Research Paper

The Effect of Red Ginger Extract, Klanceng Honey, and Their Combination on Blood Sugar, Cholesterol, and Blood Viscosity of Patients With Diabetes Mellitus

Mardi Hartono[1*], Sunarto Sunarto[2], Supriyo Supriyo[1], Sudirman Sudirman[1], Maslahtul Inayah[1]

1. Department of Nursing, Ministry of Health Polytechnic of Health, Central Java, Indonesia.
2. Department of Nutrition, Ministry of Health, Central Java, Indonesia.

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ABSTRACT

Background: The prevalence of diabetes mellitus (DM) is increasing, especially in low- and middle-income countries. DM leads to changes in blood sugar, cholesterol levels, and blood viscosity. Therefore, seeking alternative medicine with active ingredients to lower blood sugar levels, cholesterol, and blood viscosity is crucial. This study investigated the effects of red ginger extract and Klanceng honey on blood sugar levels, cholesterol, and blood viscosity in diabetic patients with hyperglycemia and hypercholesterolemia in Pekalongan City, Central Java, Indonesia.

Methods: This quasi-experimental study employed a pre-test, post-test design. The subjects were diabetic patients with hyperglycemia and hypercholesterolemia. Thirty participants were randomly assigned to three groups (ginger group, honey group, and combination of ginger and honey group), each with 10 subjects. The dose of red ginger extract was 60 mg/d, while the dose of Klanceng honey was 1 mL/kg/d. The subjects consumed 3-4 capsules of ginger extract, 15-20 mL of Klanceng honey (based on their weight), or a combination of ginger and Klanceng three times a day for 7 consecutive days. SPSS software, version 22 was used to analyze the data. Bivariate and mathematical general linear models (GLM) were applied with a significance level of 0.05.

Results: The combination of red ginger and Klanceng honey significantly reduced blood sugar levels (P=0.001; 95% CI, 10.20%, 28.80%), cholesterol (P<0.001; 95% CI, 9.44%, 25.16%), and blood viscosity (P< 0.001; 95% CI, 1.63%, 3.17%) compared to giving Klanceng honey or red ginger alone. A mathematical GLM analysis, controlling for pre-treatment blood values, showed that the combination of red ginger and Klanceng honey reduced blood sugar by 6.89% compared to Klanceng honey and 0.01% compared to red ginger alone. It also lowered cholesterol by 4.00% compared to Klanceng honey and 1.50% compared to red ginger alone. The combination of red ginger and Klanceng honey also reduced viscosity by 3.98% compared to Klanceng honey and by 1.53% compared to red ginger alone.

Conclusion: The combination of red ginger extract and Klanceng honey was more effective in reducing blood sugar, cholesterol, and blood viscosity than Klanceng honey and red ginger extract. People with hyperglycemia and hyperlipidemia may use the combination of red ginger extract and Klanceng honey to regulate blood sugar, cholesterol, and viscosity. Healthcare providers may recommend this complementary therapy for patients who benefit from it. Further studies with larger sample sizes and longer treatment periods may be useful to obtain more precise results.

*** Corresponding Author:**
Mardi Hartono
Address: *Department of Nursing, Ministry of Health Polytechnic of Health, Central Java, Indonesia.*
Tel: *+62 (858) 69865022*
E-mail: mardihartono20@gmail.com

Highlights

Ginger and honey are well-known for their use as alternative medicine for diabetic patients.

This study revealed that the combination of red ginger extract and Klanceng honey was more effective in reducing blood sugar, cholesterol, and blood viscosity in diabetic patients than administering either Klanceng honey or red ginger extract alone.

Further studies with larger sample sizes and longer treatment periods may be beneficial for obtaining more precise results.

Plain Language Summary

The incidence of diabetes mellitus (DM) is increasing, particularly in developing countries, including Indonesia. Ginger and honey are easy to find in Indonesia. Interestingly, both can be used as alternatives and traditional therapies for patients with DM. The objective of this study was to investigate the effect of red ginger and Klanceng honey on reducing blood sugar, viscosity, and cholesterol levels in patients with DM. The results of this study show that the combination of red ginger extract and Klanceng honey reduces blood sugar, cholesterol, and blood viscosity more than Klanceng honey and red ginger extract alone. Healthcare providers, especially those living in Indonesia, can also consider red ginger and Klanceng honey as complementary therapies when managing patients with DM. Moreover, the government or relevant stakeholders can incorporate the use of red ginger and Klanceng honey into nutrition education programs for patients with DM.

Introduction

The prevalence of diabetes has surged from 108 million in 1980 to 422 million in 2014, with a sharper increase observed in low- and middle-income nations compared to their high-income counterparts (WHO, 2023). The International Diabetes Federation (IDF) reported that the global prevalence of diabetes among individuals aged 20-79 in 2021 is estimated to be 10.5% (536.6 million people), and is projected to increase to 12.2% (783.2 million) by 2045. The national prevalence of diabetes in Indonesia is estimated at 6.2% in 2019 and 10.8% in 2021, placing the country among the top 10 countries with the highest prevalence of type 2 diabetes mellitus (T2DM) and also with the steepest rise (IDF, 2022). As of 2021, the prevalence of diabetes among the Indonesian population aged 20–79 years was 10.5% (World Bank, 2021). Between January and July 2021, 751 patients sought treatment for metabolic disorders in the Bendan Health Center area of Pekalongan City, Central Java, Indonesia (Bendan Public Health Centre, 2021).

Diabetes mellitus (DM) significantly contributes to blindness, kidney failure, heart attacks, strokes, and the need for lower limb amputations (WHO, 2023). Impaired glucose metabolism, resulting from insulin resistance, is a significant issue in patients with diabetes. Insulin resistance in peripheral tissues is closely related to increased lipid circulation and accumulation (Martínez & Fuerte, 2012). It will inhibit glucose transport to peripheral tissues, the initial stage of impaired glucose metabolism. Therefore, the pathophysiology of dyslipidemia is closely related to hyperglycemia (Muoio & Neufer, 2012; Pereyra et al., 2020). Furthermore, the diagnosis of T2DM frequently results in alterations in total cholesterol (TC) levels. Consequently, for diabetic patients, controlling TC levels may be crucial for reducing the risk of cardiovascular disease (Khil et al., 2023).

Damage to insulin-producing beta cells causes a decrease in insulin production or secretion. This situation can cause hyperglycemia conditions that result in diabetes. Another condition is that patients with T2DM often exhibit increased blood viscosity, potentially posing a risk for cardiovascular complications (Sun et al., 2022). Therefore, seeking an alternative medicine that contains active ingredients that lower blood sugar levels and stimulate the regeneration of beta cells is necessary. Recently, active ingredients from several medicinal plants and foods have been reported to have beneficial biological activity for the empirical treatment of diabetes (Akamine et al., 2021).

Ginger is a well-known traditional medicine used to treat diseases. Traditionally, ginger has been used to treat rheumatic diseases, asthma, stroke, toothaches, infections, muscle pain, sore throats, cramps, hypertension, nausea, fever, and diabetes (Ali et al., 2008). The main components of ginger are essential oils (1-5%), sesquiterpenoids and monoterpenoids, including gingerols, shogaols, paradols, and zingerones (Shukla et al., 2007), which have anti-inflammatory, analgesic, anti-hypertensive, and antidiabetic effects. These benefits are closely related to the main ingredients of ginger, including gingerol and shogaol, which are abundant in both fresh and dried ginger (Abdulrazaq et al., 2012). A preclinical study evaluated the hypoglycemic potential of ginger in rats induced to have diabetes by giving fresh ginger at 500 mg/kg per day for 4 weeks. The results showed that the dose effectively reduced serum glucose, cholesterol, and triacylglycerol levels (Ebrahimzadeh et al., 2021).

The hypoglycemic effect of bioactive components in ginger contributes to the restoration of pancreatic beta cell function, leading to increased insulin secretion (Wen et al., 2022). It is also reported that most plants containing flavonoids exhibit antidiabetic effects (Ali et al., 2018; Jorge-Montalvo et al., 2023; Mazumder et al., 2021). Ginger contains flavonoids, and in addition to lowering blood sugar levels, it can also help lower cholesterol levels. In addition to ginger, another natural ingredient that is thought to have a therapeutic effect on diabetic patients is Klanceng honey. This honey (Trigona honey) can be found in tropical countries such as Malaysia, the Philippines, and Indonesia. It can also be found in Australia. Trigona produces honey that tastes sour. The Javanese refer to it as madu Klanceng, while the Sundanese call it teuweul (Sabir & Sumidarti, 2016; Kek et al., 2014; Ismail et al., 2023). Trigona bees produce less honey and are more difficult to extract, but the propolis produced is more significant than that of other bees. Based on observations, propolis exhibits several benefits, acting as an antibody, antioxidant, antibacterial, antifungal, anticancer, antiviral, and anticoagulant (Hanafy et al., 2022; Wang et al., 2021).

The benefits of ginger and Klanceng honey have been widely studied (Agussalim et al., 2024; Jafarnejad et al., 2017; Li et al., 2012; Makhdoomi Arzati et al., 2017). However, no study has been found that simultaneously examines the effects of red ginger, Klanceng honey, and the combination of red ginger and Klanceng honey on blood sugar, cholesterol, and viscosity. This study determined the effect of red ginger, Klanceng honey, and their combination on blood sugar, cholesterol, and blood viscosity of patients with DM. It also analyzes the treatment that has the most effect on reducing blood sugar, cholesterol, and viscosity levels after being controlled, based on pre-treatment values of sugar, cholesterol, and blood viscosity.

Materials and Methods

Design, setting, and sample

It was a quasi-experimental study conducted at the Public Health Center of Bendan, Pekalongan City, Central Java, Indonesia. The study population consisted of diabetic patients with hyperglycemia and hypercholesterolemia at the Bendan Public Health Center in Pekalongan City, Central Java Province, Indonesia. The sample size was calculated using the Slovin formula (Equation 1) (Ariola, 2006):

$$1.\ n=\frac{N}{1+N(e)^2}$$

, where n refers to the number of samples, N is the population, and e denotes the margin of error as 0.2.

$$n=751$$

$$1+751\times(0.2)^2=751$$

$$=751/31.04$$

$$=24$$

Due to the possibility of sample attrition, 30 subjects were considered. Thirty respondents were initially recruited based on the inclusion criteria and then randomly divided into three groups. The first 10 patients who arrived were assigned to the ginger group, the next 10 to the honey group, and the following 10 to the ginger and honey combination group. The inclusion criteria were as follows: Aged 40–69, experiencing hyperglycemia and hypercholesterolemia, complete adherence to the treatment schedule, and voluntary agreement to participate. Data from patients with hyperglycemia and hypercholesterolemia were collected at the Bendan Public Health Center in Pekalongan City, Central Java. Before starting the treatment, the participant's blood was tested in a trusted Laboratory, Gadjah Mada Laboratory, Pekalongan City. The exclusion criteria included only one increase in glucose or cholesterol, as well as unstable conditions such as diabetic patients with gangrenous wounds or those in shock due to hypoglycemia or hyperglycemia.

Variables and measurements

The independent variables were the administration of red ginger extract, Klanceng honey, and a combination of red ginger and Klanceng honey. The dependent variables were sugar, cholesterol, and blood viscosity levels. These variables were measured in the same trusted laboratory, namely the Gadjah Mada laboratory in Pekalongan City, Central Java, Indonesia. The dependent variables were measured twice: Before the intervention and at the endpoint of the experiment (7 days after the initiation of the treatments). Blood sugar levels were measured in milligrams per deciliter (mg/dL). The TC level was also calculated in milligrams per deciliter (mg/dL). Blood viscosity was measured using a blood sedimentation rate examination in mL/h.

We also used a questionnaire containing questions about age, gender, diet history, family history of diabetes, activity level, and occupation. Diet history is divided into "practicing diet rule" for those who strictly adhere to a daily healthy diet and "not practicing diet rule" for those who do not follow a specific diet. For family history, those who had a family member with DM were grouped as "yes," while those who had no family member with DM were grouped as "no." The typical daily activities were grouped into "light activity" and "moderate to heavy activity." Light activity involves more fine motor movements, such as eating, drinking, and watching television. Meanwhile, heavy activity refers to activities that involve gross motor movements, such as walking and sports.

Data collection

Once ethical approval was granted, the researchers contacted the Community Health Center (Puskesmas) and nurses who served as gatekeepers. The nurses effectively communicated with respondents through regular activities for older adults in the area, specifically community-based services known as the integrated service post for the elderly.

Researchers and nurses distributed the treatment materials to the respondents and explained the rules for taking the treatment provided to each group. The treatment materials consisted of ginger, honey, and a combination of ginger and honey produced by the Scientific Center for "Jamu" in Pekalongan City, Central Java. Jamu is a local term referring to herbal medicine, and the Government of Pekalongan City owns the center. Ginger was prepared in capsules containing 300 mg ginger extract powder and honey, in liquid form, with a 10 mL bottle packaging. At the same time, the ginger and honey combination was prepared in a mixed package containing 3000 mg of ginger powder and 50 mL of liquid honey. The dosage of the treatment was based on previous studies in this field. The dosage of red ginger extract was 60 mg/kg (body weight)/d (Widiyastuti et al., 2012), while for Klanceng honey, the dose was 1 mL/kg (body weight)/d (Muntafiah et al., 2017; Wardani et al., 2016; Conte et al., 2022). The combination treatment group received two joint treatments, including red ginger extract and Klanceng honey, at the specified dosage. The participants took ginger extract 3-4 capsules three times a day (with the total dosage of ginger around 900-1200 mg depending on the participant's body weight), Klanceng honey 15-20 mL three times a day (with the total dosage of honey around 45-60 mL depending on the participant's body weight), or a combination of ginger and Klanceng for 7 consecutive days. During the study period, researchers and nurses monitored respondents by making daily phone calls and guiding them to take ginger or honey as per the research protocol. Nurses and researchers arranged regular meetings with the respondents every three days. Patient compliance in the study was measured or monitored based on their consumption of ginger extract, Klanceng honey, or a combination of both. Compliance was defined as fully following the planned intervention, while non-adherence was noted if the patient failed to comply with the intervention for even a single day.

During the treatment, the patients also received medication from the doctor, including antidiabetics and anticholesterolemic agents. The interval for administering ginger and honey was 3 hours after the patient took the medication prescribed by the doctor. Giving an interval time was crucial to prevent interaction between medicines and supplements. The patients were encouraged to engage in physical exercise and reduce their sugar consumption. Pre-treatment measurements of blood sugar, cholesterol, and viscosity data were taken on the first day before treatment began. The post-treatment measurements of blood sugar, cholesterol, and blood viscosity were taken seven days after treatment (Dahliansyah & Petrika, 2020).

Data analysis

The data were analyzed using SPSS software, version 22. Univariate analysis was used to analyze the distribution and percentage of the data related to sociodemographic characteristics. Bivariate analysis techniques were performed using dependent and independent t-tests with an α of 0.05. A dependent t-test was used to analyze

the mean of blood test results before and after treatment. Multivariate analysis was also performed using the general linear model (GLM), which controls the test based on pre-treatment values.

Normality of the data

The distribution of sample characteristic data in each group was tested using the Shapiro-Wilk test (Table 1).

Table 1 indicates that the data on viscosity, blood sugar, and cholesterol are normally distributed. Thus, a t-test could be performed to prove the effect of the treatment, which was controlled by pre-treatment data.

Results

Homogeneity of the sample

Homogeneity of demographic characteristics, as well as dependent variables, before the intervention is shown in Table 2 using analysis of variance (ANOVA) and the Fisher exact tests. Data analysis revealed a significant difference between the groups only in terms of cholesterol levels and blood viscosity before the intervention. Thus, the effect of treatment on cholesterol levels and blood viscosity must be controlled to obtain the net effect of treatment.

Comparing blood sugar levels between the three groups before and after the treatment

Figure 1a. shows that before the treatment, the mean blood sugar level in the red ginger group was 327 mg/dL, and after treatment, it decreased significantly to 310 mg/dL. For the Klanceng honey group, the mean blood sugar level before the treatment was 277 mg/dL, and after treatment, it decreased slightly to 270 mg/dL. The highest decrease was observed in the combination therapy group, which was 274 mg/dL before the treatment and 256 mg/dL after the treatment. A different level of initial blood sugar affected the final blood sugar levels; therefore, to test the effect of treatment on blood sugar, a multivariate t-test must be carried out while controlling for pre-treatment data.

Comparing cholesterol levels between the three groups before and after the treatment

Figure 1b shows that the mean blood sugar level in the red ginger group was 352 mg/dL before the treatment, which decreased slightly to 334 mg/dL after the treatment. For the Klanceng honey group, the mean cholesterol level was 282 mg/dL before the treatment, and it decreased slightly to 272 mg/dL after the treatment. The highest decrease was observed in the combination therapy group, which decreased from 267 mg/dL before treatment to 238 mg/dL after treatment.

Table 1. Normality test results of viscosity, blood sugar level, and cholesterol level in each treatment group

Variables		The Shapiro-Wilk		
		Statistic	df	P
Blood sugar after treatment	Combination of red ginger and Klanceng honey	0.94	10	0.601
	Red ginger	0.88	10	0.131
	Klanceng honey	0.87	10	0.096
Cholesterol level after treatment	Combination of red ginger and Klanceng honey	0.91	10	0.301
	Red ginger	0.89	10	0.181
	Klanceng honey	0.97	10	0.857
Blood viscosity after treatment	Combination of red ginger and Klanceng honey	0.92	10	0.331
	Red ginger	0.94	10	0.522
	Klanceng honey	0.97	10	0.895

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Table 2. Homogeneity of the sample characteristics according to the groups (n=10)

Variables		Mean±SD/No. (%)			P
		Variable Group			
		Combination of Red Ginger and Klanceng Honey	Red Ginger	Klanceng Honey	
Age (y)		57.6±5.68	51.8±7.45	56.6±6.19	0.121*
Blood sugar level before treatment		274.1±40.35	327.0±140.78	277.0±80.01	0.398*
Cholesterol level before treatment		267.0±48.77	352.0±80.11	281.9±63.21	0.016*
Blood viscosity level before treatment		40.9±8.29	28.0±1.15	28.5±2.46	<0.001*
Sex	Male	1(10)	2(20)	1(10)	1.000**
	Female	9(90)	8(80.0	9(90)	-
Diet history	Practicing a diet rule	7(70)	8(80)	8(80)	1.000**
	Not practicing the diet rule	3(30)	2(20)	2(20)	-
Family history of DM	Yes	9(90)	8(80)	8(80)	1.000**
	No	1(10)	2(20)	2(20)	-
Typical of daily activity	Light activity	5(50)	6(60)	6(60)	1.000**
	Moderate to heavy activity	5(50)	4(40)	4(40)	-
Occupation	Employed	5(50)	4(40)	4(40)	1.000**
	Not employed	5(50)	6(60)	6(60)	-

*One-way ANOVA, **The Fisher exact test.

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Comparing blood viscosity between the three groups before and after the treatment

Figure 1c. shows that the mean blood viscosity level in the red ginger group was 28 mm/h before treatment, and it decreased slightly to 25.9 mm/h after treatment. For the Klanceng honey group, the mean cholesterol level was 28.5 mm/h before the treatment, and it was reduced somewhat to 26.5 mm/h after the treatment. The highest decrease was observed in the combination therapy group, which decreased from 40.9 mm/h before the treatment to 27.4 mm/h after the treatment.

Different initial values of cholesterol and blood viscosity could have affected the final results of these variables. Thus, multivariate tests and control pre-treatment data will be used to test the effect of treatment.

Multivariate analysis

The effect of treatment on lowering blood sugar

Controlling pre-treatment blood sugar levels is crucial in assessing the net impact of treatment on blood sugar levels. Figure 2 shows that all treatment groups started with similar blood sugar levels (292.7 mg/dL). Blood sugar levels decreased to 275.4 mg/dL with red ginger, 286.4 mg/dL with Klanceng honey, and 275.0 mg/dL with their combination. GLM analysis reveals significant treatment differences (Table 3). The combination of red ginger and Klanceng honey reduced blood sugar by 6.89% compared to Klanceng honey alone and by 0.01% compared to red ginger alone.

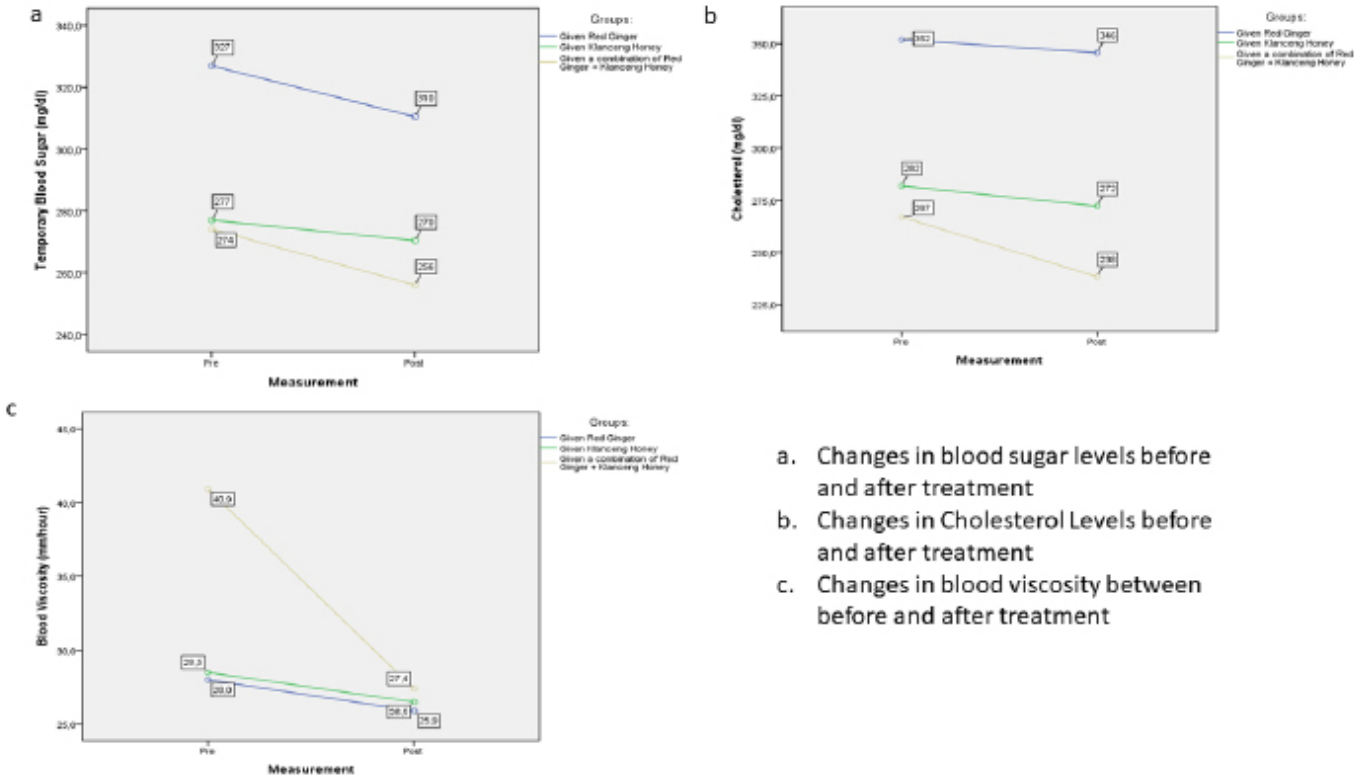

Figure 1. The changes in the sugar, cholesterol, and blood viscosity levels before and after the treatment

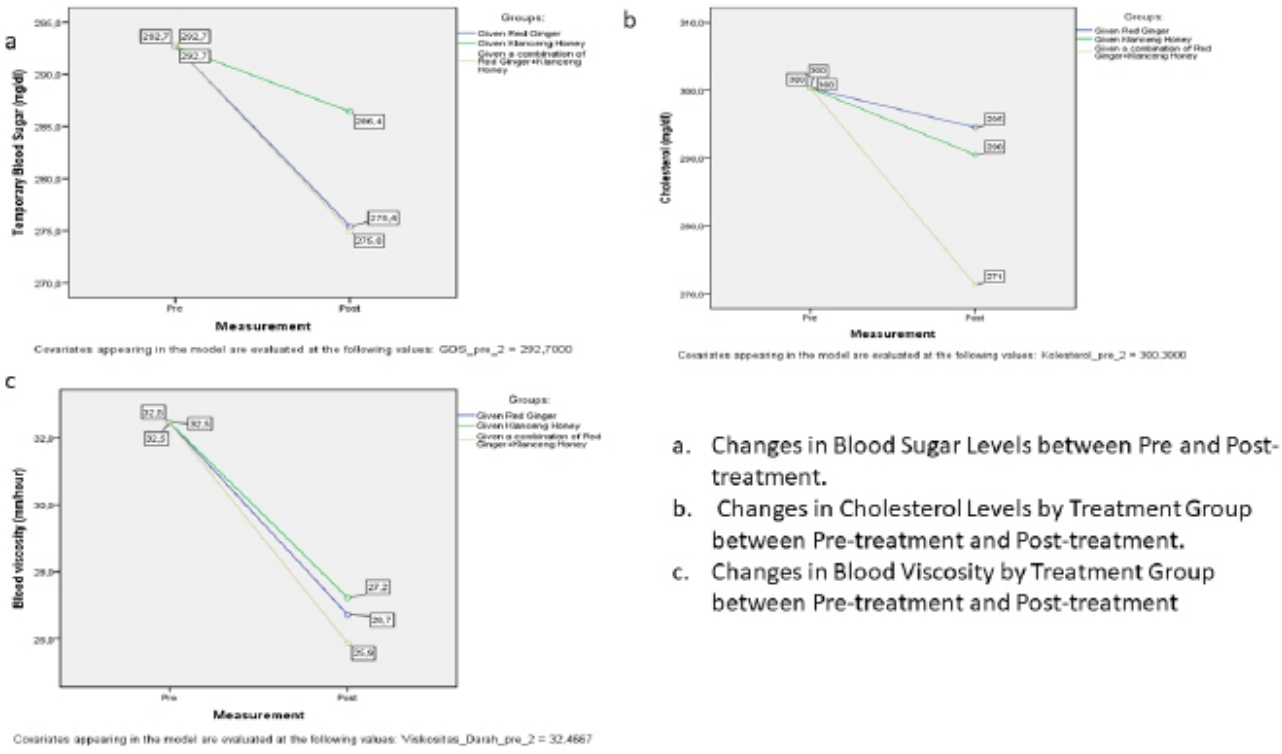

Figure 2. The changes in blood sugar, cholesterol, and blood viscosity levels before and after the treatment, after controlling for pre-treatment data

Table 3. Effects of treatment on decreasing blood sugar, cholesterol, and blood viscosity

Variables		Mean Pre-Treatment	Mean Post-Treatment	Std. Error	t	P	95% CI		Partial Eta Squared (%)
							Lower	Upper	
Blood Glucose	Red ginger	327	310	8.47	0.05	0.959	-16.96	17.84	0.01
	Klanceng honey	277	270	8.24	1.39	0.177	-5.51	28.36	6.89
	Combination of red ginger and Klanceng honey	274	256	4.11	4.74	0.001	10.2	28.8	Control group
Cholesterol	Red ginger	352	346	1.34	0.64	0.530	-1.9	3.6	1.5
	Klanceng honey	282	272	1.31	1.04	0.309	-1.33	4.05	4.0
	Combination of red ginger and Klanceng honey	267	238	3.47	4.98	<0.001	9.44	25.16	Control group
Blood viscosity	Red ginger	28	25.9	1.34	0.64	0.530	-1.9	3.6	1.53
	Klanceng honey	28.5	26.5	1.31	1.04	0.309	-1.33	4.05	3.98
Combination of red ginger and Klanceng honey		40.9	27.4	0.34	7.06	<0.001	1.63	3.17	Control group

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The effect of treatment on lowering cholesterol levels

To evaluate the impact of treatments on lowering cholesterol, pre-treatment cholesterol levels were controlled to ensure consistent analysis. Figure 2 shows that all groups started with similar cholesterol levels (300.0 mg/dL). The combination of red ginger and Klanceng honey significantly reduced cholesterol to 271.0 mg/dL, compared to 290.0 mg/dL with Klanceng honey and 295.0 mg/dL with red ginger. GLM analysis (Table 3) revealed that the combination reduced cholesterol by 4.00% compared to Klanceng honey alone and 1.50% compared to red ginger alone.

The effect of treatment on decreasing blood viscosity

To assess the impact of treatments on reducing blood viscosity, pre-treatment blood viscosity levels (32.5 mm/h) were controlled for consistent multivariate analysis. Figure 2 shows that the combination of red ginger and Klanceng honey significantly reduced blood viscosity to 25.9 mm/h, compared to 26.7 mm/h with red ginger alone and 27.2 mm/h with Klanceng honey alone. GLM analysis, adjusted for pre-treatment levels, revealed that the combination reduced viscosity by 3.98% compared to klanceng honey alone and 1.53% compared to red ginger alone (Table 3).

Table 3 also reveals that the combination of red ginger and Klanceng honey significantly lowered blood sugar levels (P=0.001; 95% CI, 10.20%, 28.80%) compared to Klanceng honey alone (P=0.177; 95% CI, -5.51%, 28.36%) or red ginger alone (P=0.959; 95% CI, -16.96%, 17.84%). This combination also effectively reduced cholesterol (P<0.001, 95% CI, 9.44%, 25.16%), exceeding the effect of Klanceng honey alone (P=0.309; 95% CI, -1.33%, 4.05%) and red ginger alone (P=0.530; 95% CI, -1.90%, 3.60%). Additionally, it significantly decreased blood viscosity (P<0.001; 95% CI, 1.63%, 3.17%) compared to Klanceng honey (P=0.309; 95% CI, -1.33%, 54.05%) or red ginger (P=0.530; 95% CI, -1.90%, 3.60%) alone.

Discussion

This study aimed to evaluate the effects of red ginger extract and Klanceng honey on blood sugar levels, cholesterol, and blood viscosity in diabetic patients with hyperglycemia and hypercholesterolemia.

Effect of treatment on lowering blood sugar

This study demonstrated that the combination of red ginger extract and Klanceng honey had a more effective reduction in blood sugar levels than the group that received either ginger or Klanceng honey alone. Ginger contains gingerol, an anti-inflammatory and antioxidant compound that provides renoprotective effects (Prom-

dam & Panichayupakaranant, 2022). The primary phenolic compounds found in ginger, including gingerols and shogaols, showed biological activities such as antidiabetic (Mao et al., 2019). Gingerols, such as 6-gingerol, 8-gingerol, and 10-gingerol, are the predominant polyphenols in fresh ginger. When subjected to heat or prolonged storage, gingerols can convert into shogaols (Mao et al., 2019).

On the other hand, honey also contains significant antioxidants such as ascorbic acid, flavonoids, phenolic acids, and carotenoids, as well as organic acids, amino acids, and proteins. The antioxidant effects of honey make it very beneficial in managing DM (Gül & Pehlivan, 2018). The effects of flavonoids on blood sugar have also been demonstrated through studies in rats. The flavonoids act by either inhibiting glucose absorption or improving glucose tolerance. Another benefit is that flavonoids can stimulate glucose uptake in peripheral tissues, regulate the activity and expression of enzymes involved in carbohydrate metabolism pathways, and act like insulin by affecting the insulin signaling mechanism, thereby decreasing blood sugar levels (Guan et al., 2023; Ayoub et al., 2023). Thus, the combination of ginger and Klanceng honey strongly reduces blood sugar as they combine active compounds from ginger (gingerol) and honey (antioxidants and flavonoids). These components work together to protect plasma insulin levels, reduce inflammation, improve glucose tolerance, and stimulate glucose uptake in peripheral tissues, all contributing to lowering blood sugar levels.

Effect of treatment on lowering cholesterol

This study revealed that the combination of red ginger extract and Klanceng honey was more effective in reducing cholesterol levels than the group that received only ginger or Klanceng honey. Ginger has gingerol and shogaol, which are flavonoid compounds (Mao et al., 2019).

Previous studies have shown that ginger, which contains flavonoids and phenols, has a cholesterol-lowering effect that can suppress the activity of the enzyme CoA reductase (HMG-CoA). This action can reduce the biosynthesis of TC at a dose of 3.2 mL/kg (body weight)/d in dyslipidemic patients (Qing et al., 2024). Studies indicate that caffeic acid phenethyl ester in propolis has stronger antioxidant activity than vitamin E and can enhance the expression of glucose-6-phosphate dehydrogenase, an antioxidant gene. Caffeic acid phenethyl ester is 4-6 times more effective against H_2O_2 and O_2^- radicals than vitamin C and N-acetyl-cysteine (Ahmed et al., 2023; Li et al., 2021). Reducing free radicals helps prevent oxidative stress and inhibits the increase in cholesterol.

Effect of treatment on lowering blood viscosity

This study also revealed that the combination of red ginger extract and Klanceng honey was more effective in reducing blood viscosity. As mentioned earlier, ginger has gingerol and shogaol, which are flavonoid compounds. Meanwhile, propolis has a wide range of beneficial effects, including boosting antibodies, providing antioxidant and anti-inflammatory properties, offering anti-spasm, anticoagulant, antifungal, antiviral, antiseptic, and antidiabetic effects, as well as acting as an analgesic, anticancer, antitumor, and antiallergic agent. Additionally, propolis offers benefits in tissue regeneration and repair (Suranto, 2010).

The anticoagulant potential of *Tetraponera laeviceps* propolis extract may be attributed to the active compounds within the flavonoid group, which prevent blood clotting processes. This opinion is supported by other researchers, who have stated that the flavonoid compounds in propolis extract are relatively high (Pu et al., 2023; Sahlan et al., 2021). Phytochemical compounds from the flavonoid group are used as anticoagulants. Flavonoid compounds prevent agglutination during injury (Wang et al., 2022). This process resulted in no blood clots when *T. laeviceps* propolis extract was added to 250 µL of blood. Flavonoid compounds are also often referred to as blood thinners because they can prevent blood clots (Wang et al., 2022).

The ingredients of ginger, such as 6-gingerol, alleviate LPS-induced lung injury and pulmonary edema by reducing excessive tissue factor and plasminogen activator inhibitor-1 expression, as well as collagen III levels, through the Runt-related transcription factor 1/ Nuclear factor kappa B pathway (Li et al., 2024). The ethanol extract of ginger rhizomes can act as an anticoagulant (Yang et al., 2023).

Conclusion

This study provided new insights into the effects of red ginger extract and Klanceng honey for healthcare providers and stakeholders. The findings showed that a combination of red ginger and Klanceng honey can significantly reduce blood sugar, cholesterol, and blood viscosity compared to treatment with ginger and Klanceng alone. According to the results of this study, it is recommended that the Government of the Republic of Indonesia, particularly the Ministry of Health, consider incorporating honey and

ginger into national health education for the diabetes community. Individuals with hyperglycemia and hyperlipidemia can consume red ginger extract and Klanceng honey in recommended amounts to help regulate blood sugar, cholesterol, and viscosity levels. Healthcare providers can also recommend complementary therapy using ginger and Klanceng honey for patients with hyperglycemia and hyperlipidemia. Further studies with larger sample sizes and longer treatment spans may be useful to obtain more precise results. Additionally, further research using a combination of red ginger extract with Klanceng honey may be warranted for different populations, such as individuals with cardiovascular disease who have hyperglycemia and hyperlipidemia.

Study limitations

Limitations of this study include the relatively short duration of the intervention (one week) and the relatively small sample size. Additionally, cholesterol levels were assessed based on TC. Nevertheless, this study offers new insights into health and traditional medicine, particularly in the use of herbal medicines to support the health of individuals with diabetes, high cholesterol, and high blood viscosity.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the Universitas Pekalongan, Central Java, Indonesia (Code: 050/B.02.01/KEPK/VII/2021). The purpose of the study and the possible side effects of the treatments were explained to the respondents, and informed consent was obtained. They were instructed not to continue the treatment and immediately refer to a nearest physician in case of experiencing discomfort (such as bloating or nausea) during the therapy. The subjects could withdraw from the study at any time.

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Authors' contributions

Conceptualization and funding acquisition: Mardi Hartono and Supriyo Supriyo; Data collection, methodology, resources, software, visualization, formal analysis, review and editing: Mardi Hartono; Investigation: Mardi Hartono, Sunarto Sunarto, Sudirman Sudirman and Maslahtul Inayah; Project administration, writing the original draft and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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