Original Article

The Effect of Tempeh Dietary Intake on Blood Glucose Levels in Prediabetics

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ABSTRACT

Background: Rediabetes is a high-risk metabolic condition that precedes type 2 diabetes mellitus and is associated with increased morbidity. Dietary intervention plays a critical role in glycemic control. Tempeh, a traditional fermented soybean product, contains bioactive compounds such as isoflavones and high-quality protein that may improve glucose metabolism. However, evidence on its effectiveness in prediabetic populations remains limited. This study aimed to evaluate the effect of daily tempeh consumption on blood glucose levels among individuals with prediabetes.

Methods: A comparative pre-experimental study with a pretest–posttest control group design was conducted at Mohammad Hoesin Hospital, Palembang. A total of 60 participants with prediabetes were randomly assigned to intervention (n=30) and control (n=30) groups. The intervention group received 250 g/day of tempeh for 14 days, while the control group followed a regular diet. Blood glucose levels were measured before and after the intervention. Data were analyzed using paired and independent t-tests with a significance level of $p<0.05$.

Results: Baseline characteristics between groups were comparable ($p>0.05$). The intervention group showed a significant reduction in mean blood glucose levels from 139.83±16.52 mg/dL to 104.30±13.11 mg/dL ($p<0.001$), while the control group also showed a smaller decrease from 137.83±14.87 mg/dL to 121.93±13.09 mg/dL ($p<0.001$). The mean reduction was significantly greater in the intervention group (35.53 mg/dL) compared to the control group (15.90 mg/dL), with a statistically significant between-group difference ($p<0.001$).

Conclusion: Daily consumption of 250 g tempeh for 14 days significantly reduces blood glucose levels in individuals with prediabetes. Tempeh may serve as an effective dietary strategy for glycemic control and prevention of diabetes progression.

Keywords: empeh; Prediabetes; Blood Glucose; Fermented Soy; Dietary Intervention.

Implications for Practice:

- Integrating tempeh-based dietary interventions into routine clinical practice may provide a simple, culturally acceptable, and evidence-based strategy to support glycemic control among individuals with prediabetes.
- Health policy initiatives should consider promoting locally available fermented soy products such as tempeh within national nutrition guidelines to strengthen preventive approaches for diabetes and reduce long-term healthcare burden.
- Midwifery education programs should incorporate nutrition-based preventive care emphasizing affordable functional foods like tempeh, particularly in Low- and Middle-

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Implications for Practice:

Income Countries (LMICs) and resource-limited settings where access to pharmacological interventions may be constrained.

Introduction

Prediabetes is a condition that occurs before the onset of diabetes mellitus. The prevalence of prediabetes mellitus increases over time. Approximately 4–9% of individuals with prediabetes develop diabetes mellitus each year. A fasting blood glucose level between 100–125 mg/dL is a sign of prediabetes. Furthermore, prediabetes mellitus carries a 1.5 times higher risk of developing heart and lung disease than healthy individuals. By making lifestyle changes, reducing weight, controlling diet, and exercising regularly, prediabetes mellitus can be managed (Basir, I. S., & Arsad, 2025).

Diet management is one of the methods used to lower blood sugar, which is done through regulating eating patterns that meet diet requirements with a nutritional intake of 25-30 kcal/kg normal body weight, protein 10-15% of total nutritional intake, fat 20-25% of total nutritional intake, carbohydrates 60-70%, fiber 23 grams/day and regular exercise. (Santi, J. S., dan Septiani, 2021). Tempeh is a food that is associated with lowering blood glucose. (Indrawati, I., & Maimaznah, 2020).

Tempeh is a processed product made through a fermentation process with the help of the mold Rhizopus sp. in tempeh. Indonesians often consider tempeh as a vegetable protein source. Tempeh is a type of food that contains a complete range of essential and non-essential amino acids, high levels of fat, isoflavones and dextrin, and a high glycemic index (glycemic index <55). In addition, tempeh is easily digested, so the blood glucose response in the tempeh is high and the increase in blood glucose levels is relatively small (Sutopo, 2021).

The content in the tea leaves that plays a role in lowering blood glucose levels includes protein, isoflavones, sorbitol, and low glycemic index. (Rahadiyanti Ayu dan Tatik Mulyati, 2017). Tempeh protein contains high amounts of arginine and glycine, which are related to the secretion of insulin and glucagon by the pancreas. (Marie Chantal Canivenc, 2023). The isoflavone content, namely geinisteine, can inhibit the action of α-glucosidase, which is involved in diabetes and various other metabolic disorders (Syafii, F., & Yani, 2024).

Tempeh is made by fermenting the fungus Rhizopus sp., particularly Rhizopus oligosporus. This traditional product is highly beneficial for health because it contains key nutrients such as protein, carbohydrates, fats, vitamins, and minerals, as well as superior bioactive compounds such as vitamin B12, antidiarrheal, anticancer, cholesterol-lowering, and antioxidants in the form of isoflavones such as daidzein, glycitein, geynsteine, and 6,7,4-trihydroxy isoflavones (**Table 1**). This functional food can be consumed by people suffering from malnutrition. Tempeh has many benefits, such as helping to overcome diarrhea, improving the immune system, maintaining heart health, slowing down the aging process, helping with weight loss, increasing vitamin B12 levels, reducing flatulence, reducing the risk of Parkinson's, improving brain function, reducing bad cholesterol levels, and helping to prevent various diseases such as coronary heart disease, osteoporosis, digestive tract disorders, cancer, anemia, diabetes mellitus, and coronary heart disease (Redi Aryanta, 2020).

Table 1. Nutrient Composition of Soy bean and Tempeh per 100 grams Of dry weight

Nutrient	Soybeans	Tempeh
Ash (g)	6.1	3.6
Protein (g)	46.2	46.5
Fat (g)	19.1	19.7
Carbohydrate (g)	28.2	30.2
Dietary Fiber (g)	3.7	7.2
Calcium (mg)	254	347
Phosphorus (mg)	781	724
Iron (mg)	11.0	9.0
Thiamine (Vitamin B1) (mg)	0.48	0.28
Riboflavin (Vitamin B2) (mg)	0.15	0.65
Niacin (Vitamin B3) (mg)	0.67	2.52
Pantothenic Acid (Vitamin B5) (μg)	430	520
Pyridoxine (Vitamin B6) (μg)	180	100
Vitamin B12 (Cobalamin) (μg)	0.2	3.9
Biotin (Vitamin B7) (μg)	35	53
Essential Amino Acids (g)	17.7	18.9

Source: Astawan (2013)

Outpatient and inpatient visit data at Moehammad Hoesin Hospital indicate that the incidence of type 2 diabetes mellitus continues to increase. In 2015, there were 578 visits by diabetes mellitus patients; this number rose to 614 in 2016 and reached 675 visits in 2017. Previous studies have investigated the effects of soybean tempeh diets on blood glucose levels in diabetic rats; however, research on the effects of soybean tempeh diets on blood glucose levels among prediabetic subjects at Moehammad Hoesin Hospital has not yet been conducted. Therefore, this study was proposed to determine the effect of soybean tempeh consumption on blood glucose levels in individuals with prediabetes.

Methods

Study Design

This study employed a comparative pre-experimental design with a pretest–posttest control group approach to evaluate the effect of tempeh consumption on blood glucose levels among individuals with prediabetes.

Participants

A total of 60 participants were recruited using random sampling from administrative staff at Mohammad Hoesin Hospital, Palembang. Eligible participants were adults aged over 25 years with random blood glucose levels ranging from 110–199 mg/dL and who consented to participate throughout the study period. Participants were equally allocated into an intervention group (n=30) and a control group (n=30).

Instruments

Blood glucose levels were measured using standard clinical procedures with calibrated glucose measurement devices. Demographic data, including age, sex, body mass index (BMI), and educational level, were collected using a structured questionnaire.

Intervention

The intervention group received a tempeh-based diet consisting of 250 grams per day, administered in three servings for 14 consecutive days. The tempeh was prepared using standardized recipes with controlled seasoning. The control group continued their usual diet without tempeh supplementation.

Data Collection

Baseline (pretest) blood glucose levels were measured prior to the intervention, followed by posttest measurements after 14 days. All data were collected using standardized procedures to ensure consistency and reliability.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21. Descriptive statistics were used to summarize participant characteristics. Paired t-tests were conducted to assess within-group differences, while independent t-tests were used to compare differences between groups. Statistical significance was set at p<0.05.

Ethical Considerations

This study was conducted in accordance with ethical principles for human research. All participants provided informed consent prior to enrollment. Confidentiality and anonymity of participant data were maintained throughout the study. Approval was obtained from the relevant institutional authority at Mohammad Hoesin Hospital.

Results

The results of the univariate analysis, consisting of the frequency distribution of respondents' characteristics, are presented in **table 2.** The majority of participants in both the intervention and control groups were aged 41–50 years (46.7%). Based on sex, most respondents were female (61.6%). According to nutritional status (BMI), the majority were classified as overweight (43.3%). Regarding educational background, most respondents had a Diploma III level of education (41.67%).

Table 2. Frequency Distribution of Respondents Characteristic

Characteristics	Intervention Group		Control Group		Σ %
	n	%	n	%	
Age (Years)					
<30 years	3	5	0	0	5
30 - 40 years	6	10	11	18,33	28,33
41 - 50 years	12	20	16	26,7	46,7
>50 years	9	15	3	5	20
Sex					
Male	11	18,33	12	20	38,33
Female	19	31,66	18	30	61,66
BMI					
Normal	6	10	8	13,33	23,33
Overweight	14	23,33	12	20	43,33
Obese	10	16,67	10	16,67	33.33
Educational Level					
Bachelor's Degree	9	15	6	10	25
Diploma III	13	21,67	12	20	41,67
Senior High School	8	13,33	12	20	33,33

As people get older, they will experience an aging process caused by a decrease in the body's metabolic activity, thus increasing the possibility of various health problems appearing. (Laila, S., & Veronika, 2024).

The characteristics of the sample frequency distribution by age in Table 2 show that the treatment and comparison groups were dominated by the 41–49 year old age group working at Mohammad Hosein Hospital. As age increases, the risk of degenerative diseases such as prediabetes and diabetes mellitus increases. Several factors increase the likelihood of developing diabetes mellitus (DM) in older age. Decreased physical activity, decreased insulin production, and increased insulin resistance are all associated with increasing age (Sari, T., dkk. 2024).

According to (Dewantari, N. M., & Sukraniti (2020) type II diabetes mellitus usually occurs in people over 45 years of age because at that age the body experiences various changes, especially in the pancreas as an organ that produces insulin in the blood. According to Bruinneir and Suiddart, age is related to the incidence of diabetes mellitus, where the older a person is, the higher the risk of developing type II diabetes mellitus (Sasmita, 2021).

The results of this study indicate a relationship between age and the incidence of type II diabetes mellitus in people over 45 years of age. This finding is in line with research (Milita, F., Handayani, S., & Setiaji, 2021) which states that age has a relationship with the incidence of type II diabetes mellitus

According to Perkeni (2021) The risk of developing glucose intolerance increases with age. People over 45 should have their blood glucose checked annually.

The research results in table 2 above show that 37 (61.66%) respondents were female, outnumbering 23 (37%) respondents by male. This finding echoes the findings of (Kriswiastiny et al., 2022) who stated that more female patients suffer from diabetes mellitus than male patients.

Women are more susceptible to prediabetes than men due to their greater body fat composition, which means they are more susceptible to abdominal and femoral fat accumulation than men. As a result, women are more susceptible to weight gain associated with obesity risk. (Nurohmi, S. dkk, 2021).

The research results in **table 2** show that 26 people (43.33%) were overweight and 20 (33.33%) were obese. Excessive body fat can trigger insulin resistance, making tissues less sensitive to insulin. Consuming too many nutrients can lead to overnutrition (Yuliastuti, L. *et al*., 2024)

One of the main risk factors for diabetes mellitus (DM), particularly type II diabetes, is obesity. There is a complex relationship between this condition and diabetes mellitus. Although obesity, as measured by Body Mass Index (BMI), is generally low in the Indian population, it remains closely associated with the incidence of glucose intolerance in both urban and rural areas. Even within the normal weight range, weight gain can increase the risk of diabetes mellitus, especially in individuals with a family history of the disease.

The educational status of the treatment and comparison groups was 5 (25%) with a bachelor's degree, 25 (41.67%) with a diploma, and 20 (33.33%) with a high school diploma. The results of the study on the distribution of formal education are shown in tabel 1, which shows that people with high educational status suffer from prediabetes mellitus. According of (Kurniawan, D. A., *et al*, 2022) The higher a person's level of education, it is hoped that their knowledge and awareness about managing the disease will increase. According of Dafriani, P., & Dewi (2019) The role of high educational status is very important based on character empowerment.

The results of the bivariate analysis regarding blood glucose levels before the administration of the soybean tempeh menu in the intervention and control groups are presented in **Table 3.** The effect of soybean tempeh menu administration on blood glucose levels among prediabetic subjects can also be seen in Table 3.

Table 3. Pre-Intervention Blood Glucose Levels in the Intervention and Control Group (n=60)

Variable	**Intervention Group**	**Control Group**	**P value**
	Before		
Random Blood Glucose Pretest	Mean ± SD	Mean ± SD	0,0624
	139,83 ± 16,518	137,83 ± 14,870	

The results of the statistical test (Independent *t*-test) in table 3 show that the pretest blood glucose levels before the administration of the soybean tempeh menu obtained a *p*-value of 0.0624, indicating that there was no significant difference between the blood glucose levels of the two groups. This finding suggests that the pretest condition of the respondents was homogeneous.

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Table 4. Mean Distribution of Blood Glucose Levels in the Intervention and Control Groups of Administrative Employees

Variable		Intervention Group Mean ± SD	P value	Control Group Mean ± SD	P value	P value
Random Blood Glucose (mg/dl)	Pre	139,83 ± 16,518	0,001	137,83 ± 14,870	0,000	0,001
	Post	104,30 ± 13,107		121,93 ± 13,091		

Paired t-test (dependent), p = 0.005; *Independent t-test, p = 0.005.

Based on **table 4**, the mean difference in blood glucose levels in the intervention group between pretest and posttest was 35.53 mg/dL. In the control group, the mean difference between pretest and posttest blood glucose levels was 15.9 mg/dL.

The results of the paired *t*-test in both the intervention and control groups showed a *p*-value of <0.001, indicating that the *p*-value in both groups was <0.005. This demonstrates that there was a significant difference in the mean blood glucose levels in both the intervention group, which received the soybean tempeh menu, and the control group, which did not receive it, in relation to the reduction of blood glucose levels.

To determine whether this difference was influenced by the administration of the soybean tempeh menu, an independent *t*-test was conducted. The result of the independent *t*-test showed a *p*-value of 0.000, indicating that the administration of the soybean tempeh menu had a significant effect on the reduction of blood glucose levels.

Discussion

The statistical test results for blood glucose levels in the treatment group showed a p-value of 0.000, thus concluding that the provision of soybean tempeh on the diet had an effect on blood sugar levels. In the comparison group, the statistical test results showed blood glucose levels with a p-value of <0.001, thus concluding that the diet without soybean tempeh on the diet had an effect on reducing blood glucose levels. This is in line with Astawan (2019) that tempeh lowers blood sugar and accelerates wound healing in diabetic rats.

In the Treatment and Comparison Groups, statistical tests obtained blood glucose levels *p < 0,001*, so it was found that there was a difference in the effect between giving a soy tempeh menu and without giving a soy tempeh menu on reducing blood sugar levels, but there was a difference in blood glucose levels between the treatment and comparison groups of 17.63 mg /dl. This is because the intake of vegetable protein is higher compared to the comparison group, and the contribution of fiber in the treatment group is more than the soy tempeh menu of 200 grams /day providing 18 grams of fiber.

One effective way to lower blood glucose levels is to adopt a diet that meets dietary requirements. This diet involves providing 25-30 kcal of energy per kg of normal body weight, 10-15% of protein, 20-25% of fat, 60-70% of carbohydrates, and 25-30 grams of fiber per day.(Santi, J. S., dan Septiani, 2021).

One effective method for lowering blood glucose levels is maintaining a healthy diet. One fermented soybean product is tempeh, which is produced with the help of the mold Rhizopus sp. in soybeans. (Putri, 2024), by changing your lifestyle, losing weight, controlling your diet, and exercising regularly, you can improve prediabetes. (Perkeni, 2021).

Soybean tempeh contains high levels of arginine and glycine, which are responsible for the pancreatic secretion of insulin and glucagon. By increasing blood glucose levels, the amino acids arginine and glycine can increase glucose-induced insulin secretion by up to twofold, thereby increasing glucose stimulation of insulin release. Furthermore, insulin will increase glucose transport to muscles, liver, and other parts of the body, returning blood glucose levels to normal. (A. C. Guyton, 2019). The protein found in soybeans is beneficial for the body and can improve insulin sensitivity in people with type II diabetes. People with type II diabetes are advised to replace some of their animal protein intake with soy protein, which is high in fiber. (PERSAGI, 2019).

Tempeh also contains isoflavones, polyphenolic compounds that act as antioxidants and help maintain blood sugar balance and improve insulin sensitivity. Plant-based proteins like tempeh are also used as a substitute for animal protein in weight-loss diets, making it a good choice because it contains probiotics, which aid digestion and are essential for the body. (K Azizah, 2020). Adopting a healthy lifestyle, such as exercising regularly, controlling your diet, and losing weight, can help reduce prediabetes. (Perkeni, 2021).

Implications and limitations

This study contributes conceptually to the growing body of evidence on functional foods by highlighting the potential role of fermented soy products, particularly tempeh, in improving glycemic control among individuals with prediabetes, thereby reinforcing theoretical links between plant-based protein, isoflavones, and metabolic regulation. It also provides scientific insight into diet-based interventions as a non-pharmacological approach within preventive health frameworks. However, several limitations should be acknowledged, including the relatively small sample size, short intervention duration, and pre-experimental design, which may limit causal inference and generalizability. In addition, potential confounding factors such as participants' overall dietary intake, physical activity, and adherence to the intervention were not fully controlled, suggesting that further large-scale, randomized controlled trials with longer follow-up periods are needed to strengthen the evidence.

Relevance to Practice

The findings of this study have important implications for clinical and community nutrition practice, particularly in the prevention and management of prediabetes. Incorporating tempeh as a daily dietary component can serve as an affordable, culturally acceptable, and nutritionally beneficial intervention to help reduce blood glucose levels. Health professionals, including nutritionists and dietitians, can recommend tempeh-based meal plans as part of dietary counseling for individuals at risk of developing diabetes. Additionally, this approach supports the promotion of plant-based protein sources and functional foods in routine care, contributing to improved metabolic health outcomes and potentially reducing the burden of diabetes in the population.

Conclusion

Daily consumption of 250 g of tempeh for 14 days significantly reduces blood glucose levels in individuals with prediabetes, indicating its potential as an effective, accessible, and culturally appropriate dietary intervention. This study underscores the importance of integrating functional foods into preventive health strategies to reduce the risk of progression to type 2 diabetes.

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CrediT Authorship Contributions Statement

Manuntun Rotua: Conceptualization, Methodology, Investigation, Supervision, Writing – Original Draft.
Sriwiyanti: Data Curation, Formal Analysis, Validation, Writing – Review & Editing.

Conflicts of Interest

There is no conflict of interest.

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