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Original Research

Protein-First Meal Sequence and Blood Glucose Response in Patients with Type 2 Diabetes Mellitus

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ABSTRACT
Background: *Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder requiring appropriate dietary management. Meal-sequence modification, particularly consuming protein before carbohydrates, may help regulate postprandial glucose levels.*

Methods: *This quasi-experimental study involved 26 patients with T2DM selected using non-probability purposive sampling. Participants received two meal-sequence interventions for two weeks: protein before carbohydrates (Intervention A) and protein together with carbohydrates (Intervention B). Group 1 received 40 g of red bean soup, while Group 2 received 22 g of beef soup. FBG and 2h-PBG were measured at each intervention stage and analyzed using the Independent Samples T-Test at a significance level of* $p < 0.05$.

Results: *After Intervention A, mean FBG was 147.54 ± 19.40 mg/dL in Group 1 and 147.31 ± 26.83 mg/dL in Group 2 (p = 0.980), while 2h-PBG was 193.38 ± 23.45 and 210.31 ± 53.40 mg/dL, respectively (p = 0.306). After Intervention B, mean FBG was 148.31 ± 20.39 and 156.23 ± 24.82 mg/dL (p = 0.383), while 2h-PBG was 189.23 ± 26.94 and 220.92 ± 55.85 mg/dL (p = 0.078), respectively.*

Conclusion: *No significant differences in FBG or 2h-PBG were observed between the plant-based and animal-based protein groups. However, the consistently lower 2h-PBG with red bean consumption suggests a potentially favorable glycemic response warranting further investigation. Meal sequencing may be considered as a complementary dietary strategy alongside appropriate dietary intake and glycemic control.*

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INTRODUCTION

Diabetes mellitus (DM) is a disease characterized by impaired metabolic control in which the body is unable to produce sufficient insulin hormone. Diabetes mellitus is marked by elevated blood glucose levels (Zakiyah et al., 2023). According to

Prawitasari (2019), diabetes mellitus belongs to a group of non-communicable metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both.

In general, diabetes mellitus is classified into two main types: type 1 diabetes mellitus and type 2 diabetes mellitus. Data from the International Diabetes (International Diabetes Federation, 2025) estimate that the number of adults aged 20–79 years living with diabetes worldwide has reached approximately 589 million. The prevalence of diabetes mellitus in Indonesia has shown an increasing trend over the past five years. Riskesdas, (2018) reported a prevalence of 10.9%, which increased to 11.7% according to the (Health Policy Agency, 2023). Based on the Malang City Health Profile, the incidence of diabetes mellitus increased from 21.697% in 2020 to 22.086% in 2021, 22.227% in 2022, and 20.771% in 2023.

The management of diabetes mellitus consists of five pillars: education, dietary management, physical exercise, pharmacological intervention, and blood glucose monitoring (Suciana et al., 2019). Dietary management is one of the key strategies in controlling blood glucose levels in individuals with diabetes mellitus. Diet is considered the primary therapeutic approach for patients with diabetes mellitus, and each individual must adhere to an appropriate dietary pattern to prevent complications (Wahyuni et al., 2019). An appropriate dietary pattern plays an essential role in diabetes management, as it directly contributes to glycemic control and the prevention of complications. The Indonesian Society of Endocrinology (PERKENI, 2021) emphasizes appropriate meal type, amount, and timing as important components of dietary management in diabetes. Modifying meal sequence by consuming protein or vegetables before carbohydrate-rich foods has been proposed as a strategy to attenuate postprandial glucose excursions in individuals with type 2 diabetes (Okami et al., 2022).

A study conducted by (Ridwanto et al., 2024) on the association between protein intake and 2-hour postprandial blood glucose levels in patients with type 2 diabetes mellitus demonstrated that protein intake has a significant impact on glycemic control. Protein is known to reduce the postprandial glycemic response by slowing gastric emptying and stimulating incretin hormones such as glucagon-like peptide-1 (GLP-1), which enhances insulin secretion and suppresses glucagon release (Anjom-shoae et al., 2024). Blood glucose levels may become dysregulated when protein requirements are not met (Mensink, 2024) In such conditions, the body utilizes amino acids as an energy source through gluconeogenesis, converting amino acids into glucose (Corsetti et al., 2024).

This mechanism differs from carbohydrate metabolism, in which carbohydrates are rapidly broken down into simple glucose and quickly absorbed into the bloodstream. Protein has a slower and more stable effect on blood glucose elevation due to its more complex metabolic processes (Nagy et al., 2026). Protein consumption may reduce the postprandial glycemic response by slowing gastric emptying and stimulating incretin hormones such as glucagon-like peptide-1 (GLP-1), thereby enhancing insulin secretion (Smedegaard et al., 2023).

Another study by Basturk et al., (2021) reported that protein has a positive effect on glycemic response and may be recommended for individuals with diabetes mellitus. Protein intake exerts a relatively limited contribution to endogenous glucose production under postprandial conditions, although amino acids from dietary protein can serve as substrates for gluconeogenesis (Yanagisawa et al., 2023). High protein intake may produce a delayed and sustained postprandial glycemic response, with increases in blood glucose occurring several hours after protein consumption, potentially due to the contribution of amino acids to endogenous glucose production (Siedlecki et al., 2022).

Protein is one of the components influencing the glycemic index (GI) of foods; higher protein content is generally associated with a lower glycemic index (Arif et al., 2014). Animal-based protein sources typically have a low or zero glycemic index because they contain no carbohydrates. For instance, beef does not significantly increase blood glucose levels after consumption (Probosari, 2019). Adequate protein intake may help reduce blood glucose levels and HbA1c in patients with diabetes mellitus by improving insulin sensitivity and stimulating insulin secretion through specific amino acids such as leucine.

Legumes, particularly red kidney beans (*Phaseolus vulgaris* L.), are good sources of plant-based protein due to their protein, fiber, and resistant starch content (Dias & Imai, 2017). Red kidney beans have a low to moderate glycemic index, depending on preparation methods and food combinations (Xu et al., 2022). The soluble fiber content in red kidney beans slows glucose absorption, thereby contributing to glycemic control. They also contain resistant starch, which is not fully digested and helps regulate blood glucose by delaying carbohydrate digestion and absorption. Consumption of foods rich in dietary fiber and resistant starch may reduce hunger and appetite in patients with diabetes mellitus, thus potentially lowering insulin requirements during digestion (Imai & Dias, 2020).

Based on the background described above, this study investigated the glycemic response to consuming plant-based and animal-based protein sources before carbohydrate intake in patients with type 2 diabetes mellitus. Previous studies have reported that consuming protein before carbohydrates may reduce postprandial blood glucose levels. However, studies comparing different protein sources, particularly plant-based and animal-based proteins, in relation to the sequence of protein and carbohydrate consumption remain limited.

Therefore, this study compared the glycemic response to red bean soup as a plant-based protein source and beef soup as an animal-based protein source when consumed before carbohydrates and when consumed together with carbohydrates. This comparison provides additional information on whether the type of protein source and the sequence of consumption are associated with differences in blood glucose responses in patients with type 2 diabetes mellitus. The study was conducted at Janti Public Health Center, Malang City, in July 2025. The findings may provide additional evidence for the use of meal-sequence modification and appropriate protein sources as part of dietary management for patients with type 2 diabetes mellitus (Malang City Health Office, 2023).

MATERIALS AND METHOD

This study employed a quantitative approach using a quasi-experimental design with a pretest–posttest group design. A quasi-experimental design was selected because the study aimed to evaluate changes in blood glucose levels following a controlled dietary intervention while maintaining the study conditions in the clinical setting. The participants were selected using non-probability purposive sampling based on the established inclusion and exclusion criteria and were then randomly assigned to two groups. The two groups were used to compare the glycemic responses to plant-based and animal-based protein sources.

In the first week, Group 1 received 40 g of red kidney bean soup before consuming rice, while Group 2 received 22 g of beef soup before consuming rice (Intervention A). In the second week, the same protein sources were provided to the same groups, but the protein and rice were consumed simultaneously (Intervention B). Fasting blood glucose (FBG) and 2-hour postprandial blood glucose (2h-PBG) were measured before and after each intervention to assess the glycemic response to the different meal sequences.

The study population consisted of outpatients with type 2 diabetes mellitus registered in the working area of Janti Public Health Center, Malang City. Based on data from June 2025, the number of patients with type 2 diabetes mellitus in this area was recorded at 165 individuals. The sample was selected using a non-probability sampling method with a purposive sampling technique, based on the following inclusion criteria: patients diagnosed with type 2 diabetes mellitus; aged 40–75 years; nutritional status within a body mass index (BMI) range of 18.5–29.9 kg/m² (normal to obese); no known allergy to plant-based or animal-based protein sources; not receiving insulin therapy; taking the same oral hypoglycemic agents, such as glibenclamide or metformin; diagnosed with diabetes mellitus without complications or with mild complications such as hypertension, hyperuricemia, or hypercholesterolemia; and willing to participate in the study until completion after receiving an explanation and signing informed consent.

The exclusion criterion was respondents who experienced a decline in physical condition requiring special medical care during the data collection period. The sample size was calculated using the formula proposed by Charan (2013):

$$\boxed{n = \frac{r+1}{r} \frac{SD^2(Z_\beta + Z_{\frac{\alpha}{2}})^2}{d^2}}$$

n: Required sample size per group
r: Ratio of control to intervention group (r = 1)
SD: Standard deviation
Zβ: Standard normal deviate corresponding to the desired statistical power
Zα/2: Standard normal deviate corresponding to a two-tailed significance level of 5%
d: Expected mean difference between intervention and control groups

The data used in this study were primary data, including respondents' characteristics (sex, age, nutritional status, education level, occupation, comorbidities, medication use, and history of diabetes), fasting blood glucose (FBG), 2-hour postprandial blood glucose (2h-PBG), and dietary intake. FBG and 2h-PBG were measured six times over the two-week intervention period. Blood samples were collected and blood glucose measurements were performed by trained nurses at Janti Public Health Center to ensure standardized and reliable measurement procedures. Dietary intake data were collected using 4 × 24-hour dietary recalls and a Food Frequency Questionnaire (FFQ). The dietary intake data were processed using NutriSurvey 2007 and Microsoft Excel to calculate average energy and nutrient intake and assess adherence to the 3J dietary principle, including appropriate food type, amount, and meal schedule.

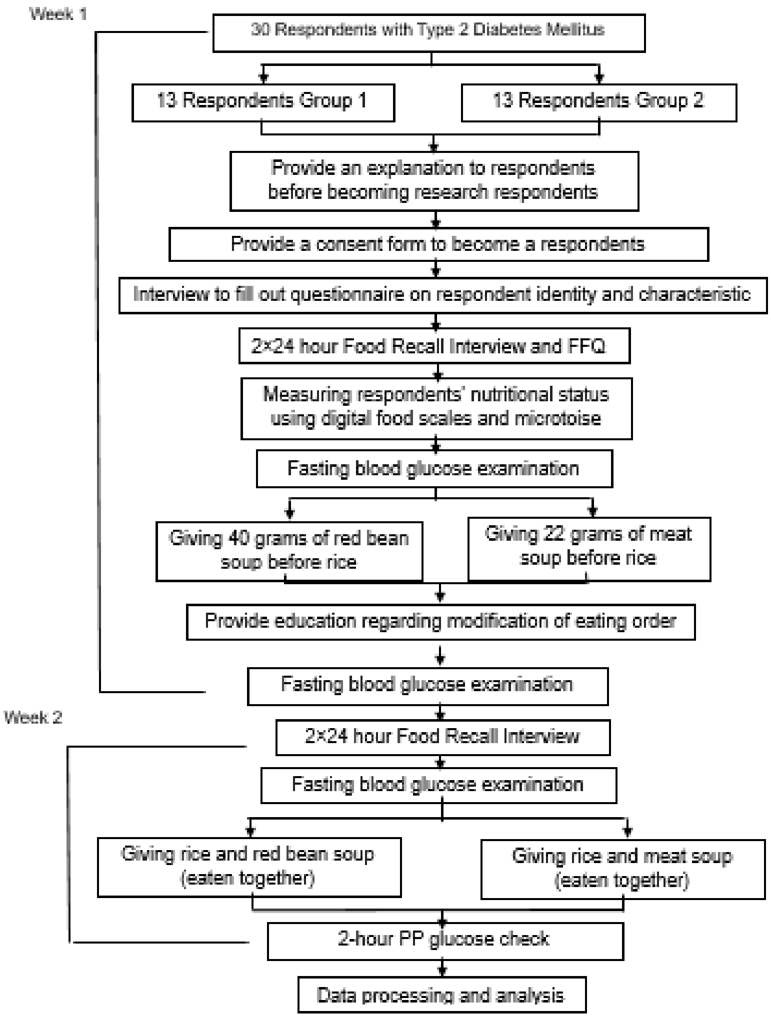

Figure 1. Research Flow

The intervention consisted of red kidney bean soup (40 g cooked; equivalent to 20 g raw) and beef soup (22 g cooked; equivalent to 40 g raw), which were consumed after fasting blood glucose measurement. A 10–15 minute interval was provided before respondents consumed 57 g of rice (±100 kcal), in accordance with carbohydrate management recommendations for patients with diabetes. During the two-hour period prior to the postprandial blood glucose examination, respondents received brief education regarding meal sequence modification through a leaflet. Data collection was carried out according to each group's schedule. If a respondent was unable to attend, a home visit was conducted to ensure data completeness.

Data analysis was performed using SPSS version 25, including univariate and bivariate analyses. Univariate analysis was used to describe respondents' characteristics based on frequency distributions and percentages. Bivariate analysis was conducted to test the study hypothesis, beginning with the Shapiro–Wilk normality test. If the data were normally distributed, the Independent Samples t-test was applied; if not, the Mann–Whitney U test was used.

This study received ethical approval from the Research Ethics Committee of Universitas Yatsi Madani (Approval No. 237/LPPM-UYM/I/2025). All respondents provided informed consent before participating in the study. Participation was voluntary, and respondents were informed of their right to withdraw at any time. The confidentiality and privacy of respondents were maintained throughout the study. The ethics approval letter is provided as a supplementary document.

RESULTS

Table 1 presents the characteristics of the respondents. The mean age of respondents in Group 1 was 61.85 ± 9.20 years, while in Group 2 it was 62.38 ± 9.17 years, with no statistically significant difference between the two groups ($p = 0.883$). Nutritional status based on body mass index (BMI) showed a mean of 28.50 ± 5.83 kg/m² in Group 1 and 26.11 ± 3.29 kg/m² in Group 2. The statistical test also indicated no significant difference between groups ($p = 0.212$). These BMI values suggest that the majority of respondents were classified as overweight to obesity class I (25–29.9 kg/m²).

Table 1. Characteristics of Quantitative Respondents

Variabel	Mean ± SD		*p-value*
	Group 1	Group 2	
	Quantitative Data		
Age (years)	61.85 ± 9.20	62.38 ± 9.17	0.883
Weight (kg)	67.15 ± 9.36	63.64 ± 9.72	0.358
Height (cm)	154.15 ± 7.04	155.84 ± 6.96	0.544
Nutritional status (kg/m^2)	28.50 ± 5.83	26.11 ± 3.29	0.212
DM History (year)	2.69 ± 1.54	3.54 ± 1.61	0.185

Description: * $p < 0.05$, based on Independent t-test.

Data are presented as mean ± SD. Statistical analysis was performed using the Independent Samples T-Test.The gender distribution in both groups showed the same proportion, namely 69.2% of women and 30.8% of men. Comorbidities in group 1 were as many as (46.2%) and in group 2 as much as (53.8%). Respondents in group 1 took antidiabetic drugs as much as 23.1%, while in group 2 it was recorded as 61.5%.

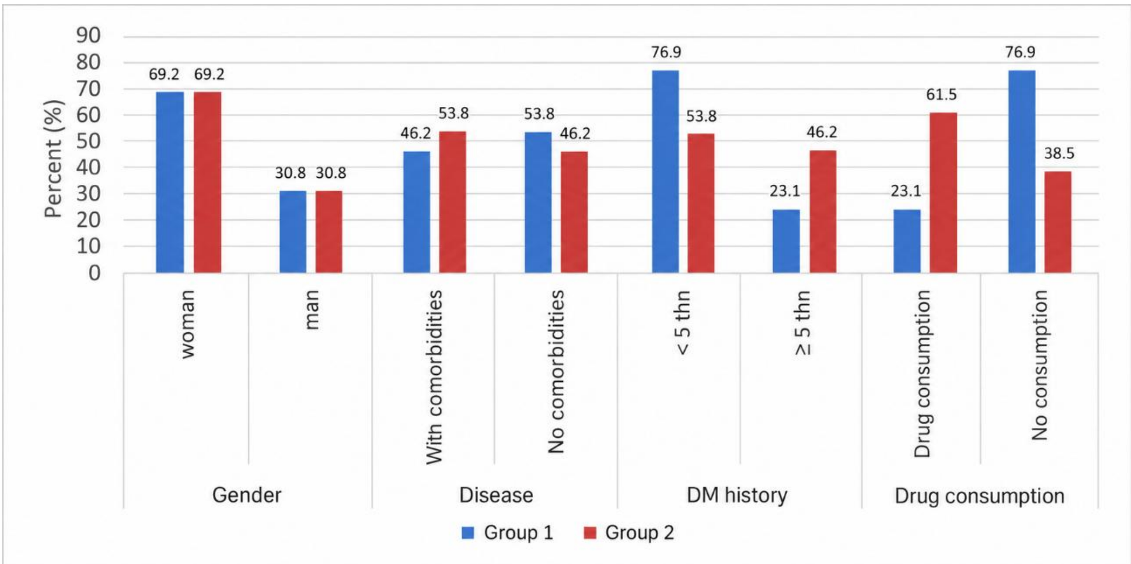

Figure 2. Qualitative Respondent Characteristics

Table 2 shows the difference in the average GDP levels pre and post intervention A in groups 1 and 2. Before intervention A, the GDP levels of groups 1 and 2 were found to be as follows: 141.69 ± 25.25 and 145.08 ± 31.46 ($p = 0.765$). After the administration of intervention A for three times, there was a change in GDP levels in both groups, namely 147.54 ± 19.40 and 147.31 ± 26.83, but the difference was not statistically significant ($p = 0.980$). In intervention B, the average difference in GDP levels in group 1 and group 2 was 151.23 ± 22.96 and 154.54 ± 22.26, respectively ($p = 0.713$). After the administration of intervention A for three times, there was a change in GDP levels in both groups, namely 148.31 ± 20.39 and 156.23 ± 24.82, which were also not significantly different ($p = 0.383$).

Table 2. Difference in Average GDP Levels of Group 1 and Group 2

Variabel	Mean ± SD		p-value
	Group 1	Group 2	
Pre-Intervention A	141,69 ± 25,25	145,08 ± 31,46	0,765
Post Intervention A	147,54 ± 19,40	147,31 ± 26,83	0,980
Pre-Intervention B	151,23 ± 22,96	154,54 ± 22,26	0,713
Post Intervention B	148,31 ± 20,39	156,23 ± 24,82	0,383

Description: * $p < 0.05$, based on Independent t-test.

Table 3 differences in GD2JPP levels in group 1 and group 2 shows that in Intervention A there was no significant difference between the kidney bean group and the beef group. Before further analysis, the normality of the FBG and 2-hour postprandial blood glucose (2h-PBG) data was assessed using the Shapiro–Wilk test. A p-value > 0.05 was considered indicative of a normal distribution. Because the data were normally distributed, differences in blood glucose levels between Group 1 and Group 2 were analyzed using the Independent Samples T-Test. Statistical significance was set at $p < 0.05$. The mean GD2JPP of group 1 was 193.38 ± 23.45 mg/dl, while group 2 was 210.31 ± 53.40 mg/dl, with a p value = 0.306. The tendency for lower GD2JPP levels in the kidney bean group may be related to the lower soluble fiber content and glycemic index, which is known to lower the postprandial glucose response (Zafar et al., 2020).

In Intervention B, group 1 had an average GD2JPP of 189.23 ± 26.94 mg/dl, while group 2 increased to 220.92 ± 55.85 mg/dl, with a p value = 0.078. The increase in GD2JPP levels in the beef group is influenced by differences in the composition of animal proteins that have a lower insulinogenic response than vegetable proteins, so when consumed together with carbohydrates can produce a higher glucose spike (Fernández-García et al., 2019).

Table 3. Difference in Average GD2JPP Levels of Group 1 and Group 2

Variabel	Mean ± SD		p-value
	Group 1	Group 2	
Intervention A	193. 38 ± 23.45	210.31 ± 53.40	0.306
Intervention B	189.23 ± 26.94	220.92 ± 55.85	0.078

Description: * $p < 0.05$, based on Independent t-test.

DISCUSSION

The results of this study showed that the sequence of protein consumption before carbohydrates did not provide a significant change in fasting blood glucose levels and 2 hours post prandial ($p>0.05$). These results are in line with the research of Shukla et al., (2015) and Imai et al., (2014) who reported that eating protein before carbohydrates can indeed lower blood sugar after meals, but the effect is relatively small and not always noticeable in everyone. This is in line with the recommendations of the *American Diabetes Association*, (2022) which emphasizes that meal sequence regulation strategies can support glycemic control, but the effect is strongly influenced by protein type and overall dietary pattern.

A comparison of fasting blood glucose (GDP) and 2-hour post-prandial blood glucose (GD2JPP) levels in both groups showed that the group receiving plant-based protein tended to experience a slightly better decline, both when consumed before carbohydrates and at the same time. These differences indicate that the fiber content in kidney bean soup contributes to slowing down glucose absorption and lowering the glycemic response, in line with the finding that soluble fiber increases chyme viscosity, slows gastric emptying, and decreases the rate of glucose absorption (Solomon et al., 2021). This mechanism also explains why the plant protein group shows a better glycemic response than animal protein in the short term.

In general, although the intervention did not produce statistically significant changes, the findings still suggest that consuming both plant-based and animal-based protein before carbohydrates may help dampen postprandial glucose increases. Recent studies show that protein consumption before or with carbohydrates can decrease the postprandial glucose response through incretin stimulation, increased insulin secretion, as well as a slowdown in gastric emptying (Yasunaga et al., 2023). The effects of plant-based protein appear to be more consistent because their fiber content provides a synergistic effect in slowing down the glycemic response (Fernández-García et al., 2022). Meal sequence management strategies remain relevant as a method of supporting glycemic control, especially when combined with a low-glycemic index diet and carried out consistently (Zafar et al., 2024).

The intervention still did not provide consistent changes in blood glucose levels, one of which was because respondents still often consumed foods with moderate to high glycemic index (GI) outside of the intervention session. Foods such as white rice, noodles, processed bread, crackers, fried foods, and sweet foods are known to raise blood glucose faster due to their easy-to-digest nature and cause glycemic spikes (Wolever & Jenkins, 2018). These consumption patterns make the effects of providing protein before carbohydrates less visible, as high IG intake can mask the glycemic lowering effects of the intervention (Augustin et al., 2020). Recent research shows that the higher the glycemic load of the food consumed, the greater the increase in blood glucose levels in patients with type 2 diabetes (Nisrina et al., 2024).

All respondents still did not meet the accuracy of the amount of energy, protein, carbohydrates, fat, and fiber intake, and inaccuracies in the type of food were also found in both groups. Respondents also continued to consume medium to high IG foods. Irregular meal schedules in all respondents also contribute to blood glucose fluctuations, as inconsistent meal times can disrupt the stability of insulin response and glycemic control (Marquez & Johnson, 2021). Other studies have also explained that inaccurate intake amounts and irregular diets are associated with increased blood glucose levels in patients with type 2 diabetes (Siregar et al., 2019). The combination of these various factors is thought to be the main cause of the insignificant change in blood glucose levels after the intervention.

The findings of this study have several implications for dietary management in patients with type 2 diabetes mellitus. Although no significant reductions in fasting blood glucose or 2-hour postprandial blood glucose were observed, consuming plant-based or animal-based protein before carbohydrates may still be considered as a simple complementary approach to meal planning. The lower tendency of 2-hour postprandial blood glucose observed in the red kidney bean group suggests that plant-based protein sources may be a practical option within a balanced diet. However, meal sequencing should not be considered as a stand-alone strategy and should be combined with appropriate food selection, portion control, regular meal schedules, medication adherence, and other recommended diabetes management practices.

This study has several strengths, including the comparison of plant-based and animal-based protein sources and the assessment of both fasting and 2-hour postprandial blood glucose responses under two different meal-sequence patterns. However, several limitations should be considered. The sample size was relatively small, involving only 26 participants, and the intervention period was limited to two weeks. Dietary intake outside the intervention sessions could not be fully controlled, and respondents continued to consume foods with moderate- to high-glycemic-index values. Variations in energy and nutrient intake, meal schedules, and antidiabetic medication use may also have influenced the blood glucose responses.

The findings have practical implications for dietary management in patients with type 2 diabetes mellitus. Although no significant changes in fasting or 2-hour postprandial blood glucose were observed, the red kidney bean group showed a tendency toward lower postprandial glucose levels, suggesting that plant-based protein may be considered as part of a balanced diet. The strengths of this study include the comparison of plant-based and animal-based protein sources and two meal-sequence patterns. However, the small sample size (n = 26), short intervention period (two weeks), and limited control of dietary intake, meal schedules, and antidiabetic medication may have influenced the results. Future studies should use larger samples, longer intervention periods, and better control of dietary intake and other factors affecting blood glucose, preferably through randomized controlled trials.

CONCLUSION

There was no statistically significant difference between the two groups, analysis of glycemic parameters showed that both GDP and GD2JPP levels tended to decrease more consistently in the group that received kidney beans, especially in Intervention B. In contrast, the group receiving beef showed a more volatile pattern with a tendency to slightly increase, especially in postprandial glucose levels. These findings suggest that kidney beans may be considered as a plant-based protein source within a balanced dietary pattern for patients with type 2 diabetes mellitus. However, further studies with larger samples and longer intervention periods are needed to confirm this potential benefit.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest between the author and any party related to the implementation of research, writing process, or publication of this article.

DECLARATION USE AI

Artificial intelligence (AI) tools were used solely to improve the grammar and language clarity of the background, materials and methods, and results section without altering the scientific content.

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