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Effectiveness of Probiotic Milk Supplementation on Blood Pressure in Pregnant Women with Hypertension

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ABSTRACT
Hypertensive disorders in pregnancy can affect pregnancy and birth outcomes. One non-pharmacological intervention is probiotic milk, which may be beneficial for hypertension in pregnancy. The purpose of this study was to determine the effectiveness of probiotic administration on blood pressure in pregnant women with hypertension. This study uses a quasi-experimental design (pretest-posttest with a control group). In this design, there are two groups: the intervention group (n = 30) and the control group (n = 30). This study uses simple random sampling. Data collection was conducted at health service facilities, namely health centres in the Kediri city area. Data collection began from March to July 2024. Probiotic milk supplementation of 125 ml was administered once daily for 63 days, while the control group received standard care. The results of the study using the t-test obtained the average post-test blood pressure in the intervention group, namely m = 124.07 mmHg, SD = 5.521 and the average diastolic pressure m = 75.60 mmHg, SD = 7.356. The average post-test systolic pressure in the control group was m = 141.83 mmHg, SD = 7.091, and the average diastolic pressure was m = 87.67 mmHg, SD = 9.132, with a p-value = 0.000. This shows that blood pressure (systolic and diastolic) in the intervention group was lower than in the control group. Probiotic milk supplementation given to pregnant women with hypertension has a greater potential to reduce blood pressure compared to the control group. Health workers need to be able to recommend probiotic consumption to pregnant women with hypertension. Further research should consider improved study designs and long-term monitoring of probiotic milk supplementation with a larger number of participants.

Keywords: Blood Pressure, Hypertension, Probiotics, Women.

ABSTRAK
Gangguan hipertensi pada kehamilan dapat memengaruhi kehamilan dan hasil persalinan. Salah satu intervensi nonfarmakologis adalah susu probiotik yang dapat bermanfaat untuk hipertensi pada kehamilan. Tujuan penelitian ini adalah untuk mengetahui efektivitas pemberian probiotik terhadap tekanan darah pada ibu hamil dengan hipertensi. Penelitian ini menggunakan desain kuasi-eksperimental (desain pretest-posttest dengan kelompok kontrol). Dalam desain ini terdapat dua kelompok, yaitu kelompok intervensi (n = 30) dan kelompok kontrol (n = 30). Penelitian ini menggunakan simple random sampling. Pengumpulan data dilakukan di fasilitas pelayanan kesehatan, yaitu puskesmas di wilayah Kota Kediri. Suplemen susu probiotik sebanyak 125 ml dikonsumsi sekali sehari selama 63 hari, sedangkan kelompok kontrol menerima perawatan standar. Hasil penelitian menggunakan uji t menunjukkan tekanan darah rata-rata pasca-uji pada kelompok intervensi adalah m = 124,07 mmHg, SD = 5,521, dan tekanan diastolik rata-rata m = 75,60 mmHg, SD = 7,356. Tekanan sistolik rata-rata pasca-uji pada kelompok kontrol adalah m = 141,83 mmHg, SD = 7,091, dan tekanan diastolik rata-rata m = 87,67 mmHg, SD = 9,132, dengan nilai p-value = 0,000. Hal ini menunjukkan bahwa tekanan darah (sistolik dan diastolik) pada kelompok intervensi lebih rendah dibandingkan dengan kelompok kontrol. Pemberian suplemen susu probiotik kepada ibu hamil dengan hipertensi memiliki potensi lebih besar untuk menurunkan tekanan darah dibandingkan dengan kelompok kontrol. Penting bagi petugas kesehatan untuk dapat merekomendasikan konsumsi probiotik kepada ibu hamil dengan hipertensi. Pengembangan penelitian lebih lanjut perlu mempertimbangkan desain studi yang lebih baik dan pemantauan jangka panjang suplemen susu probiotik dengan jumlah peserta yang lebih besar.

Kata Kunci: Tekanan Darah, Hipertensi, Probiotik, Wanita.

INTRODUCTION

Hypertensive disorders of pregnancy are a significant public health problem, affecting pregnancy and birth outcomes. According to data from the World Health Organization (WHO), the prevalence of hypertension in pregnancy has increased markedly, increasing from 13.3% to 15.9% from 2017 to 2019 (Ford et al., 2022). Hypertensive disorders complicate between 5% and 10% of all pregnancies worldwide (P. Li et al., 2022).

Some risk factors for hypertension in pregnancy are Body Mass Index (BMI) (Lane-Cordova et al., 2018), anemia (Chen et al., 2018), advanced maternal age (< 40 years) (Smith, Merriam, Jung, & Gyamfi-Bannerman, 2018), history of hypertension in previous pregnancies (Ying, Catov, & Ouyang, 2018), Gestational diabetes mellitus (GDM) (Lara-Barea et al., 2022), twin pregnancy (Narang, Szymanski, Kane, & Rose, 2021), and family history of hypertension in pregnancy (Gray, Saxena, & Karumanchi, 2018). In addition to bad habits such as smoking (Morisaki et al., 2023), alcohol consumption is a risk factor for hypertension in pregnancy (Metoki et al., 2022).

High blood pressure during pregnancy can complicate about 5-10% of pregnancies, which can cause health risks to the mother, fetus, and newborn (Agrawal & Wenger, 2020). Pregnant women with high blood pressure during pregnancy are at higher risk of developing chronic high blood pressure after delivery (Behrens et al., 2017; Brouwers et al., 2018), impaired kidney function (Dai, Chen, Sun, & Liu, 2018; Hitti, Sienas, Walker, Benedetti, & Easterling, 2018), and cardiovascular disease (Brouwers et al., 2018; Riise et al., 2018). Not only does it affect the mother, but high blood pressure during pregnancy can also have an impact on the fetus by increasing the risk of low birth weight (LBW) (Poudel et al., 2021), perinatal death, fetal death, neonatal death, fetal growth restriction, congenital malformations, and premature babies (F. Li et al., 2021).

Treatment for hypertension during pregnancy is essential. The goal is to treat symptoms as they appear and reduce the risk of progression to eclampsia (Wilkerson & Ogunbodede, 2019). There are two treatment methods: pharmacological and non-pharmacological. For pharmacological therapy, drugs that can be used include methyldopa, beta-blockers, and hydralazine as oral antihypertensives (Metoki et al., 2022). If the patient has high blood pressure accompanied by seizures, magnesium sulfate should be given (Pascoal et al., 2019). However, the use of antihypertensives during pregnancy can increase the risk of placental abruption, premature birth, and increase congenital disabilities by 2.3 times (Fitton et al., 2021). Therefore, non-pharmacological therapy is needed that can lower blood pressure in pregnant women safely for the mother and her fetus. Non-pharmacological interventions include a healthy lifestyle, such as maintaining a healthy diet, exercising, avoiding stress, reducing alcohol consumption, and meeting nutritional needs through the Dietary Approaches to Stop Hypertension (DASH) approach. This includes consuming fruits, vegetables, foods rich in potassium ($K+$), magnesium (Mg^{2+}), calcium (Ca^{2+}), phosphorus, and dairy products (Mahmood et al., 2019).

Probiotics may reduce blood pressure by modulating the composition and metabolic activity of the gut microbiota, thereby increasing the production of beneficial short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate. These metabolites improve vascular homeostasis by suppressing systemic inflammation, enhancing endothelial nitric oxide (NO) bioavailability, and reducing oxidative stress. In addition, probiotics may influence the renin–angiotensin–aldosterone system (RAAS) by producing bioactive peptides with angiotensin-converting enzyme (ACE)-inhibitory activity, thereby reducing vasoconstriction and peripheral vascular resistance. Collectively, these mechanisms contribute to improved endothelial function, lower arterial stiffness, and better regulation of blood pressure, supporting the potential role of probiotics as a complementary strategy for managing hypertension (Chen et al., 2025; Młynarska et al., 2024; Stuivenberg, Poon, Burton, & Spence, 2024).

Processed forms of probiotics that may be beneficial for hypertension in pregnancy. In a review of 23 randomised controlled trials, it was found that probiotic consumption caused a significant reduction in systolic and diastolic blood pressure, with an average reduction of 3.05 mmHg and 1.51 mmHg, respectively (Qi, Nie, & Zhang, 2020). In addition, probiotics are available as probiotic yoghurt, which has emerged as a potential dietary intervention for managing hypertension during pregnancy. The study involved 70 pregnant women in their third trimester, who were randomly assigned to consume either conventional yoghurt or probiotic yoghurt daily

for 9 weeks. Although the primary focus was on calcium, the implications extend to overall health management, including hypertension (Asemi & Esmaillzadeh, 2013).

Probiotic milk has attracted attention for its potential benefits in managing hypertension during pregnancy, especially in relation to preeclampsia. Research suggests that regular consumption of probiotic milk products may reduce the risk of preeclampsia in pregnant women. A study involving 33,399 primiparous women revealed that daily intake of probiotic milk was significantly associated with lower rates of mild and severe preeclampsia (Brantsaeter et al., 2011). Dairy products can be an alternative to treat hypertension during pregnancy because they contain calcium, which can help lower blood pressure (Mahmood et al., 2019).

In terms of dosage, studies suggest that a daily intake of about 150-200 ml of probiotic yoghurt may be beneficial for pregnant women. Although many studies have shown potential benefits associated with probiotics, such as improved gut microbiota and immune function during pregnancy, evidence regarding their effects on hypertension remains inconclusive. Many studies lack robust methodology and the large sample sizes needed to draw generalizable conclusions about the efficacy and safety of probiotics during pregnancy (McDougall et al., 2024).

In another study, probiotics were administered as a product previously shown to be safe. In this study, probiotic milk preparations were provided as a product made from 100% fermented fresh milk containing beneficial bacteria, such as lactic acid bacteria. These bacteria remain active during the production process because they are not heated, which can kill them and make them useless.

Although previous studies have suggested that probiotic supplementation may benefit blood pressure regulation and pregnancy outcomes, the available evidence remains inconclusive. Most clinical trials have focused on healthy pregnant women or women with gestational diabetes mellitus rather than pregnant women with hypertension, limiting the generalizability of the findings to this high-risk population. Furthermore, substantial heterogeneity exists across probiotic strains, formulations, dosages, intervention durations, and outcome measures, making direct comparisons between studies difficult. Recent systematic reviews have also concluded that the current evidence is insufficient to establish the effectiveness of probiotics in preventing or managing hypertensive disorders during pregnancy, due to the limited number of high-quality randomised controlled trials and relatively small sample sizes. In addition, few studies have evaluated commercially available fermented probiotic milk administered alongside standard antihypertensive therapy in primary healthcare settings. Therefore, further well-designed clinical studies are needed to determine the effectiveness of probiotic milk supplementation in reducing blood pressure among pregnant women with hypertension (Fernández, Orgaz, & Rodríguez, 2024; McDougall et al., 2024; Movaghar, Farshbaf-Khalili, Hajizade, MirzaRezaei, & Shahnazi, 2022; Zarezadeh et al., 2023). This study aimed to evaluate the effectiveness of commercially available probiotic milk supplementation on blood pressure in pregnant women with hypertension.

RESEARCH METHODS

This type of research is quantitative, using the Quasi-Experimental research method (pretest-posttest with a control group design). In this design, there are two groups: the intervention group (n = 30) and the control group (n = 30). This study uses simple random sampling. Data collection was conducted at health service facilities, namely health centres in the Kediri city area. Data collection began from March to July 2024.

The inclusion criteria for this study were: pregnant women in the second and third trimesters, experiencing hypertension during pregnancy with a minimum blood pressure of 140/90 mmHg, a Mean Arterial Pressure (MAP) value > 90 mmHg, and willing and committed to being respondents. The exclusion criteria of this study were pregnant women who experienced hypertension in pregnancy with complications of heart disease, kidney disease, experiencing musculoskeletal discomfort, severely immunocompromised patients, and had allergies.

The sample size for the difference in the average of two groups uses the formula (Lemeshow et al., 1997) as follows:

$$n = n^2 = \frac{2\delta^2(Z_{1-}\alpha + Z_{1-}\beta)^2}{(\mu_1 - \mu_2)^2}$$
$$n = n^2 = \frac{2(7.43)^2(1.96 + 1.28)^2}{(10)^2}$$
$$n = n^2 = \frac{(14.86)^2(3.24)^2}{(10)^2}$$
$$n = n^2 = \frac{(220.81)(10.49)}{100}$$
$$n = n^2 = \frac{2316.29}{100}$$
$$n = n^2 = 23.16$$

To anticipate the possibility of selected respondents dropping out, corrections were made.

$$N' = \frac{N}{1 - f}$$
$$N' = \frac{23.16}{1 - 0.20}$$
$$N' = 29.95 \approx 30$$

The sample size was 30 respondents in the intervention group and 30 in the control group, for a total of 60 respondents. The sampling technique in this study used the Simple Random Sampling approach. The sample was determined using a computer program, namely Microsoft Excel.

The instrument used in this study for blood pressure measurements was a tensiometer, the Omron JPN 600 Tensimeter Digital JAPAN, made in Japan. Trained researchers and enumerators carried out blood pressure measurements. Before the digital tensiometer was used, calibration was carried out. Blood pressure was assessed on the left arm because the left arm is closer to the heart, allowing for more accurate readings. Requirements before conducting a blood pressure examination: has been sitting for about 5 minutes, is in a calm condition, has emptied the bladder (has urinated), does not speak during the measurement, sits in a comfortable position, back supported by a chair, feet on the floor, hands on the table and parallel to the heart. Blood pressure measurements were carried out by trained researchers and enumerators in the morning at 06.00, before physical activity, for 9 weeks (63 days). Then the results of systolic and diastolic blood pressure measurements were recorded in the daily observation sheet.

On the first day, the intervention group conducted a pre-test of blood pressure measurement using a Yuwell-brand digital tensiometer on the left arm, with the respondents sitting comfortably. Then the researchers provided probiotics in processed milk with a dose of 125 ml which was drunk once a day for 63 days. The composition of probiotics includes: Water, Sugar, Full cream milk powder, Skim milk powder, Vegetable stabilizer, Animal stabilizer (beef gelatin), Streptococcus thermophilus and Lactobacillus delbrueckii subsp. Bulgaricus cultures. With the number BPOM MD 201511028465. Probiotic milk was drunk every morning after breakfast at 7-8 am, the milk was drunk without tea or coffee, and 1-2 hours after taking antihypertensive medication from a health facility. The product was given once a week, the product must be stored in the refrigerator at a temperature of 4-8 °C. Compliance with probiotic consumption was monitored daily via video calls at 8 am to ensure participants had consumed the probiotic milk. Observation results were recorded on a probiotic milk observation sheet, which participants completed. Throughout the study, the intervention group also received standard care, taking nifedipine 3 times daily at 10 mg per dose. A post-intervention test was conducted on the 64th day after the intervention.

On the first day, the control group underwent a pre-intervention test, measuring blood pressure with a Yuwell digital tensiometer on the left arm, with the participants seated comfortably. Throughout the study, the control group received standard care, including antihypertensive

medication such as nifedipine, prescribed by a doctor. A post-intervention test, measuring blood pressure, was conducted on the 64th day.

To determine the magnitude of the intervention effect beyond statistical significance, Cohen's *d* was calculated for posttest blood pressure differences between the intervention and control groups. The effect size for systolic blood pressure was 2.79, while the effect size for diastolic blood pressure was 1.46. According to Cohen's criteria, both values represent large effect sizes, indicating that probiotic milk supplementation produced not only statistically significant reductions but also clinically meaningful improvements in blood pressure among pregnant women with hypertension. The research data were analysed using t-tests (independent and dependent) in SPSS version 26. All participants who agreed to participate in the study have signed the informed consent form. Ethical clearance was obtained from the Health Research Ethics Commission of the Health Polytechnic of the Ministry of Health of Malang, number No. DP.04.03/F.XXI.31/0908/2024.

RESULTS

This study used a sample of 60 participants, divided into two groups: the intervention group (n = 30) and the control group (n = 30). During the study, no participants dropped out.

Table 1. Participant characteristics.

Characteristics	Group				p-value
	Intervention Group (n=30)		Control Group (n=30)		
	F/M	%/SD	F/M	%/SD	
Age					0.685[a]
< 20 Years	1	3.3	1	3.3	
20 – 30 Years	17	56.7	20	66.7	
> 30 Years	12	40	9	30	
ucation					0.657[a]
Primary	0	0	1	3.3	
Secondary	20	66.7	22	73.3	
Higher	10	33.3	7	23.3	
cupation					0.620[a]
Government	10	33.3	8	27.3	
Business	1	3.4	4	13.3	
Housewives	19	63.3	18	59.4	
Gestational Age					0.676[a]
14 – 27 Weeks	4	13.3	10	33.3	
28 – 40 Weeks	26	86.7	20	66.7	
od pressure					
Systolic Blood Pressure	124.07	±5,521	147.83	±7,091	0.519[b]
Diastolic Blood Pressure	75.60	±7,356	87.67	±9,132	0.788[b]

Description: *a. Wilcoxon test, b. t-test*

Most respondents in the intervention and control groups were 20-30 years old: 17 (56.7%) in the intervention group and 20 (66.7%) in the control group, with a p-value of 0.685. Based on the last education, most respondents in both the intervention and control groups were educated at the secondary level: the intervention group had 20 participants (66.7%) and the control group had 22 participants (73.3%), with a p-value = 0.657. By occupation, most participants in the intervention group were housewives (19 participants, 63.3%), whereas none in the control group were (18 participants, 59.4%), with p-value = 0.620. Based on gestational age, most participants in the intervention group were 26 (86.7%), and in the control group, 20 (66.7%), with a p-value of

0.676. The average systolic blood pressure in the intervention group was 124.07 mmHg, and the diastolic blood pressure was 75.60 mmHg, with a p-value of 0.519. Meanwhile, the average systolic blood pressure of the control group was 147.83 mmHg, and the average diastolic blood pressure was 87.67 mmHg, with a p-value of 0.788 (Table 1).

Table 2. Blood Pressure Before and After Probiotic Milk Administration in the Intervention Group

Variables	Intervention Group (n=30)		p-value
	Pretest	Posttest	
	Mean ± SD	Mean ± SD	
Systolic (mmHg)	143.93 ± 7.478	124.07 ± 5.521	0.000
Diastolic (mmHg)	90.80 ± 11.839	75.60 ± 7.356	0.000

Description: *paired t test*

The results of the blood pressure analysis in the intervention group showed that the average systolic pretest was m = 143.93 mmHg (SD = 7.478) and the average diastolic was m = 90.80 mmHg (SD = 11.839). The average systolic posttest in the intervention group was m = 124.07 mmHg (SD = 5.521), and the average diastolic was m = 75.60 mmHg (SD = 7.356), with a p-value of 0.000. It can be concluded that blood pressure in pregnant women with hypertension (intervention group) after consuming probiotic milk experienced a significant decrease (Table 2).

Table 3. Blood Pressure of Pregnant Women with Hypertension in the Control Group.

Variables	Control Group (n=30)		p-value
	Pretest	Posttest	
	Mean ± SD	Mean ± SD	
Systolic (mmHg)	147.03 ± 8.058	141.83 ± 7.091	0.098
Diastolic (mmHg)	92.47 ± 6.902	87.67 ± 9.132	0.479

Description: *Paired t-test*

The results of the blood pressure analysis in the control group are shown in the table: the average systolic data during the pretest is 147.03 mmHg (SD=8.058), and the average diastolic is 92.47 mmHg (SD=6.902). While the average systolic result during the posttest in the control group is 141.83 mmHg (SD=7.091) and the average diastolic result is 87.67 mmHg (SD=9.132). Based on the average pretest and posttest, the results show that there was no significant decrease in blood pressure in the control group. The results of the Paired Sample T-Test for blood pressure in the control group showed a significant p-value of 0.577. This can be concluded that blood pressure did not experience a significant decrease in the control group (Table 3)

T**able 4.** Differences in posttest blood pressure in the intervention group and control group.

Variables	Intervention Group (n=30)		Control Group (n=30)		p-value
	Mean	SD	Mean	SD	
Systolic (mmHg)	124.07	5.521	141.83	7.091	0.000
Diastolic (mmHg)	75.60	7.356	87.67	9.132	0.000

Description: *Independent-samples t-test*

The average posttest results showed that the average systolic in the intervention group was m = 124.07 mmHg (SD = 5.521) and the average diastolic was m = 75.60 mmHg (SD = 7.356). While the average posttest systolic in the control group was m = 141.83 mmHg (SD = 7.091) and the average diastolic was m = 87.67 mmHg (SD = 9.132), with a p-value of 0.000. This shows that there is a difference in blood pressure in the two groups of pregnant women with hypertension, blood pressure in the intervention group is lower than in the control group (Table 4)

DISCUSSION

The study was conducted from March to July 2024 and consisted of 2 groups: the intervention group (n = 30) and the control group (n = 30). No participants dropped out. All participants participated in the study for 63 days. The results showed that the average systolic blood pressure in the intervention group decreased by 19.86 mmHg and the diastolic blood pressure decreased by 15.2 mmHg. The probiotics used in this study were in the form of products that have been proven safe in previous studies. In this study, probiotic milk preparations were provided as products made from 100% fermented fresh milk containing beneficial bacteria, such as lactic acid bacteria. These bacteria remain active during the production process because they do not experience the heat that can kill them and render them useless.

It is concluded that blood pressure decreased after being given probiotic milk to pregnant women with hypertension. Probiotic milk contains potassium, calcium and magnesium. The balance of potassium, calcium and magnesium intake in the body is very good for lowering blood pressure. High potassium intake can lower blood pressure through vasodilatory effects. Stimulation of the Na+/K+-ATPase reduces intracellular sodium content, locks sarcolemmal proteins, and maintains calcium homeostasis in the heart, thereby causing vasodilation. In addition to its direct vasodilatory effect on vascular smooth muscle cells, a high-potassium diet opens potassium channels and stimulates the Na+/K+ pump in endothelial cells. Vasodilation decreases systemic vascular resistance and increases blood flow, resulting in a decrease in blood pressure (Su, Yang, & Ellison, 2020). Calcium plays an important role in reducing hypertension problems during pregnancy. This can be achieved by reducing parathyroid calcium release and intracellular calcium concentration, thereby relaxing smooth muscles and dilating blood vessels Radjulaeni, Suhartono, & Mardiyono, 2023). Magnesium plays a role in regulating the physical properties and permeability of cell membranes. Also, it acts as a calcium antagonist, modulating the tone and contraction of blood vessel smooth muscle, thereby relaxing blood vessels.

Beyond the mineral content of probiotic milk, several biological mechanisms may explain the antihypertensive effects observed in this study. Probiotic microorganisms can modulate gut microbiota composition and increase the production of short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate. These metabolites improve endothelial function by reducing systemic inflammation, decreasing oxidative stress, and enhancing nitric oxide (NO) bioavailability, thereby promoting vasodilation and lowering vascular resistance. Furthermore, bioactive peptides released during milk fermentation exhibit angiotensin-converting enzyme (ACE)-inhibitory activity, which may suppress the renin–angiotensin–aldosterone system (RAAS) and contribute to lowering blood pressure. These complementary mechanisms support the role of probiotic milk as a non-pharmacological adjunct in hypertension management (Chen et al., 2025; Młynarska et al., 2024; Stuivenberg et al., 2024).

This study aligns with a meta-analysis suggesting that an intervention period of ≥ 8 weeks is required to effectively lower blood pressure (Mähler, Wilck, Rauch, Dechend, & Müller, 2020). Another meta-analysis using randomised controlled trials (RCTs) has examined probiotic products containing live bacteria administered to the intervention group for >8 weeks. 26 studies showed that probiotic supplementation significantly reduced office systolic blood pressure by 2.18 mmHg. A trial using probiotic dairy products showed a significant reduction in blood pressure by 3.22/2.11 mmHg. The results of the study suggest that long-term probiotic consumption (≥8 weeks) has beneficial effects on blood pressure (Zhao et al., 2023). A systematic review and meta-analysis used 23 randomised controlled trials involving 2037 participants, namely adult patients aged 18 years or older who met the inclusion criteria. Probiotic consumption significantly changed systolic blood pressure by 3.05 mmHg and diastolic blood pressure by 1.51 mmHg. This effect can only last in the short term, namely 8 or 10 weeks (Qi et al., 2020).

The current findings are generally consistent with previous studies, although differences in probiotic formulation, dosage, and intervention duration need to be considered. Previous studies have shown that probiotic supplementation for at least 8 weeks significantly reduces systolic and diastolic blood pressure and may improve maternal health outcomes during pregnancy, although evidence specifically in hypertensive pregnant women is limited. (McDougall et al., 2024; Qi et al., 2020; Zarezadeh et al., 2023). Unlike many previous randomised trials using probiotic

capsules or mixtures of bacterial strains, this study evaluated fermented probiotic milk at a dose of 125 mL daily for 63 days, alongside standard antihypertensive therapy. The greater reduction in systolic blood pressure observed in this study may be due to the combined effects of the probiotic microorganisms, bioactive peptides derived from fermented milk, and the longer intervention duration.

Dairy products that can help lower blood pressure in pregnant women include probiotic milk. According to the latest definitions from the Food and Agriculture Organisation and the World Health Organisation (WHO), probiotics are non-pathogenic live microorganisms that, when consumed in adequate amounts, provide health benefits to the host (Maldonado Galdeano, Cazorla, Lemme Dumit, Vélez, & Perdigón, 2019). The study evaluated the effects of probiotic supplementation containing Lactobacillus acidophilus LA-5, Bifidobacterium BB-12, Streptococcus thermophilus STY-31, and Lactobacillus delbrueckii bulgaricus LBY-27 on systolic and diastolic blood pressure in pregnant women with diabetes. Probiotics were given in capsule form for 8 weeks. The results showed that probiotic supplementation significantly prevented an increase in blood pressure during pregnancy after 2 weeks of supplementation. Probiotics can be recommended for the treatment of hypertension in pregnancy because they have anti-inflammatory and antioxidant properties (Hajifaraji et al., 2017). This is supported by other studies showing that consumption of dairy products containing probiotics, with a minimum dose of 140 ml per day, is associated with a reduced risk of preeclampsia, especially severe preeclampsia, in this study, there is a suggestion regarding specific strains/species needed using randomized controlled trials for further evaluation of the effects of probiotics on preeclampsia (Brantsaeter et al., 2011). Probiotic milk intake during late pregnancy was associated with a reduced risk of preeclampsia, and intake during early pregnancy was associated with a reduced risk of preterm delivery. However, these observational studies cannot prove a cause-and-effect relationship. The pathophysiological effects of probiotics on maternal inflammatory responses need to be further studied, including through randomised controlled trials focusing on specific strains orrobiotic species (Nordqvist et al., 2018).

The control group in this study was not given the intervention of probiotic milk. However, in the control group, respondents were still given standard care by consuming antihypertensive drugs from the doctor. The average systolic results during the pretest in the control group were m = 147.03 mmHg, and the average diastolic results were m = 92.47 mmHg. While the average systolic results during the posttest in the control group were m = 141.83 mmHg and the average diastolic results were m = 87.67 mmHg. In the control group, blood pressure decreased, but the change was not significant. This is likely due to factors that influence hypertension, namely physical activity and/or exercise has been shown to delay the development of hypertension. Aerobic and resistance training have been shown to effectively lower blood pressure. Because brisk walking is one of the easiest, cheapest, simplest, and most effective ways to exercise, this type of aerobic exercise can be recommended to the public. All professional organisations and government agencies recommend moderate-intensity aerobic exercise for at least 30 minutes, at least 3 days a week, or resistance training 2-3 days a week. The training sessions can last continuously for 30 minutes or consist of at least 10 minutes of short exercise duration up to a daily total of 30 minutes. Overall, a 5 mmHg reduction in blood pressure with regular exercise can be achieved (Xiao, 2020). In addition, reducing salt and alcohol intake, weight loss, and a healthy diet can also affect hypertension. Consuming a diet rich in fruits, vegetables, and low-fat dairy products can lower systolic and diastolic blood pressure (Filippou et al., 2020).

Several studies have used probiotic dietary supplements containing live bacterial strains. In this study, probiotics were administered as fermented milk. This choice was based on the fact that in fermented milk, the dominant microbes are lactic acid bacteria. These bacteria, such as Lactobacillus and Bifidobacteria, are commonly used in dairy products for probiotic cultures. During milk fermentation, milk proteins are degraded by proteinases in the cell walls of lactic acid bacteria, producing bioactive peptides such as Angiotensin-Converting Enzyme (ACE) inhibitors. These peptides, such as valyl-prolylproline (VPP) and isoleucyl-prolyl-proline (IPP), are well known for their antihypertensive effects. For this reason, fermented milk products are often recommended as a non-pharmacological strategy in managing hypertension (Şanlier, Gökcen, & Sezgin, 2019).

The results of this study provide insight that giving probiotics in milk form can maximise the reduction in blood pressure in hypertensive pregnant women receiving conventional treatment, compared with the control group receiving only conventional treatment. Giving probiotic milk for 9 weeks is safe during pregnancy.

The advantages of this study are that the intervention is probiotic milk, available on the market, safe, and standardised. This ensures that the dose given to each respondent is the same, minimising dose bias. The number of participants in this study was greater than in the previous study, which lasted 9 weeks.

The limitations of this study include other factors related to hypertension, such as lifestyle (activity, diet, and psychology), participant compliance with medication prescribed by doctors, which cannot be directly observed by researchers, and blood pressure measurements taken only once by the researchers. In contrast, it would be better to take two measurements four hours apart in a relaxed state.

Based on the research results, several implications can be used to improve the health sector the potential of probiotics as a non-pharmacological approach in cardiovascular health management during pregnancy. The implementation of probiotics must be carefully considered and adjusted to the conditions of each individual, as well as managed comprehensively, to manage hypertension in pregnant women.

CONCLUSION

The findings of this study demonstrate the potential of probiotic supplementation in lowering blood pressure in pregnant women with hypertension. Probiotic supplementation is a complementary alternative that offers additional benefits in lowering blood pressure when combined with conventional therapy. Further research using randomised controlled trials with larger participant numbers is needed to evaluate the long-term potential of probiotics.

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