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The effects of glucomannan from Porang tuber (*Amorphophallus muelleri Blume*) and moringa leaf extract (*Moringa oleifera*) on hemoglobin levels and blood viscosity in obese rats

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Abstract

Abnormal hemoglobin levels and blood viscosity in obese individuals can lead to severe health complications. This study investigates the effects of glucomannan from Porang tubers and Moringa leaf extract on hemoglobin and blood viscosity in obese rats. The objective was to evaluate the impact of these compounds and determine the effective dosage for normalizing hemoglobin and blood viscosity levels. Twenty-four male Wistar rats, aged eight weeks and weighing between 250-275 grams, were randomly assigned to one of eight experimental groups (n=3 each). One group served as the positive control (K+) while the remaining seven were classified as the hypercholesterolemic groups on a high-fat diet (HFD). Over five weeks, the HFD received varying combinations of Porang glucomannan and Moringa extract. Blood samples were collected post-treatment for analysis. Results indicated significant differences in hemoglobin levels and blood viscosity across the various dosages of the combination treatment. Notably, the group receiving 120 mg/kg of Porang glucomannan and 80 mg/kg Moringa (P2) exhibited remarkable improvements in blood viscosity. Additionally, significant differences in hemoglobin levels were observed when comparing the K+ to the K- groups. These findings suggest that combination treatment effectively normalizes hemoglobin levels and blood viscosity in obese rats.

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Introduction

In Indonesia, the epidemiological transition has resulted in shifting disease patterns. In recent decades, non-communicable or degenerative diseases have emerged as a significant public health challenge. Research indicates that chronic degenerative diseases are rising at an alarming rate (1). While these diseases are not contagious, they are chronic conditions that include heart disease, hypertension, obesity, and diabetes. Stroke ranks as the leading cause of death in Indonesia, with obesity being the fifth leading cause. Various factors contribute to the development of degenerative diseases, with lifestyle, dietary habits, stress, physical activity, and environment and occupational influences being the primary contributors (2). Obesity is defined as an abnormal accumulation of body fat that negatively impacts health. This fat accumulation is often linked to elevated cholesterol levels and can be viewed as a component of the double burden of malnutrition. The prevalence of obesity is not limited to high-income countries; it is also a growing concern in low- and middle-income nations. A body mass index (BMI) of 25 or higher indicates being overweight, while a BMI of 30 or above classifies an individual as obese (3). Data from the Indonesian Ministry of Health reveals that 13.5% of adults aged 18 and older are classified as overweight. Furthermore, 28.7% of the population is considered obese, defined by a BMI of 25 or greater, with 15.4% of the population reaching obesity levels with a BMI

of 27 or higher, according to the RPJMN indicators from 2015 to 2019. As reported by sindonews.com, Indonesia ranks as the tenth most obese country in the world and the fourth in ASEAN region. In 2017, the Economist Intelligence Unit estimated that Indonesia allocates between 8% and 16% of its total state budget to obesity-related health care (4). Individuals with obesity face a higher risk of various health complications. Early onset obesity significantly increases the likelihood of developing cardiovascular disease in adulthood. Additional risks include high blood pressure, metabolic syndrome, thickening of blood vessel walls, endothelial dysfunction, and left ventricular hypertrophy (5). Studies indicate that obese women tend to have higher white blood cell counts and hemoglobin levels. In one study, the prevalence rates for underweight, normal weight, overweight, and obesity among women were 4.4%, 28.1%, 37.6%, and 29.9%, respectively (6). The obese group showed significantly higher hemoglobin levels and white blood cell counts compared to their non-obese counterparts. Compared to individuals with a normal BMI, those who are overweight or obese exhibited increased hemoglobin levels. Furthermore, being overweight can negatively impact blood viscosity, potentially leading to chronic conditions such as anemia, heart failure, inflammation, and kidney failure (7). Research (8) has shown a significant increase in blood viscosity across all obesity categories, with the highest viscosity levels found in individuals with upper body obesity (2.84 ± 0.08 mPa.s) compared to those with lower body obesity (3.29 ± 0.09 mPa.s), demonstrating a statistically significant difference ($P<0.05$). Obesity is influenced by a variety of interrelated factors. Dietary habits, upbringing, and genetics play indirect roles in the development of obesity. Additionally, a lack of physical activity and an unhealthy lifestyle can contribute to weight gain. In individuals with obesity, the likelihood of being overweight generally increases with age, peaking in the 40-59 age group. Women are more frequently affected by obesity, particularly among those who are homemakers (9). The World Health Organization has classified obesity as an epidemic, with over seven million deaths attributed to this condition in 2017. Data indicate that from 1975 to 2016, the prevalence of obesity in children and adolescents aged 5-19 has more than quadrupled globally, rising from 4% to 18%. This increase has been particularly pronounced in developing countries, surpassing 30%, while developed nations have seen more modest changes (10). To mitigate the risk of obesity and the chronic diseases associated with it, individuals can benefit from consuming foods that help prevent excessive weight gain. One natural solution is the porang tuber. Porang (*Amorphophallus muelleri* Blume) has gained popularity among farmers worldwide and is in high demand (11). This plant, belonging to the Araceae family, is notable for its high glucomannan content (12). Its life cycle is distinct from that of other plants, taking 38-48 months from nursery to harvest, which is divided into four growing seasons (GP). The timing of porang's use is determined by its growth periods, with GP2 and GP3 commonly utilized for industrial purposes; the highest glucomannan content is found in GP3 (13). Glucomannan is a polysaccharide that consists of a chain of galactose, glucose and mannose linkages. Known as konjac glucomannan (KGM), it is derived from porang tubers and is widely used as an ingredient in traditional Asian foods (14). The extraction of glucomannan from fresh tubers yields a highly purified product, typically processed into a flour-like substance after drying (15). In Indonesia, porang tubers are often simply processed into chips (16). The glucomannan in porang tubers has numerous health benefits, including lowering blood cholesterol and promoting a feeling of fullness, which can help reduce obesity rates and associated complications (17). Furthermore, research indicates that consuming porang jelly and inulin can support weight loss efforts, lower BMI, reduce fat, and inhibit increases in total cholesterol and triglyceride levels in adults with obesity (18). In addition to Porang, *Moringa oleifera* has been shown to provide various health benefits, particularly in the management of obesity and diabetes (19). Although Moringa is not widely recognized, especially in developing countries like Bangladesh, its potential health advantages are significant (20). Moringa (*Moringa oleifera*) is a well-regarded plant that belongs to the *Moringaceae* family (21). Research indicates that Moringa can effectively reduce obesity levels and improve metabolic disorders (22). Furthermore, studies have demonstrated that Moringa leaves possess anti-obesity and lipid-lowering properties when administered to mice on a high-fat diet, supporting previous findings. Specifically, the administration of Moringa leaves led to a significant reduction in fat tissue accumulation in obese mice. The combination of Porang glucomannan and Moringa leaf extract has shown the greatest effectiveness in combating obesity, presenting a promising approach to addressing obesity-related issues. This is further corroborated by findings (23,24) that indicate this combination effectively reduces body weight and food intake.

However, more research is needed to investigate the effects of Porang glucomannan alongside Moringa leaf extract on obesity-related factors such as hemoglobin concentration and blood viscosity. Understanding how this combination influences hemoglobin levels and blood viscosity is essential, as these factors may serve as important biomarkers in obesity management. Therefore, a thorough analysis of hemoglobin levels and viscosity in obese individuals is warranted. Consequently, the focus of this research is to examine the Hemoglobin Levels and Blood Viscosity of Obese Wistar Strain Rats Given a Combination of Porang Tuber Glucomannan (*Amorphophallus muelleri* Blume) with Moringa Leaf Extract. The primary objective of this study is to analyze how the combination of Porang tuber glucomannan (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) affects hemoglobin

levels and blood viscosity in obese Wistar strain rats. Additionally, the study aims to identify the effective dosage of this combination that can normalize hemoglobin levels and blood viscosity.

Materials and methods

Ethical approve

The animal treatment procedures adhered to established guidelines and received approval from the Research Ethics Committee of the Faculty of Medicine, Muhammadiyah University of Surakarta, with approval number 4139/A.1/KEPK-FKUMS/III/2022.

Study designs

This study utilized a randomized experimental design (RAL) with a posttest-only control group. In addition to the K+ group, which served as the positive control, and the K- group as the hypercholesterolemia control (previously treated with a high-fat diet for two weeks), several other hypercholesterolemia groups were induced using varying combinations of glucomannan (GAmB) and *Moringa oleifera* leaf extract (MoLE). A total of eight groups were included in this study: K+ (positive control) and K- (negative control with hypercholesterolemia on a high-fat diet). The dosing regimen for Porang glucomannan and Moringa leaf extract in the treatment groups was based on previous research, with modifications to include additional doses; P1: hypercholesterolemia with HFD + 100 mg/kg GamB and 100 mg/kg MoLE; P2: hypercholesterolemia with HFD + 120 mg/kg GAmB and 80 mg/kg MoLE; P3: hypercholesterolemia with HFD + 80 mg/kg GAmB and 120 mg/kg MoLE; P4: hypercholesterolemia with HFD + 50 mg/kg GamB and 50 mg/kg MoLE; P5: hypercholesterolemia with HFD + 60 mg/kg GAmB and 40 mg/kg MoLE; P6: hypercholesterolemia with HFD + 40 mg/kg GAmB and 60 mg/kg MoLE. After five weeks of the treatment, 1.5 mL of blood was collected from each rat via the orbital sinus following a 12-hour fast, and were stored in microtubes without anticoagulant.

Materials

The instruments used in this study included knives, digital scales, a flour press, sieves (mesh sizes 40 and 60), an oven, baking sheets, a centrifuge, a blender, maceration vessels, filter paper, a rotary evaporator, rat cages, oral probes, spatulas, a freeze dryer, microtubes with red lids, a hemocytometer, Hb pipettes, toothpicks, and plastic bowls. The materials comprised porang tubers, moringa leaves, 24 male Wistar strain rats, Dreagendroff reagent, ferric chloride (1% HCl), magnesium powder, 50 and 70% ethanol, distilled water, salts, BR-1 (a high-fat diet), duck egg yolk (5%), 0.1 N HCl, cow oil (20%), and 1.5 mL of white rat blood.

Sample

Male Wistar rats (*Rattus norvegicus*), averaging 162 grams in weight and eight weeks old, were obtained from CV. Dunia Kaca, accompanied by an animal health certificate from the Karanganyar District Agriculture, Food, and Fishery Office (number 696 / SKKH / VII / 2022). Inclusion criteria included male Wistar strain rats weighing between 130-160 grams at 8 weeks of age, in good health, and not previously used in research. Exclusion criteria involved any rats that died prior to data collection. The rats were housed in ventilated cages with controlled temperature, humidity, and lighting, covered with wire and containing natural zeolite.

Preparation of *Amorphophallus muelleri* Glucomannan Combined with *Moringa oleifera* Leaves

To produce porang flour, start with 15 kilograms of porang tubers, which should be cut into chips. Clean the chips thoroughly with water, then dry them in an oven at 55°C for 14 hours (25,26). After drying, blend the tubers and sieve them through an 80 mesh screen. The glucomannan extracted from the porang tubers is then purified using a ratio of 1:30 with distilled water. Further purification occurs in a hot plate mixer set to 55°C, operating at a speed of 1000-1500 rpm (27). Next, combine the filtrate with 50% ethanol in a 1:1 ratio and stir until a precipitate forms. This precipitate is then dried in an oven at 40°C for 24 hours, ground, and sieved through a 60 mesh screen. Next, prepare moringa flour by sorting and cleaning 9 kilograms of fresh moringa leaves using airflow. After cleaning, dry the leaves in an oven at 55°C for 12 hours until they become brittle. To create moringa leaf extract, macerate 800 grams of moringa flour in 70% ethanol under sealed conditions for 72 hours, stirring daily (28). After maceration, filter the extract through filter paper. The extract is then concentrated by evaporating the 70% ethanol using a rotary evaporator set to 40°C and 7 rpm. Finally, further evaporation is conducted in a water bath at 50°C until the extract thickens.

Assessment parameters

Blood samples of 1.5 mL were collected from each rat after a 5-week treatment period using a 3cc syringe through the orbital sinus. These samples were promptly analyzed for the hemoglobin (Hb) levels and blood viscosity. To determine hemoglobin levels, fill a hemocytometer diluent tube with 0.1 N HCl up to 2 mark. Use a Hb pipette to aspirate capillary blood to the 20 mark. Remove any blood clinging to the tip of the pipette before transferring it into the hemocytometer diluent tube by lightly dipping the tip into the HCl solution to prevent clotting. Aspirate the HCl back into the pipette and repeat this process three times. Allow the mixture to stand for 1-2 minutes, then dilute with distilled water drop by drop, stirring with a rod until the color matches the standard. The Hb value corresponds to the number on the hemocytometer dilution tube that aligns with the height of

the blood solution (29). To measure blood viscosity based on clotting time, drip blood from the orbital sinus onto a sterile plastic bowl and record the time from when the blood emerges until fibrils are visible. Finally, scrape the blood across the bowl's surface with a toothpick until fibrin strands appear on the tip, recording the time taken for this process (30).

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 26, and are presented as mean with standard deviations (SD). The significance of changes in hematological parameters was assessed using analysis of variance (ANOVA) followed by Dunn's post hoc test. Statistical significance was determined at a p-value of less than 0.05 (31).

Results

Following the test for hemoglobin and viscosity levels, the data were analyzed using the licensed version of the SPSS 26 statistical software package. The mean ± standard deviation (SD) values were calculated to assess the impact of Porang tuber glucomannan combined with Moringa leaf extract on hemoglobin levels and blood viscosity in obese rats (Table 1). The study included evaluations of data normality and homogeneity; however, the results indicated that the dataset was neither normally distributed nor homogeneous. As a result, non-parametric statistical methods, specifically the Kruskal-Wallis test, were employed for hypothesis testing. Both the one-way ANOVA and Kruskal-Wallis tests showed statistically significant differences in mean hemoglobin and blood viscosity levels among the groups (P≤ 0.05) (Table 1).

Table 1: Hemoglobin and blood viscosity analysis results

Groups	Variables		p values	
	Hemoglobin (g/dL)	Blood viscosity	Hemoglobin (g/dL)	Blood viscosity
K-	7.50±0.50	1.25±0.23		
K+	15.50±1.50	11.42±0.12		
P1	12.67±0.57	6.64±2.87		
P2	14.83±0.28	8.39±0.11		
P3	12.16±1.04	8.20±0.01		
P4	10.67±0.76	3.49±0.46	0.003*	0.004*
P5	8.33±0.28	2.67±0.344		
P6	9.50±0.50	3.68±0.28		

Note : *Significant (p < 0.05). Abbreviations: K+ = positive control group; K- = hypercholesterolemia with high-fat diet (HFD) negative control group; P1 = hypercholesterolemia with HFD + 100 mg/kg GamB and 100 mg/kg MoLE; P2 = hypercholesterolemia with HFD + 120 mg/kg GAmB and 80 mg/kg MoLE; P3 = hypercholesterolemia with HFD + 80 mg/kg GAmB and 120 mg/kg MoLE; P4 = hypercholesterolemia with HFD + 50 mg/kg GamB and 50 mg/kg MoLE; P5 = hypercholesterolemia with HFD + 60 mg/kg GAmB and 40 mg/kg MoLE; P6 = hypercholesterolemia with HFD + 40 mg/kg GAmB and 60 mg/kg MoLE.

Further analysis was conducted using Dunn's post hoc test to identify differences in hemoglobin and blood viscosity values between the groups. The mean hemoglobin value of the negative control group (K-) was significantly different from that of the treatment group receiving 120 mg/kg body weight (BB). Additionally, a notable difference was found in the blood viscosity value parameter for the 80 mg/kg weight (P2) treatment group. A significant difference in hemoglobin levels was also observed between the positive control group (K+) and the negative control group (K-), as illustrated in Figure 1 and detailed in Table 2. Other groups exhibited differences, but these did not reach statistical significance (Table 2).

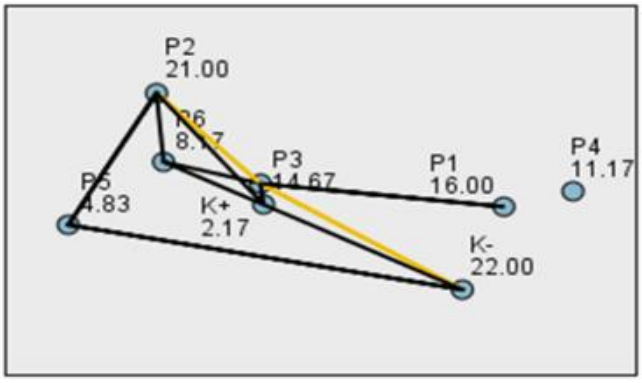

Figure 1: Average order results of treatment samples (each point represents the average order of the Porang Tuber Extract Glucomannan treatment samples combined with Moringa Leaf Extract).

Table 2: Results of Dunn's post hoc test on hemoglobin count and blood viscosity values across different groups

Group	Mean	p values
K+ vs. P5	-0.83	1
K+ vs. P6	-2	1
K+ vs. P4	-3.17	1
K+ vs. P3	-4.66	0.84
K+ vs. P1	0.86	0.45
K- vs. P2	-0.89	0.03*
K+ vs. K-	-3.92	0.01*
P5 vs. P6	4.65	1
P5 vs. P4	4.84	1
P5 vs. P3	0.13	1
P5 vs. P1	1.69	1
P5 vs. P2	-0.06	0.141
P5 vs. K-	-3.09	0.08
P6 vs. P4	6.01	1
P6 vs. P3	1.3	1
P6 vs. P1	2.86	1
P6 vs. P2	1.11	0.72
P6 vs. K-	-1.92	0.45
P4 vs. P3	2.47	1
P4 vs. P1	-0.75	1
P4 vs. P2	2.28	1
P4 vs. K-	-0.75	1
P3 vs. P1	5.52	1
P3 vs. P2	3.77	1
P3 vs. K-	0.74	1
P1 vs. P2	4.28	1
P1 vs. K-	1.25	1
P2 vs. K-	3.41	1

Note : *Significant (P<0.05). Abbreviations: K+ = positive control group; K- = hypercholesterolemia with HFD negative control group; P1 = hypercholesterolemia with HFD + 100 mg/kg GamB and 100 mg/kg MoLE; P2 = hypercholesterolemia with HFD + 120 mg/kg GAmB and 80 mg/kg MoLE; P3 = hypercholesterolemia with HFD + 80 mg/kg GAmB and 120 mg/kg MoLE; P4 = hypercholesterolemia with HFD + 50 mg/kg GamB and 50 mg/kg MoLE; P5 = hypercholesterolemia with HFD + 60 mg/kg GAmB and 40 mg/kg MoLE; P6 = hypercholesterolemia with HFD + 40 mg/kg GAmB and 60 mg/kg MoLE.

Discussion

Hemoglobin consists of heme, which includes globulin proteins and various non-protein components. Its primary role is to transport oxygen (O_2) throughout the body (32). In this study, the mean hemoglobin level in the positive control group was 15.50 g/dL, while the negative control group had a mean of 7.50 g/dL. The P1 group showed a mean of 12.67 g/dL, and the P2 group had a mean of 14.83 g/dL. The mean hemoglobin levels for groups P3, P4, P5, and P6 were 12.16 g/dL, 10.67 g/dL, 8.33 g/dL, and 9.50 g/dL, respectively (Table 1). These findings indicate that the mean hemoglobin level in the positive control group is slightly higher than that in the P2 group, which consisted of hypercholesterolemic rats (HFD) receiving 120 mg/kg body weight (bw) of glucomannan and 80 mg/kg bw of Moringa leaf extract. The elevated hemoglobin levels in the positive control group align with the typical range for healthy white rats, which is generally between 13 g/dL (33) and 17.6 g/dL (34). In contrast, the hypercholesterolemic rats on a regular diet exhibited the lowest hemoglobin levels, likely influenced by obesity. Research indicates that individuals with a body mass index (BMI) over 30 kg/m² tend to have lower hemoglobin levels (12.5 ± 1.0 g/dL vs. 13.0 ± 0.9 g/dL, p = 0.02) compared to their non-obese counterparts (35).

The treatment group receiving the combination of glucomannan and Moringa leaf extract (P2) showed the most significant effectiveness, particularly in managing hypercholesterolemia in rats. The administration of 120 mg/kg of GAmB and 80 mg/kg of MoLE led to a notable normalization of hemoglobin levels. This increase may be attributed to the higher protein and lower fat content of both Porang and Moringa, which likely contributed to improved hemoglobin levels in obese subjects. Additionally, the combination of Porang and Moringa in the diets resulted in the most substantial weight loss, as indicated by the mean weight loss data, lower daily feed consumption, and significant reductions in fasting and postprandial glucose levels. The high fiber content in Porang and Moringa may help reduce daily feed intake by delaying gastric emptying.

Moreover, both Porang and Moringa have been recognized as potential anti-diabetic and anti-obesity agents (36). In a separate study, a diabetic diet supplemented with konjac glucomannan resulted in a hemoglobin value of 6.54%, which was similar to the healthy control group's hemoglobin value of 6.62% (37). This similarity may be attributed to the high iron content present in these foods (38). Moringa leaves are rich in essential proteins, vitamins, and minerals, including vitamin C, calcium, and iron (39), with vitamin C known to enhance iron absorption significantly (40).

Blood viscosity is a crucial parameter in hemorheology, reflecting the inherent resistance encountered during blood circulation through vessels (41). In the positive control group, the average blood viscosity was measured at 11.42/min, while the negative control group showed a significant lower viscosity of 1.25/min. The viscosity levels for groups P1, P2, P3, P4, P5, and P6 were 6.64/min, 8.39/min, 8.20/min, 3.49/min, 2.67/min, and 3.68/min, respectively. These results indicate that the average blood viscosity and clotting time in the positive control group and the P2 treatment group-comprised of hypercholesterolemia rats on a high-fat diet treated with a combination of 120 mg/kg glucomannan (GamB) and 80 mg/kg Moringa leaf extract (MoLE)-were slightly longer than those observed in

the other groups with faster clotting times. The extended clotting time in Group P2, despite the high-fat diet, can be attributed to the beneficial effects of the glucomannan and moringa extract combination, which effectively lowered LDL cholesterol levels and improved lipid profiles in Group P5. The combination of 120 mg/kg of GAmB and 80 mg/kg of MoEL (Group P4) had the most pronounced effect on reducing triglycerides (TG), total cholesterol (TC), and LDL-C levels, while increasing HDL-C levels. Blood viscosity values showed a positive correlation with creatinine, uric acid, and total and LDL cholesterol (42).

Porang tubers, also known as *iles-iles*, have multiple names and possess numerous health benefits due to their constituents. These tubers can be processed into cosmetics, medicines, and industrial raw materials (43). The key component is glucomannan, which comprises approximately 15% to 64% of the dried porang tubers and can be utilized for food and health applications (44). Glucomannan can lower blood cholesterol levels in the small intestine by binding bile acids to extract cholesterol from the blood for bile salt formation (45). Its ability to absorb water and form a gel-like substance in the digestive tract enhances feelings of fullness, suppresses appetite, and aids in weight management by reducing overall calorie intake. Moreover, porang glucomannan helps lower blood glucose levels and increase glucose concentrations in the portal vein and bloodstream (46). Salivary and pancreatic amylases cannot break down glucomannan, which consists of β-D-glucose and β-D-mannose polysaccharide chains. As an intact polysaccharide, glucomannan acts as a prebiotic, promoting the growth of beneficial gut bacteria and enhancing insulin production (47).

The other key ingredient in this combination is *Moringa oleifera*, which offers numerous benefits across its various parts, serving as both a nutritional supplement and a traditional medicine (48,49). Moringa leaves are rich in vitamins (B1, B2, B3, C and D) (50), minerals, and antioxidants (51). Previous studies have demonstrated that *Moringa oleifera* possesses a wide range of beneficial properties, including anti-diabetic, anti-cancer, anti-inflammatory, antihypertensive (52) and anti-obesity effects (53). In studies involving untreated obese control mice, Moringa extract increased adiponectin gene expression while decreasing the expression of leptin and resistin mRNA. These improvements in gene expression were associated with reduced body weight, enhanced atherogenic indices and coronary artery health, decreased glucose levels, and improved insulin resistance, all without affecting liver or kidney function (54).

The combination of glucomannan and Moringa leaves offers enhanced protection when administered in the appropriate dosage. Both Moringa and Porang are characterized by lower lipid content and higher protein levels, making their combined diet particularly effective for weight loss. This diet not only resulted in significant reduction in fasting and postprandial glucose levels but also led to the lowest daily feed consumption. The high fiber content in Porang and Moringa contributes to decreased daily feed intake by delaying gastric emptying. Research has demonstrated the effectiveness of Moringa and Porang in treating diabetes and obesity (55). The leaf extract of *Moringa oleifera* and glucomannan from Amorphophallus muelleri Blume have been shown to help obese male Wistar rats reduce both food consumption and body weight. Specifically, the K4 treatment group, which received a combination of 80 mg/kg of Moringa leaf extract and 120 mg/kg of glucomannan, exhibited a notable increase in food intake by 4.29 g and a reduction in body weight by 36.67 g (24).

For male rats with hypercholesterolemia, the combination of glucomannan and Moringa leaf extract effectively modified their lipid profiles. The P5 group (HFD + 80mg/kg of glucomannan and 120mg/kg of Moringa leaf extract) experienced the most significant improvements in lipid levels, including reductions in total cholesterol (TC) by -30.33 ± 11.59 mg/dL, triglycerides (TG) by -33.00 ± 16.70 mg/dL, and low-density lipoprotein cholesterol (LDL-C) by -30.33 ± 11.59 mg/dL, alongside an increase in high-density lipoprotein cholesterol (HDL-C) by 31.00 ± 3.00 mg/dL.

The observed decrease in hemoglobin levels and rapid blood clotting times can be attributed to obesity in the rats. However, some groups showed the potential for normalization due to the effective treatment with the combination of Porang tuber glucomannan and Moringa leaf extract at the appropriate dose (Table 1). BMI is significant in this context (56), as increases in BMI are linked to fat accumulation (particularly LDL). Plasma LDL is a diverse mixture of particles that vary in structure, density, size, and atherogenic properties (57). Insulin resistance is also associated with this accumulation, contributing to atherogenesis through rapid buildup in arterial wall and increased oxidation (58).

There is a correlation between the rapid blood clotting times observed in obese rats and the administration of less effective dosage. The relationship between hyperlipidemia and blood viscosity remains somewhat unclear; while increased viscosity is often associated with elevated blood lipid levels, lipid-lowering treatments do not always normalize viscosity (59). In this study, the negative control group, which did not receive a high-fat diet, exhibited reduced hemoglobin levels. The P2 treatment group showed a hemoglobin level of 14.83 g/dL and a blood viscosity of 8.39, both within ranges comparable to normal levels. The hemoglobin levels typically range from 13.9 to 15.9 g/dL (60), while normal blood viscosity levels fall between 3.5 and 5.5 cP (61). Despite the viscosity value in treatment P1 being closer to normal, hemoglobin levels remained below the standard range, and viscosity values continued to exceed normal levels.

Iron is a crucial component for the formation of blood and is essential for hemoglobin synthesis, which is vital for increasing hemoglobin levels (62). However, chronic inflammation associated with obesity can trigger the release of cytokines like IL-6. This response leads to increased expression of hepcidin, which impairs iron absorption in the duodenum. Consequently, this can disrupt iron levels, which are easily affected by the inflammatory state linked to obesity, as indicated by changes in ferritin levels. Hepcidin can be secreted by adipose tissue, and leptin may also contribute to the elevation of hepcidin expression (61). It is important to note that this study has limitations, including the need to explore additional hematological profiles.

Conclusion

The study's findings highlighted significant variations in hemoglobin levels and blood viscosity among the different treatment groups. In the positive control group (K+), hemoglobin levels reached 15.5 g/dL, accompanied by a viscosity of 11.42. The standard level for rats is approximately 13 g/100 mL. In contrast, the highest hemoglobin and viscosity levels in the treatment group, which combined Porang tuber glucomannan with Moringa leaf extract, were found in group P2, with hemoglobin at 14.83 g/dL and blood viscosity at 8.39. This suggests that the most effective dosage of the glucomannan mixture from Porang tuber and Moringa leaf extract is in the P2 treatment, which consists of 120 mg/kg of Moringa leaf extract and 80 mg/kg of glucomannan. The results from the P2 treatment indicated hemoglobin levels of 14.83 g/dL and blood viscosity levels of 8.39, both of which are comparable to normal ranges. Normal hemoglobin levels typically fall between 13.9 and 15.9 g/dL, while normal blood viscosity levels range from 3.5 to 5.5 cP.

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Conflict of interest

The authors declare that there is no conflict of interest.

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تأثير الجلوكومانان من درنة بورانج ومستخلص أوراق المورينجا على مستويات الهيموجلوبين ولزوجة الدم لدى الجرذان السمان

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الخلاصة

يمكن أن تؤدي مستويات الهيموجلوبين غير الطبيعية ولزوجة الدم لدى الأفراد المصابين بالسمنة إلى مضاعفات صحية خطيرة. اختبرت هذه الدراسة تأثير الجلوكومانان من درنات بورانج ومستخلص أوراق المورينجا على الهيموجلوبين ولزوجة الدم لدى الجرذان السمان. وكان الهدف هو تقييم تأثير هذه المركبات وتحديد الجرعة الفعالة لتطبيع مستويات الهيموجلوبين ولزوجة الدم. تم توزيع أربعة وعشرين من ذكور جرذان ويستار، تتراوح أعمارهم بين ثمانية أسابيع ويزنون ما بين ٢٥٠-٢٧٥ جرامًا، بشكل عشوائي على واحدة من ثماني مجموعات تجريبية (ن=٣ لكل منها). عملت مجموعة واحدة كعنصر تحكم إيجابي (+K) بينما تم تصنيف المجموعات السبع المتبقية على أنها مجموعات فرط كوليستيرول الدم على نظام غذائي غني بالدهون. على مدى خمسة أسابيع، تلقت الحيوانات مجموعات مختلفة من مستخلص بورانج جلوكومانان ومورينجا. تم جمع عينات الدم بعد العلاج لتحليلها. وأشارت النتائج إلى وجود فروق كبيرة في مستويات الهيموجلوبين ولزوجة الدم عبر الجرعات المختلفة من العلاج المركب. والجدير بالذكر أن المجموعة التي تلقت ١٢٠ ملغم/كغم من بورانغ جلوكومانان و٨٠ ملغم/كغم من المورينغا (P2) أظهرت تحسينات ملحوظة في لزوجة الدم. بالإضافة إلى ذلك، لوحظت فروق كبيرة في مستويات الهيموجلوبين عند مقارنة مجموعات +K مع مجموعات -K. تشير هذه النتائج إلى أن العلاج المركب يعمل بشكل فعال على تطبيع مستويات الهيموجلوبين ولزوجة الدم لدى الجرذان السمان.