glimepiride is still limited.

Given the issues outlined above, it is important to explore whether the consumption of moringa leaf tea can provide additional benefits for fasting blood glucose levels in patients already receiving standard pharmacological therapy. Therefore, this study aims to determine the relationship between moringa leaf tea consumption and fasting blood glucose levels in diabetes mellitus patients undergoing therapy with metformin and glimepiride. The results of this study are expected to provide additional information on the potential benefits of moringa leaf tea in DM management and offer guidance for patients and healthcare practitioners in selecting safe and effective adjunct therapies.

Materials and Methods

This study uses an analytical observational method with a cross-sectional approach, conducted by collecting and observing secondary data in the form of assessment results on the regularity of Moringa leaf tea consumption and fasting blood glucose levels in diabetes mellitus patients undergoing metformin and glimepiride therapy at Klinik Pratama Sidabowa, Banyumas Regency. The regularity of Moringa leaf tea consumption was assessed based on the number of tea bags (1 dose) consumed by patients, categorized as regular if patients consumed at least 80% of the 28 tea bags provided, irregular if consumption was less than 80% of the total tea bags provided, and as not consumed if the patient did not drink any of the tea bags provided. The study population consisted of type 2 diabetes mellitus prolans patients at Klinik Pratama Sidabowa, Patikraja District, Banyumas Regency, whose data were available in medical records. The samples for this study were type 2 diabetes mellitus prolans patients at Klinik Pratama Sidabowa, Patikraja District, Banyumas Regency, whose data were available in medical records and who met the inclusion criteria. The independent variable was the level of regularity in Moringa leaf tea consumption and the dependent variable was fasting blood glucose level. The sampling technique used was total sampling with a sample size of 17.

Tools and Materials

The data collection tools used consist of information in the form of respondents' personal data, data on medication ad-

herence levels measured using the MMAS-8 questionnaire, and the types of antihyperglycemic drugs consumed to categorize inclusion criteria, data on the regularity of consuming moringa leaf tea based on a checklist table of the number of tea bags consumed over 14 days, and data from fasting blood glucose test results.

Research Process

The research was conducted from September 21 to October 5, 2024. The study began with obtaining permission to access data on type 2 diabetes mellitus prolanis patients at Sidabowa Primary Clinic, Banyumas Regency. Next, data was collected on patient identities, results of medication adherence levels measured using the MMAS-8 questionnaire, and information related to the types of antihyperglycemic drugs consumed by the patients. After that, the samples obtained were sorted according to inclusion and exclusion criteria. Then, from the selected samples, data was collected on the regularity of consuming moringa leaf tea based on a checklist table of the number of tea bags consumed over 14 days, as well as data from the most recent fasting blood glucose measurement. The collected data was processed and analyzed to determine the relationships between the variables.

Data Analysis

The collected data were analyzed using univariate and bivariate methods. Univariate analysis shows the distribution of research subject characteristics and research variable data, which are presented in table form. The distribution of subject characteristic data includes gender, age, last education, occupation, and duration of diabetes mellitus, while the distribution of research variable data includes the assessment results of routine moringa leaf tea consumption and respondents' fasting blood glucose levels. Bivariate analysis was conducted to test the significance of the relationship between moringa leaf tea consumption and fasting blood glucose levels in diabetes mellitus patients undergoing metformin and glimepiride therapy at Sidabowa Primary Clinic, Banyumas Regency, using the nonparametric Kruskal-Wallis test.

Results

Analysis was conducted on 17 samples that met the inclusion criteria and had complete sample data. Based on Table 1, the characteristics of respondents were dominated by females, totaling 13 individuals (76.5%). The most common age group among respondents in this study was ≥ 65 years old, with 9 individuals (52.9%). The highest level of education was junior high school, dominating among respondents with 8 individuals (47.1%). The most common occupation was housewife, with 10 respondents (58.8%). Individuals who had been suffering from diabetes mellitus for ≥ 5 years formed the majority, totaling 9 people

(52.9%). Regarding the habit of drinking moringa leaf tea, the majority of respondents in this study did not drink moringa leaf tea, totaling 8 people (47.1%).

Based on Table 2, the lowest median fasting blood glucose level was found in the group that did not regularly drink moringa leaf tea, which was 129 (112-154) mg/dL. Meanwhile, the highest median fasting blood glucose level was found in the group that did not drink moringa leaf tea at all, which was 149 (78-363) mg/dL. Table III shows that using the nonparametric Kruskal-Wallis statistical analysis, a p-value of 0.772 ($p > 0.05$) was obtained, indicating that there is no significant relationship between moringa leaf tea consumption and fasting blood glucose levels in diabetes mellitus patients at the Sidabowa Clinic, Banyumas Regency. However, based on the results, respondents who regularly and irregularly drank moringa leaf tea had lower median fasting blood glucose levels compared to the group of respondents who did not drink moringa leaf tea.

Discussion

In this study, the distribution of research subjects between males and females was dominated by females, totaling 13 individuals (76.5%), because in general, the number of DM Prolanis participants at Sidabowa Primary Clinic is dominated by women. In addition, according to data from the 2018 Basic Health Research (Riskesdas), the prevalence of diabetes mellitus in Central Java is higher among women than men, at 40.17% and 34.83% respectively. (Darmawan, 2019). The majority of respondents in this study were aged ≥ 65 years, totaling 9 people (52.9%), as almost all active DM sufferers in the Prolanis program are those over 50 years old. The highest level of education among the respondents was junior high school (SMP), with 8 people (47.1%), as most sufferers are elderly people in rural areas whose economic status falls into the lower-middle category, so at that time, many could only attain education up to junior high school or even elementary school. The most common occupation among respondents was housewife, with 10 people (58.8%), as the study sample was predominantly elderly women. Individuals who had suffered from DM for ≥ 5 years dominated, with 9 people (52.9%). Based on the respondents' characteristics concerning the regular consumption of moringa leaf tea, most did not drink moringa leaf tea, totaling 8 people (47.1%). This may be because moringa leaf tea is still considered new to them, so some people might still be hesitant to use it as a complementary therapy.

Based on Table 3, the group of respondents with the lowest fasting blood glucose levels were those who did not regularly drink moringa leaf tea, with a median fasting blood glucose level of 129 (113-177) mg/dL, while the highest fasting blood glucose levels were found in the gro-

up that did not drink moringa leaf tea at all, with a median of 149 (78-363) mg/dL. Meanwhile, the group of respondents who routinely drank moringa leaf tea had fasting blood glucose levels similar to the non-regular drinkers, with a median of 130.5 (112-154) mg/dL.

Nonetheless, according to the nonparametric statistical test using Kruskal-Wallis, there was no significant difference in fasting blood glucose levels among respondents who routinely drank, did not routinely drink, and did not drink moringa leaf tea at all, with a p-value of 0.772.

Table 1 Characteristics of Research Respondents

	Variable	Frequency	Percentage
Gender	Male	4	23,5%
	Female	13	76,5%
Age	≥65 years old	9	52,9%
	<65 years old	8	47,1%
Last Education	Elementary School	4	23,5%
	Junior High School	8	47,1%
	Senior High School	2	11,8%
	Diploma/bachelor's degree	3	17,6%
Work	Retiree	5	29,4%
	Private sector employee	2	11,8%
	Housewife	10	58,8%
Suffering from diabetes mellitus	≥5 years old	9	52,9%
	<5 years old	8	47,1%
The Habit of Drinking Moringa Leaf Tea	Routine	4	23,5%
	Not Routine	5	29,4%
	Did Not Drink	8	47,1%

Table 2 Characteristics of Respondents Based on Fasting Blood Glucose Levels

Group	N	Median	Minimum	Maximum
Regularly Drinking Moringa Leaf Tea	4	130.5	112	154
Not Regularly Drinking Moringa Leaf Tea	5	129	113	177
Not Drinking Moringa Leaf Tea	8	149	78	363

Table 3 The Relationship between Moringa Leaf Tea Consumption and Fasting Blood Glucose Levels

Group	N	GDP levels (mg/dL)	P-value
Regularly Drinking Moringa Leaf Tea	4	130.5 (112-154)	0.772
Not Regularly Drinking Moringa Leaf Tea	5	129 (113-177)	
Not Drinking Moringa Leaf Tea	8	149 (78-363)	

This finding is not in line with the study by Rofianti and Septiani (2022), which stated that there was a relationship between the provision of moringa leaf tea and blood glucose levels in pre-elderly and elderly individuals in the working area of Cakung District Health Center, with a p-value of 0.01. The difference in results may be due to the different methods used. The study by Rofianti and Septiani (2022) used an experimental design with a pretest-posttest control group involving 30 samples. The study measured

initial blood glucose levels (pretest) three hours after eating in both the intervention and control groups. Then, the intervention group was given 3 grams of dried moringa leaves brewed with 200 ml of boiling water, and after two hours, blood glucose levels were measured again in both groups. The results showed that in the intervention group, the average initial blood glucose was 241.93 mg/dL and the final was 211.13 mg/dL, while in the control group, the average initial was 227.4 mg/dL and the final was 210.4

mg/dL. The average difference in blood glucose levels in the intervention group was greater compared to the control group (p-value = 0.01) [10]. Meanwhile, our study used an analytic observational design that compared fasting blood glucose levels among groups who routinely, irregularly, and did not drink moringa leaf tea after consuming moringa leaf tea for two weeks at a dose of 5.32 grams/day. In this study, only the final fasting blood glucose levels were measured after two weeks of consuming moringa leaf tea; therefore, changes in respondents' fasting blood glucose levels before and after consuming moringa leaf tea could not be analyzed.

Furthermore, in the study by Rofianti and Septiani (2022), the final blood glucose level was measured exactly two hours after administering moringa leaf tea, which is theoretically based on the bioavailability of EGCG (epigallocatechin-3-gallate) contained in moringa leaves, as it will reach its peak in the blood plasma one to two hours after consumption. EGCG plays a role in maintaining the antioxidant compounds in moringa leaves and will increase insulin sensitivity in body tissues, so when its level peaks in the blood plasma, its effect in lowering blood glucose levels will also be at its maximum [10].

This study also does not align with the research conducted by Mujianti and Sukmawati (2018), which stated that there is a significant relationship between the consumption of moringa leaf tea and fasting blood glucose levels in adult women with prediabetes. The differences between our study and theirs are, first of all, seen in the characteristics of the samples used. Although Mujianti and Sukmawati (2018) used a smaller sample size—only 12 samples compared to our 17 samples—the sample characteristics in their study were more homogeneous, consisting only of women aged 20-60 years with prediabetic conditions (FBG 100-125 mg/dL) [8]. Meanwhile, in our study, the sample characteristics were too diverse, so a larger sample size would have been necessary to ensure the data were normally distributed.

In addition, Mujianti and Sukmawati's (2018) study used a longer research duration, namely 28 days, by measuring fasting blood glucose levels before and after administering moringa leaf tea, allowing them to analyze the changes in respondents' fasting blood glucose levels before and after consuming the moringa leaf tea. In contrast, this study used a duration of 14 days, and fasting blood glucose levels were only measured after consuming moringa leaf tea and then compared between the three different groups. The reason for using a 14-day duration for administering moringa leaf tea to respondents was based on the research by Laksana et al. (2022) on white rats that had previously been conducted. That study found that administering a moringa leaf tea extract dose of 250 mg/kgBW/day for 14 days was effective in reducing oxidative stress in the liver, which is an important organ for regulating blood glucose levels [12]. Therefore, in this

study conducted on human subjects, the duration and dosage referred to were those that had been converted to human doses in hopes of providing the same effectiveness as shown in studies on rats. However, many external factors were not controlled in this study with human subjects, which affected the lack of significant association between moringa leaf tea consumption and fasting blood glucose levels. Although different results were shown, findings from the study by Laksana et al. (2022) regarding the effectiveness of moringa leaf extract in reducing oxidative stress in white rats, which impacted blood sugar, indicate the potential of moringa leaf tea in lowering fasting blood glucose in humans. This suggests that under certain conditions, consumption of moringa leaf tea may provide a positive effect in reducing blood glucose levels, but further research using stricter methods such as experimental or clinical trials accompanied by control of external factors that may influence the study outcomes is needed.

The management of diabetes mellitus is carried out simultaneously through four main pillars consisting of education, medical nutrition therapy or dietary regulation, physical exercise or sports, and pharmacological therapy. Research conducted by Duri et al. (2024) on the effectiveness of adherence to the implementation of the four pillars of diabetes mellitus in relation to blood glucose and HbA1c levels in patients with type 2 diabetes mellitus found that there is a relationship between adherence to the four pillars of diabetes mellitus management and blood glucose and HbA1c levels, with a p-value of 0.000 ($p < 0.05$). Type 2 diabetes mellitus is a complex disease, therefore it requires comprehensive management according to the PERKENI 2021 guidelines, which is through the four pillars of diabetes mellitus management [13]. In line with the research by Fardiansyah (2020), which states that there is a difference in blood sugar levels in DM patients before and after counseling on the four pillars of diabetes mellitus management, with a p-value of 0.000 ($p < 0.05$) [14]. Thus, the management of diabetes mellitus can be effective if carried out comprehensively and holistically in accordance with the PERKENI 2021 guidelines through the four pillars of diabetes mellitus management.

Of these four pillars, this study only observed one pillar, namely related to the pharmacological therapy of metformin and glimepiride with the adjuvant therapy of moringa leaf tea, without considering or controlling the other three pillars. In fact, according to the PERKENI 2021 consensus, the management of diabetes mellitus must be carried out holistically, comprehensively, and simultaneously according to the four pillars described previously. Therefore, the lack of significant results in this study may be influenced by the insufficient control of complex external factors that affect DM patient management. Hence, future research should consider cont-

rolling dietary patterns, physical activity, and education in accordance with the four pillars of diabetes mellitus management in order to thoroughly understand the effects of moringa leaf tea for people with diabetes mellitus.

Conclusion

The group of respondents who regularly drank moringa leaf tea and those who did not drink moringa leaf tea regularly had lower fasting blood glucose levels than the group that did not drink moringa leaf tea at all. However, statistically, there was no significant relationship between moringa leaf tea consumption and fasting blood glucose levels in diabetes mellitus patients at the Sidabowa Primary Clinic, Banyumas Regency.

Supplementary Material

None

Author Contributions

MIB : Conceptualization, Methodology, Writing-Original Draft. **LKB** : Conceptualization, Data Curation, Formal Analysis, Visualization. **MAW** : Conceptualization, Supervision, Writing- Review & Editing. **ASD** : Conceptualization, Supervision, Writing- Review & Editing. **PS** : Conceptualization, Supervision, Writing-Review & Editing. **SC** : Supervision, Writing- Review & Editing. All authors should have approved the final version of the manuscript and agree to be accountable for their contributions.

Conflict of Interest

The authors have no financial conflicts of interest to declare.

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