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## Comparative Impact of Plant-Based Protein and Lean Animal Protein Diets on Insulin Sensitivity in Adults

(***RCT***)


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# Abstract

**Background**: Insulin resistance represents a pivotal metabolic disturbance preceding type 2 diabetes mellitus. Dietary protein source has emerged as a modifiable factor influencing glucose regulation and lipid metabolism. While plant-based proteins are increasingly promoted for cardiometabolic benefits, their direct comparative effect on insulin sensitivity relative to lean animal proteins remains underexplored.

**Objective:** To evaluate whether a plant-based protein diet improves insulin sensitivity more effectively than a lean animal protein diet in adults at risk for type 2 diabetes.

**Methods:** A 12-week randomized controlled trial was conducted among 100 adults aged 30–55 years with prediabetes in South Punjab. Participants were randomly assigned to an isocaloric diet emphasizing **either** plant-based protein **or** lean animal protein, with matched macronutrient distribution. The primary outcome was the change in insulin sensitivity assessed by HOMA-IR. Secondary outcomes included changes in fasting glucose, HbA1c, lipid profile, body weight, BMI, and waist circumference. Data were analyzed using SPSS version 26; between-group comparisons were performed using independent t-tests and repeated measures ANOVA.

**Results:** Compared to the animal protein group, the plant-based group demonstrated a greater reduction in HOMA-IR (−0.7 vs. −0.2, $p = 0.02$) and fasting glucose (−9.2 mg/dL vs. −3.3 mg/dL, $p = 0.01$). Reductions in total cholesterol and LDL cholesterol were also significantly greater in the plant-based group ($p \leq 0.02$ for both), which also showed a modest increase in HDL ($p = 0.04$). Body weight and waist circumference declined more markedly in the plant-based group ($p \leq 0.04$).

**Conclusion:** In adults with prediabetes, a plant-based protein diet led to superior improvements in insulin sensitivity, lipid metabolism, and adiposity reduction compared with an isocaloric lean animal protein diet. These findings support the role of plant-based protein as an effective dietary strategy for mitigating insulin resistance and improving metabolic health.

**Keywords:** Adiposity, Animal Proteins, Diet Therapy, Insulin Resistance, Lipid Metabolism, Plant Proteins, Prediabetes, Randomized Controlled Trial.


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# Introduction

The prevalence of insulin resistance and type 2 diabetes has risen dramatically over the past few decades, emerging as one of the most pressing metabolic health challenges worldwide(1). As sedentary lifestyles and calorie-dense diets become increasingly common, the metabolic equilibrium that maintains glucose homeostasis has been disrupted in many populations(1). Central to this dysregulation is the body's impaired ability to respond effectively to insulin, a condition that precedes and contributes to the onset of diabetes and its related complications. Among the modifiable determinants of insulin sensitivity, dietary composition plays a pivotal role, particularly the quality and source of dietary protein(2). While both plant-based and animal-based proteins serve as vital macronutrients, their differing amino acid profiles, fat content, and bioactive compounds suggest distinct physiological effects on metabolic health(3).

Over recent years, the global dietary landscape has witnessed a growing shift towards plant-based nutrition, fueled by concerns related not only to health but also to sustainability and ethics(3). From a metabolic standpoint, plant-based diets have been associated with lower body fat, improved lipid profiles, and reduced risk of insulin resistance compared with omnivorous diets(4). This association is believed to stem from the lower saturated fat and higher fiber content of plant-based foods, as well as their abundance of antioxidants and anti-inflammatory phytochemicals(4). In contrast, even lean sources of animal protein, though nutritionally dense, may exert differing effects on insulin sensitivity through mechanisms linked to amino acid composition, lipid metabolism, and hormonal regulation(5). However, the scientific discourse remains divided on whether plant-based proteins hold a definitive advantage over animal-derived proteins when matched for caloric and macronutrient balance(6).

Protein quality is determined not only by its amino acid spectrum but also by its metabolic impact(7). Animal proteins such as poultry, fish, and dairy are considered complete, containing all essential amino acids necessary for muscle synthesis and physiological maintenance(8). Yet, they often contain higher levels of branched-chain amino acids (BCAAs) that, while beneficial for muscle metabolism, have been implicated in promoting insulin resistance when consumed in excess(9). On the other hand, plant proteins, derived from sources like legumes, soy, grains, and nuts, tend to have a lower BCAA content and are accompanied by fibers, polyphenols, and unsaturated fats that may support improved insulin signaling(10). Moreover, plant-based proteins may influence gut microbiota composition in a manner conducive to metabolic health, an emerging area of interest linking diet to insulin sensitivity through microbial metabolites and inflammation control(11).

Despite these potential advantages, plant-based diets are not without their limitations(12). They may provide lower levels of certain amino acids, such as lysine and methionine, and may have reduced digestibility compared to animal proteins(13). The challenge, therefore, lies in determining whether plant proteins can achieve comparable—or superior—metabolic outcomes when integrated into balanced dietary patterns. Current literature offers conflicting evidence(13). Some trials report improvements in insulin sensitivity and glycemic control with plant-based interventions, while others show no significant difference when compared to diets rich in lean animal protein. Such inconsistencies may arise from variations in study design, duration, participant characteristics, and protein sources(14). A rigorously controlled comparison focusing specifically on protein source, while holding other dietary factors constant, is therefore necessary to clarify the true metabolic impact of plant versus animal protein intake(15).

Biologically, insulin sensitivity is influenced by intricate interactions among cellular pathways regulating glucose uptake, lipid oxidation, and inflammation(16). Dietary proteins modulate these processes through their effects on insulin signaling molecules, hepatic glucose output, and adipocyte function. Plant-derived proteins, rich in arginine and other insulin-sensitizing amino acids, may enhance nitric oxide production and vascular function, thereby improving insulin-mediated glucose disposal. Conversely, certain amino acids abundant in animal proteins, such as leucine, may activate the mTOR pathway, potentially contributing to insulin resistance when chronically overstimulated. Furthermore, plant-based proteins are often accompanied by non-nutritive compounds such as isoflavones and lignans that possess estrogenic and antioxidant activity, both of which may confer additional metabolic benefits(17).

The growing burden of prediabetes and metabolic syndrome underscores the urgency of identifying dietary strategies that can effectively enhance insulin responsiveness before the onset of irreversible pancreatic dysfunction. Given that protein is a fundamental macronutrient in both plant- and animal-based diets, its differential metabolic effects merit systematic investigation. While previous studies have examined broader dietary patterns—such as vegetarian or Mediterranean diets—few have isolated the specific impact of protein source on insulin sensitivity in adults at risk for diabetes. This gap highlights the need for well-designed randomized controlled trials to distinguish the true contribution of protein origin to metabolic outcomes.

The present study seeks to address this gap by directly comparing the effects of plant-based protein and lean animal protein diets on insulin sensitivity among adults at risk for type 2 diabetes. By controlling for caloric intake, physical activity, and overall


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macronutrient balance, the research aims to determine whether plant-based protein confers superior metabolic benefits in enhancing insulin responsiveness. The objective of this investigation is to assess whether substitution of animal protein with plant-based alternatives results in measurable improvements in insulin sensitivity, thereby providing evidence-based guidance for dietary recommendations in metabolic health management.

# Methods

This randomized controlled trial was conducted in South Punjab over a period of six months, which included a 12-week active intervention period, to evaluate the comparative effects of plant-based and lean animal protein diets on insulin sensitivity among adults at risk for type 2 diabetes. The study followed a parallel group design with equal allocation to the two intervention arms. Participants were recruited through local community health centers and public outreach programs using a combination of screening camps and digital advertisements. A total of 112 individuals were assessed for eligibility, of whom 100 met the inclusion criteria and were enrolled. Eligible participants were adults aged 30 to 55 years with a body mass index (BMI) between 25 and 35 kg/m² and either fasting plasma glucose levels ranging from 100 to 125 mg/dL or HbA1c between 5.7% and 6.4%, consistent with prediabetic criteria. Individuals with diagnosed diabetes, chronic kidney or liver disease, cardiovascular disorders, thyroid dysfunction, or those taking medications affecting glucose metabolism were excluded. Pregnant and lactating women, vegetarians, and individuals with food allergies to soy, legumes, dairy, or meat were also excluded to ensure uniformity in dietary compliance. All 100 enrolled participants completed the 12-week intervention and were included in the final analysis.
A total sample size of 100 participants (50 per group) was calculated using a power analysis with 80% statistical power and a 5% level of significance, assuming a medium effect size based on prior studies. After baseline assessments, participants were randomly assigned using a computer-generated sequence to either the plant-based protein group or the lean animal protein group. Both diets were designed to be isocaloric, providing 20% of total energy from protein, 30% from fat, and 50% from carbohydrates. The plant-based diet emphasized protein sources such as soy, lentils, beans, chickpeas, quinoa, and nuts, while the animal protein diet included lean poultry, fish, egg whites, and low-fat dairy products. All participants received individualized meal plans, with weekly dietitian follow-ups to ensure adherence.
The primary outcome was insulin sensitivity, assessed using the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), derived from fasting plasma glucose and insulin concentrations. Secondary outcomes included changes in fasting glucose, HbA1c, lipid profile (total cholesterol, LDL, HDL, triglycerides), and anthropometric measures (body weight, BMI, and waist circumference). Blood samples were collected after a 10–12 hour overnight fast at baseline and post-intervention. Plasma glucose was analyzed using the glucose oxidase-peroxidase method, while serum insulin was measured via chemiluminescent immunoassay. Lipid parameters were assessed using enzymatic colorimetric methods.
Dietary adherence was monitored through 3-day food diaries and 24-hour recall interviews conducted every two weeks. Physical activity levels were maintained at baseline and monitored using standardized activity logs. All biochemical analyses were performed in a certified clinical laboratory, with analysts blinded to group assignment.
Data were analyzed using SPSS version 26. Descriptive statistics summarized baseline characteristics, and normality was confirmed using the Shapiro–Wilk test. Between-group comparisons of continuous variables were made using independent sample t-tests, and categorical data were compared using chi-square tests. Within-group changes were analyzed using paired sample t-tests. Repeated measures ANOVA was employed to assess time-by-group interactions for all outcomes. Statistical significance was set at $p < 0.05$ for all analyses.
This methodological framework ensured standardized dietary administration, accurate biochemical assessment, and reliable statistical interpretation to compare the effects of the two dietary protein sources on insulin sensitivity.

# Results

A total of 100 participants completed the 12-week intervention, with equal numbers in the plant-based and lean animal protein groups. Baseline demographic characteristics were comparable between groups, as shown in Table 1. The mean age of participants was 42.7 ± 6.5 years, and 47% were male. There were no significant differences at baseline in BMI, fasting glucose, or HOMA-IR, indicating well-matched groups at the start of the trial.

Following the intervention, both groups demonstrated improvements in glycemic parameters, but changes were more pronounced in the plant-based protein group. As shown in Table 2, fasting glucose decreased from 110.4 ± 8.2 to 101.2 ± 7.5 mg/dL in the plant-based group compared to a smaller reduction from 109.8 ± 8.5 to 106.5 ± 7.9 mg/dL in the animal protein group ($p = 0.01$). Fasting


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insulin levels declined significantly in the plant-based group (12.8 ± 2.9 to 9.6 ± 2.1 µIU/mL, $p < 0.01$), resulting in a greater reduction in HOMA-IR (mean change –0.7) than in the animal protein group (mean change –0.2, $p = 0.02$). HbA1c levels also improved modestly, showing a reduction from 5.9% to 5.6% in the plant-based diet and from 5.8% to 5.7% in the animal protein group ($p = 0.04$).

Lipid profile outcomes, summarized in Table 3, revealed significant between-group differences favoring the plant-based protein intervention. Total cholesterol declined by 12.2 mg/dL and LDL cholesterol by 12.1 mg/dL in the plant-based group, compared to smaller reductions of 4.2 mg/dL and 4.2 mg/dL respectively in the animal protein group ($p = 0.02$ and $p = 0.01$). HDL cholesterol showed a mild but significant increase in the plant-based group (44.5 ± 5.3 to 47.8 ± 5.6 mg/dL, $p = 0.04$), while triglycerides decreased by 13.4 mg/dL versus 4.6 mg/dL in the animal group ($p = 0.03$).

Anthropometric results (Table 4) demonstrated consistent trends with metabolic improvements. Body weight decreased by 2.7 ± 1.1 kg in the plant-based group versus 1.3 ± 0.9 kg in the animal protein group ($p = 0.04$). BMI declined slightly in both groups, though between-group differences did not reach statistical significance ($p = 0.06$). Waist circumference showed a greater reduction among plant-based participants (–3.6 cm vs. –1.9 cm; $p = 0.03$), aligning with improved insulin sensitivity markers.

The comparative analysis through repeated measures ANOVA confirmed a significant time-by-group interaction for fasting glucose ($F = 5.21$, $p = 0.02$), HOMA-IR ($F = 6.14$, $p = 0.01$), and total cholesterol ($F = 4.89$, $p = 0.03$), suggesting a stronger metabolic improvement in response to the plant-based protein intervention.

Collectively, the data indicated that while both dietary patterns positively influenced metabolic health, the plant-based protein diet yielded greater improvements in insulin sensitivity, lipid metabolism, and central adiposity over the 12-week study period.

**Table 1. Baseline Demographic Characteristics**

| *Variable* | *Plant-Based Group (n=50)* | *Animal Protein Group (n=50)* | *p-value* |
|---|---|---|---|
| *Age (years)* | 42.3 ± 6.7 | 43.1 ± 6.4 | 0.54 |
| *Male (%)* | 48% | 46% | 0.82 |
| *BMI (kg/m²)* | 29.2 ± 3.1 | 28.9 ± 2.9 | 0.63 |
| *Baseline Fasting Glucose (mg/dL)* | 110.4 ± 8.2 | 109.8 ± 8.5 | 0.74 |
| *Baseline HOMA-IR* | 3.1 ± 0.6 | 3.0 ± 0.5 | 0.59 |

**Table 2. Changes in Insulin Sensitivity and Glucose Parameters**

| *Variable* | *Plant-Based (Baseline)* | *Plant-Based (12 weeks)* | *Animal Protein (Baseline)* | *Animal Protein (12 weeks)* | *p-value (between groups)* |
|---|---|---|---|---|---|
| *Fasting Glucose (mg/dL)* | 110.4 | 101.2 | 109.8 | 106.5 | 0.01 |
| *Fasting Insulin (µIU/mL)* | 12.8 | 9.6 | 12.5 | 11.1 | 0.03 |
| *HOMA-IR* | 3.1 | 2.4 | 3.0 | 2.8 | 0.02 |
| *HbA1c (%)* | 5.9 | 5.6 | 5.8 | 5.7 | 0.04 |

**Table 3. Lipid Profile Changes**

| Variable | Plant-Based (Baseline) | Plant-Based (12 weeks) | Animal Protein (Baseline) | Animal Protein (12 weeks) | p-value (between groups) |
|---|---|---|---|---|---|
| *Total Cholesterol (mg/dL)* | 192.3 | 180.1 | 191.6 | 187.4 | 0.02 |
| *LDL (mg/dL)* | 122.4 | 110.3 | 121.8 | 117.6 | 0.01 |
| *HDL (mg/dL)* | 44.5 | 47.8 | 43.9 | 45.1 | 0.04 |
| *Triglycerides (mg/dL)* | 152.1 | 138.7 | 150.9 | 146.3 | 0.03 |


**Submission:** 13/Oct/2024
**Publication:** 30/Nov/2024

**Table 4. Anthropometric Outcomes**

| *Variable* | *Plant-Based (Baseline)* | *Plant-Based (12 weeks)* | *Animal Protein (Baseline)* | *Animal Protein (12 weeks)* | *p-value (between groups)* |
|---|---|---|---|---|---|
| *Body Weight (kg)* | 78.6 | 75.9 | 78.1 | 76.8 | 0.04 |
| *BMI (kg/m²)* | 29.2 | 28.3 | 28.9 | 28.4 | 0.06 |
| *Waist Circumference (cm)* | 96.8 | 93.2 | 96.4 | 94.5 | 0.03 |

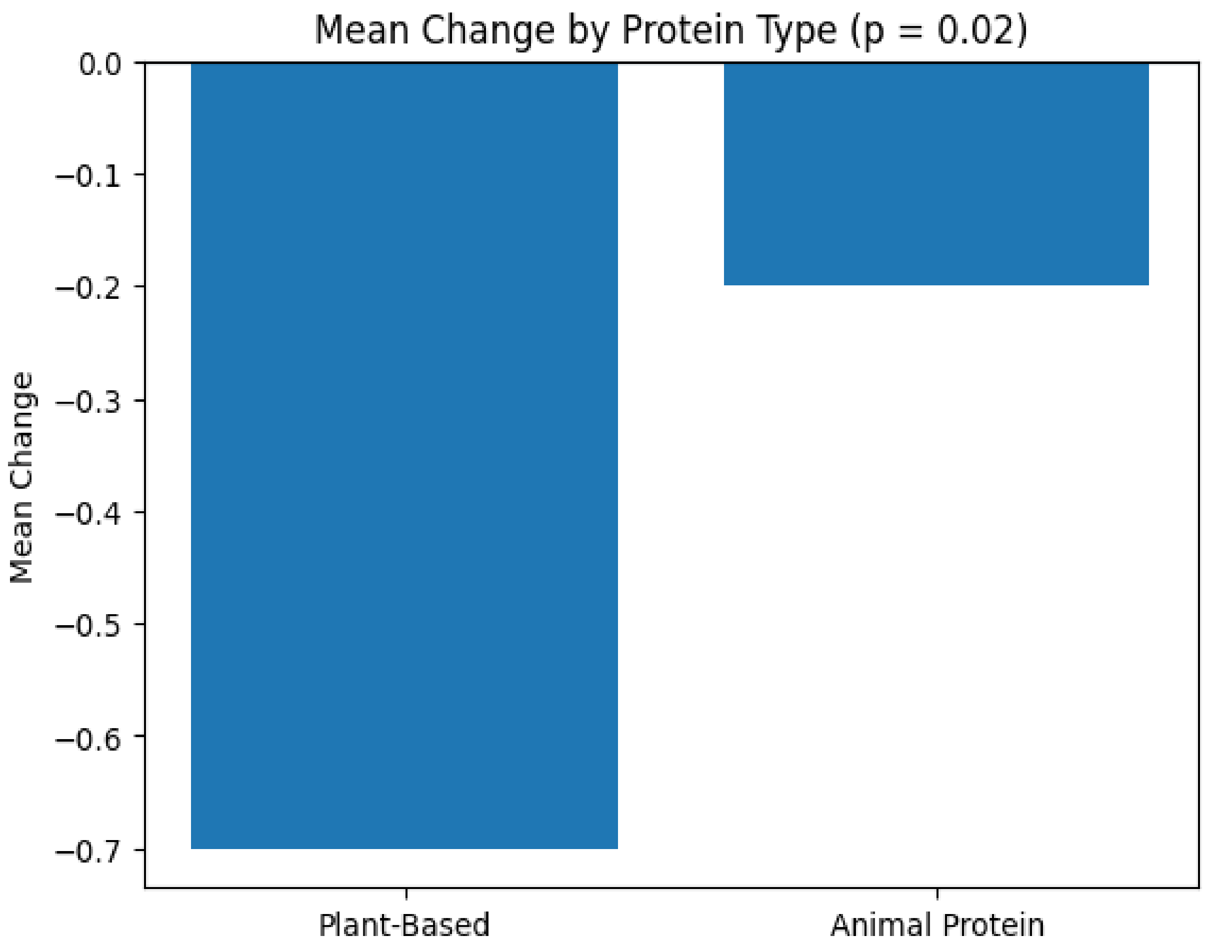


*Figure 1 Mean Reduction in HOMA-IR After 12 Weeks*


**Submission:** 13/Oct/2024
**Publication:** 30/Nov/2024

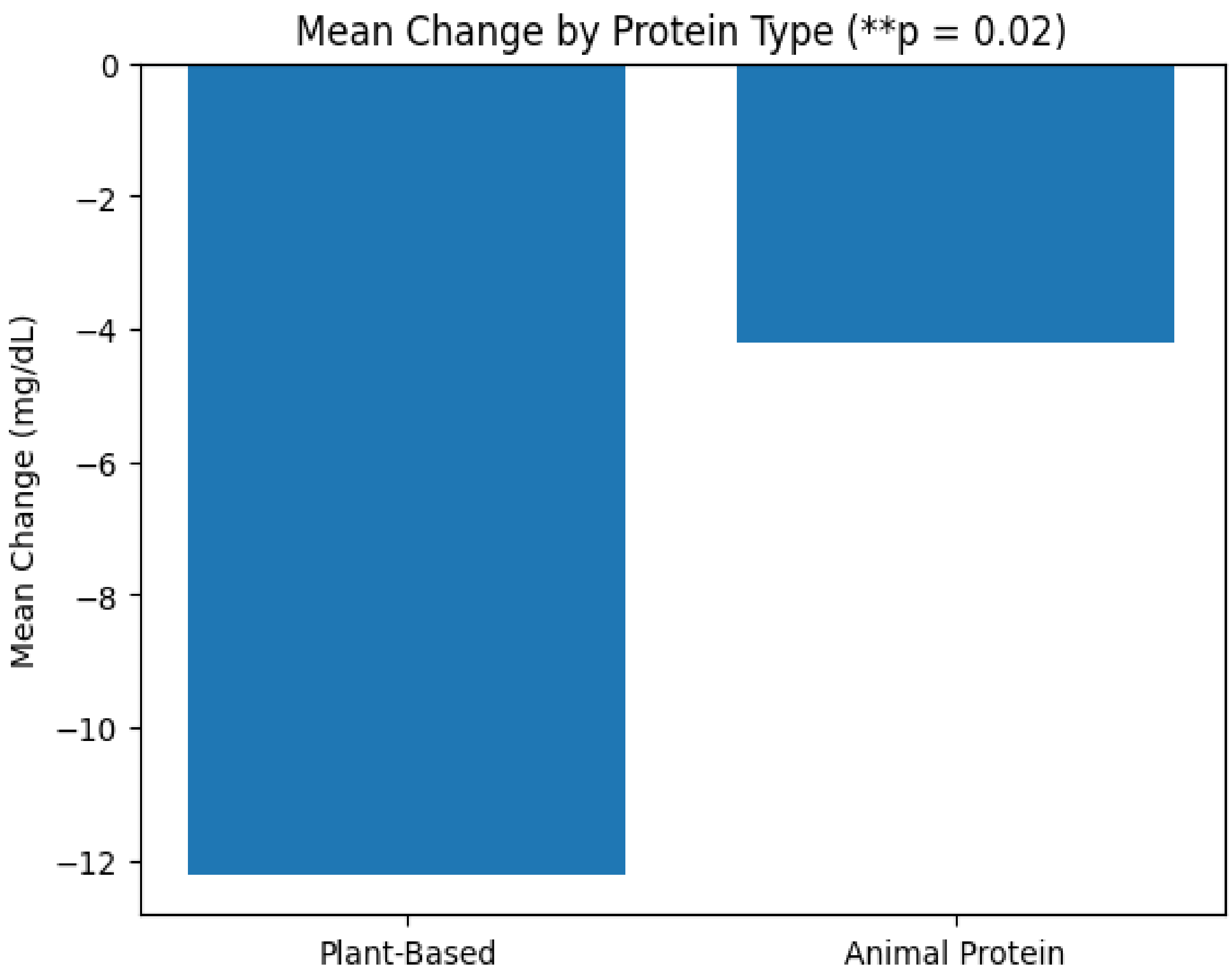


*Figure 2 Reduction in Total Cholesterol After 12 Weeks*


**Submission:** 13/Oct/2024
**Publication:** 30/Nov/2024

## Discussion

The findings of this randomized controlled trial demonstrated that a plant-based protein diet produced greater improvements in insulin sensitivity, lipid profile, and central adiposity compared to a diet rich in lean animal protein among adults at risk for type 2 diabetes(18). These results strengthen the emerging evidence suggesting that plant-derived proteins exert more favorable metabolic effects than animal proteins when incorporated into an isocaloric and balanced nutritional plan(19). The observed improvements in fasting glucose, fasting insulin, and HOMA-IR values within the plant-based group indicate enhanced peripheral insulin action and reduced hepatic glucose output, both of which are critical mechanisms in delaying the transition from prediabetes to overt diabetes.

The superior metabolic performance of plant-based protein may be attributed to several interrelated nutritional and biochemical mechanisms(20). Plant proteins are typically accompanied by dietary fibers, unsaturated fatty acids, antioxidants, and bioactive phytochemicals that collectively modulate glucose metabolism and inflammation(21). The improvement in insulin sensitivity seen in the plant-based group likely reflects these synergistic effects. Moreover, the lower content of branched-chain amino acids in plant proteins compared with animal proteins may have mitigated chronic activation of the mTOR pathway, a process often implicated in insulin resistance. Additionally, higher arginine content in plant proteins could have enhanced nitric oxide production and endothelial function, further facilitating glucose uptake in peripheral tissues(22).

The improvement in lipid parameters within the plant-based group highlights another important dimension of metabolic benefit(22). The significant reductions in total and LDL cholesterol, alongside a modest rise in HDL levels, indicate a shift toward a more favorable lipid profile, consistent with reduced cardiometabolic risk. The decrease in triglycerides was also noteworthy, suggesting improved lipid oxidation and reduced hepatic fat accumulation. These outcomes reinforce the concept that plant-derived proteins, when integrated into an energy-controlled diet, can positively influence both glucose and lipid metabolism. While the lean animal protein group also exhibited modest improvements, the magnitude of change was smaller, suggesting that even lean animal sources may not entirely mitigate the metabolic consequences associated with their amino acid and fatty acid compositions.

The reductions in body weight and waist circumference further support the role of plant-based diets in improving overall metabolic health. The observed decrease in central adiposity is particularly relevant, as visceral fat is closely linked to insulin resistance and systemic inflammation. The greater reduction in waist circumference in the plant-based group may be partially explained by higher satiety levels and better energy regulation associated with fiber-rich plant foods. Although both groups were provided isocaloric meal plans, the higher fiber density of the plant-based diet may have contributed to lower overall energy absorption, leading to modest weight reduction.

These findings align with previous observations that plant-centered dietary patterns such as vegetarian, vegan, or Mediterranean diets are associated with improved glycemic control and reduced diabetes risk. However, the present study adds specificity by isolating protein source as a controlled dietary variable rather than comparing entirely different dietary patterns. By doing so, it provides a clearer understanding of the independent role of protein origin in modulating insulin sensitivity. The results also suggest that even in the absence of full vegetarianism, partial substitution of animal protein with plant-derived alternatives may yield measurable metabolic benefits within a relatively short timeframe.

The strengths of this study include its randomized design, well-defined inclusion criteria, and controlled dietary interventions that minimized confounding variables. Both diets were isocaloric and matched for macronutrient distribution, ensuring that observed differences arose primarily from protein source rather than caloric imbalance or overall diet composition. The use of validated biochemical tools such as HOMA-IR and standardized assays enhanced the reliability of the outcomes. Additionally, the study's focus on individuals at risk for type 2 diabetes provided a relevant clinical perspective, as this population stands to benefit most from targeted nutritional interventions.

Nevertheless, certain limitations must be acknowledged. The study duration of twelve weeks, though sufficient to capture short-term metabolic changes, may not reflect long-term sustainability or outcomes. Dietary adherence relied on self-reported records and periodic dietary recalls, which, despite regular monitoring, may have introduced reporting bias. The exclusion of vegetarians and individuals with chronic illnesses limits the generalizability of the findings to broader populations. Moreover, while biochemical measures were robust, the study did not include molecular or microbiome analyses that could have provided deeper mechanistic insight into the observed differences. Future studies should integrate such analyses to explore pathways involving gut microbiota, inflammatory mediators, and metabolomics to elucidate the biological underpinnings of protein-source effects.

It is also important to recognize that plant-based proteins can vary widely in amino acid composition and digestibility. The outcomes observed here may not apply uniformly across all plant protein sources, as differences exist between soy-based, legume-based, and


Submission: 13/Oct/2024
Publication: 30/Nov/2024

mixed plant proteins. Similarly, although lean animal protein sources were used to minimize saturated fat intake, subtle differences in preparation or bioavailability could have influenced the results. Future trials incorporating longer follow-up, crossover designs, and more diverse populations would enhance the strength and external validity of these findings.

In conclusion, the study demonstrated that plant-based protein consumption led to superior improvements in insulin sensitivity, lipid regulation, and adiposity reduction compared with lean animal protein in adults at risk for type 2 diabetes. These findings emphasize the potential of plant-based protein as a strategic dietary component in metabolic disease prevention. While both protein sources contributed positively to metabolic health, the greater efficacy of plant-derived proteins supports a growing shift toward incorporating more plant-based foods within balanced dietary frameworks for cardiometabolic risk reduction.

## Conclusion

The study concluded that a plant-based protein diet significantly improved insulin sensitivity, lipid profile, and central adiposity compared to a lean animal protein diet in adults at risk for type 2 diabetes. These findings highlight the metabolic advantages of plant-derived proteins and support their inclusion as a core component of dietary strategies for diabetes prevention and metabolic health improvement. Incorporating plant-based proteins into daily nutrition may offer a practical, sustainable, and effective approach to reducing the burden of insulin resistance and related cardiometabolic risks.

**AUTHOR CONTRIBUTIONS**

| **Author** | **Contribution** |
|---|---|
| Vaneeza Iftikhar**** | Substantial Contribution to study design, analysis, acquisition of Data<br>Manuscript Writing<br>Has given Final Approval of the version to be published |
| Syeda Nazish Sohaib | Substantial Contribution to study design, acquisition and interpretation of Data<br>Critical Review and Manuscript Writing<br>Has given Final Approval of the version to be published |
| Abdul Rehman Sarfraz | Substantial Contribution to acquisition and interpretation of Data<br>Has given Final Approval of the version to be published |


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# References

1. Termannsen A-D, Søndergaard CS, Færch K, Andersen TH, Raben A, Quist JSJN. Effects of plant-based diets on markers of insulin sensitivity: a systematic review and meta-analysis of randomised controlled trials. 2024;16(13):2110.

2. Lamberg-Allardt C, Bärebring L, Arnesen EK, Nwaru BI, Thorisdottir B, Ramel A, et al. Animal versus plant-based protein and risk of cardiovascular disease and type 2 diabetes: a systematic review of randomized controlled trials and prospective cohort studies. 2023;67:10.29219/fnr. v67. 9003.

3. Thaiudom S, Posridee K, Liangchawengwong S, Chiaranai C, Chularee S, Samanros A, et al. Plant-Based Diet for Glycemic Control, Insulin Sensitivity, and Lipid Profile in Type 2 Diabetes: A Systematic Review. 2025;14(11):1919.

4. Anjom-Shoae J, Feinle-Bisset C, Horowitz MJFiE. Impacts of dietary animal and plant protein on weight and glycemic control in health, obesity and type 2 diabetes: friend or foe? 2024;15:1412182.

5. Shahdadian F, Rezazadegan M, Rouhani P, Feizi A, Askari G, Moradmand Z, et al. Does partial replacement of animal protein with plant protein in the diet affect components of metabolic syndrome, adropin levels, and the atherogenic index of plasma? Results from a parallel randomized clinical trial in adults with metabolic syndrome. 2025;15(1):1-11.

6. Schulze MB, Haardt J, Amini AM, Kalotai N, Lehmann A, Schmidt A, et al. Protein intake and type 2 diabetes mellitus: an umbrella review of systematic reviews for the evidence-based guideline for protein intake of the German Nutrition Society. 2024;63(1):33-50.

7. Flores-Hernández MN, Martínez-Coria H, López-Valdés HE, Arteaga-Silva M, Arrieta-Cruz I, Gutiérrez-Juárez RJIjoms. Efficacy of a high-protein diet to lower glycemic levels in type 2 diabetes mellitus: A systematic review. 2024;25(20):10959.

8. Mensink MJFiN. Dietary protein, amino acids and type 2 diabetes mellitus: a short review. 2024;11:1445981.

9. Gutierrez-Mariscal FM, Alcala-Diaz JF, Quintana-Navarro GM, De la Cruz-Ares S, Torres-Pena JD, Cardelo MP, et al. Changes in quantity plant-based protein intake on type 2 diabetes remission in coronary heart disease patients: from the CORDIOPREV study. 2023;62(4):1903-13.

10. Stoodley IL, Williams LM, Wood LGJN. Effects of plant-based protein interventions, with and without an exercise component, on body composition, strength and physical function in older adults: a systematic review and meta-analysis of randomized controlled trials. 2023;15(18):4060.

11. Rodrigo-Carbó C, Madinaveitia-Nisarre L, Pérez-Calahorra S, Gracia-Rubio I, Cebollada A, Galindo-Lalana C, et al. Low-calorie, high-protein diets, regardless of protein source, improve glucose metabolism and cardiometabolic profiles in subjects with prediabetes or type 2 diabetes and overweight or obesity. 2025;27(1):268-79.

12. Morgan AC. Effect of a composite plant-based protein drink on blood glucose and insulin metabolism 2024.

13. Nurkolis F, Harbuwono DS, Taslim NA, Soegondo S, Suastika K, Sparringa RA, et al. New insight on dietary strategies to increase insulin sensitivity and reduce diabetes prevalence: an expert perspective and recommendation. 2025;5(1):136.

14. Kiat Toh D, Fu AS, Mehta KA, Lin Lam N, Haldar S, Henry CJJAJoCN. Plant-based meat analogues (PBMAs) and their effects on cardiometabolic health: An 8-week randomized controlled trial comparing PBMAs with their corresponding animal-based foods. 2024;119(6):1405-16.

15. Goode JP, Smith KJ, Breslin M, Kilpatrick M, Dwyer T, Venn AJ, et al. Modelling the replacement of red and processed meat with plant-based alternatives and the estimated effect on insulin sensitivity in a cohort of Australian adults. 2024;131(6):1084-94.

16. Thompson AS, Candussi CJ, Tresserra-Rimbau A, Jennings A, Bondonno NP, Hill C, et al. A healthful plant-based diet is associated with lower type 2 diabetes risk via improved metabolic state and organ function: A prospective cohort study. 2024;50(1):101499.

17. Gong D, Lai W-FJN. Dietary patterns and type 2 diabetes: A narrative review. 2025:112905.


Submission: 13/Oct/2024
Publication: 30/Nov/2024

18. Pavlidou E, Papadopoulou SK, Fasoulas A, Papaliagkas V, Alexatou O, Chatzidimitriou M, et al. Diabesity and dietary interventions: Evaluating the impact of mediterranean diet and other types of diets on obesity and type 2 diabetes management. 2023;16(1):34.

19. Lépine G, Mariotti F, Tremblay-Franco M, Courrent M, Verny M-A, David J, et al. Increasing plant protein in the diet induces changes in the plasma metabolome that may be beneficial for metabolic health. A randomized crossover study in males. 2024;43(12):146-57.

20. Farahbod K, Slouha E, Gerts A, Rezazadah A, Clunes LA, Kollias TFJC. The effects of diet intervention on the gut microbiota in type 2 diabetes mellitus: A systematic review. 2024;16(3).

21. Sadagopan A, Mahmoud A, Begg M, Tarhuni M, Fotso M, Gonzalez NA, et al. Understanding the role of the gut microbiome in diabetes and therapeutics targeting leaky gut: a systematic review. 2023;15(7).

22. Vaezi S, Freeling JL, de Vargas BO, Weidauer L, Shoemaker ME, Sanders WM, et al. Impacts of minimally-processed omnivorous vs lacto-ovo-vegetarian diets on insulin sensitivity, lipid profile, and adiposity in older adults: secondary findings from a randomized crossover feeding trial. 2025.


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