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Efficacy of Bitter Melon Powder on Type 2 Diabetes

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ABSTRACT

Background: Momordica charantia (bitter melon) is commonly used in traditional medicine for the management of diabetes, due to its insulin-like properties. This study was conducted to assess the effectiveness of bitter melon powder in managing Type 2 diabetes by evaluating its impact on Random Blood Glucose (RBG), Fasting Blood Glucose (FBG), and Glycosylated Hemoglobin (HbA1c) levels. **Methods:** The study was carried out over five months at the Diabetic Clinic of Benazir Bhutto Hospital, Rawalpindi, involving 60 patients (30 males and 30 females) aged 35 to 60 years, selected through convenience sampling based on inclusion criteria. Patients were given 1/2 teaspoon of bitter melon powder daily before breakfast. The patients followed a sugar-free, low-fat diet, and blood glucose levels were measured through biochemical tests before and after the intervention. Data analysis and statistical validation were conducted using ANOVA. **Results**: The treatment group showed a significant reduction in RBG (244.43 to 201.20 mg/dl, *P*=0.001) compared to an increase in the control group (246.63 to 275.10 mg/dl, *P*=0.005). FBG decreased in the treatment group (11.21 to 10.43 mg/dl, *P*=0.02), while the control group slightly increased (11.21 to 11.26 mg/dl, *P*=0.10). HbA1c levels also dropped in the treatment group (8.09 to 7.62%, *P*=0.01) versus a rise in the control group (8.02 to 8.14%, *P*=0.09). **Conclusions:** The findings indicate that bitter melon supplementation can significantly lower blood glucose levels and provide a safe alternative to conventional diabetes treatments.

Introduction

Momordica Charantia (bitter melon, bitter gourd) is widely grown in Asia, Africa, and Caribbean for its edible fruit. It is accessible in many shapes and varieties. It has simple leaves 4–12 cm long, with three to seven deep lobes. It has a certain rectangular shape, which is hollow in cross section having a thin layer of flesh surrounding a central cavity with seeds inside. Bitter melon is consumed as a vegetable and is cooked in different cuisine in different ways depending upon their tradition and taste (Islam and Jalaluddin, 2019).

In Chinese cuisine, bitter melon is consumed as stir fries with soup or herbal tea. In Indian cuisine, it is simply cooked in curry form with yogurt. In Pakistan, it is known as karela and is often cooked

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as sabzi and served with riata or mint chatni. It is also consumed as whole, unpeeled bitter melon to be boiled and then stuffed with cooked minced beef, served with hot tandoori naan, chappati (Jan *et al.*, 2019).

Bitter melon has been used as herbal medicine in many Asian and African countries, particularly as traditional remedy for treating different ailments. Especially in India and Pakistan, it is a known remedy for managing diabetes, because bitter melon has some insulin like properties due to which it is considered as an effective remedy for its treatment. It is also used in the prevention of many other problems such as HIV AIDS, cancer, hepatitis, fever, gout, diabetes and many other infections (Tanwar *et al.*, 2022). However, small research studies conducted on animals have shown its hypoglycemic effect. It has been shown that bitter melon juice or consumed raw form can effectively lower the blood glucose level (Saeed *et al.*, 2018).

Bitter melon has three main active ingredients which are charantin, lectin, and vicine which have insulin like properties and having compound like polypeptide-p, which lowers the blood glucose level (Kumaree and Prasansuklab, 2023). This substance not only controls the insulin level within the blood but also helps in the impairment of b-cells production and its functioning. These constituents of bitter melon provide pharmacologic effects including a hypoglycemic effect, antiviral, and antineoplastic activities (Tanwar *et al.*, 2022).

Glycosylated hemoglobin A1C (HbA1C) is a test performed for the diabetic patient. This test depicts the mean sugar level of 3 months of individual. Bitter melon has very surprising results effects on lowering the blood glucose level, but all depends upon its use. It should be avoided in pregnant women because it can lead towards miscarriages and also it has some antifertility effects on female mice and spermatogenesis was inhibited in dogs after being fed bitter melon fruit extract for two months. Two case reports in children resulted in hypoglycemic coma after bitter melon tea; therefore, it should be avoided in children (Demmers and Jurriaan, 2023).

Diabetes is the most common and prevailing problem at the present time. Many different drugs and alternative medicines are used to cure and treat diabetes, which may have some side effects. The chemical present in the drugs can damage vital organs leading to many other chronicproblems. For this purpose, alternative medicines from natural products can be used which have no side effect. Diabetes is lifelong disease that cannot be cured but it can be managed by proper diet, exercise and medication. Bitter melon is used as an alternative medicine for curing and managing type 2 diabetes (Kim *et al.*, 2023).

This research has following objectives.

- To identify the effectiveness of bitter melon powder in managing diabetes.
- To compare changes in fasting blood glucose (FBG) levels, HbA1C, and insulin sensitivity between males and females after bitter melon powder supplementation.

Effect of bitter melon powder on managing type 2 diabetes in male and female patients was studied over a 6-month period.

Materials and Methods

Sample collection

Bitter melons were collected from the local market in Rawalpindi district. Selected sample of bitter melon were purely green in color which were slightly ripe and were medium in size, elongated in shape and hollow from inside having seeds inside. Bitter melon has rough and hard texture with an uneven surface. The harder the texture of bitter melon, the less ripe it is and vice versa.

Sample preparation

Bitter melon samples were placed in a basket for air drying for few minutes. After that, samples were properly washed and placed in a tray for drying. Once drying, samples were cut into small pieces by slightly removing the peel and then placed back in a tray for additional drying. Dried samples were grinded to make smooth powder and stored in an airtight container (Azwanida, 2015).

Study design

The study involved 60 type 2 diabetes patients

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(30 males and 30 females) aged 35–60 years. Participants were selected through convenience sampling and divided equally by gender to examine potential differences in the effects of bitter melon powder. Random blood glucose (RBG), fasting blood glucose (FBG), and HbA1C were measured at baseline and after five months of supplementation. However, this study primarily focused on the overall effect of bitter melon powder, and gender-specific subgroup analysis was not conducted due to resource limitations.

This study was a randomized controlled trial (RCT) designed to evaluate the effects of bitter melon powder on blood glucose levels in Type 2 diabetes patients.

Study area

Research was conducted in Benazir Bhutto Hospital Rawalpindi in the Diabetic Clinic, under the supervision of the head of department (HOD). Both male and female between the age group of 35-60 years were taken from upper- and lower-class family. This study was carried out for 6 months in order to get the best possible results.

Inclusion exclusion criteria

The study included individuals aged 35 to 60 years who were diagnosed with type 2 diabetes and had HbA1C levels greater than 6.5% at baseline. Exclusion criteria were patients with type 1 diabetes or gestational diabetes, pregnant or lactating women, those with known allergies to bitter melon or its components, and patients using other herbal supplements or undergoing insulin therapy during the study period. Those patients who were not willing to give informed consent for participation were excluded.

Dietary plan

Participants were advised to consume a sugar-free, low-fat diet designed based on their ideal body weight. Caloric and protein intake were adjusted accordingly. On average, the participants consumed 1500±200 kcal/day, which included approximately 50–60 g protein/day. The dietary plan was monitored weekly to ensure compliance.

Compliance with the intervention was assessed through regular follow-ups with participants and by recording the daily intake of bitter melon powder. Non-compliant participants were excluded from the analysis.

Control group

A control group consisting of participants who did not receive bitter melon powder was included to compare the effects of the intervention on blood glucose levels. The control group followed the same dietary plan but did not consume the bitter melon supplement.

Data collection tools

Data collection involved several tools to ensure comprehensive information. A general questionnaire was utilized to gather demographic details such as age, gender, and socioeconomic status of the participants. Dietary history was assessed using a 24-hour dietary recall form to monitor adherence to the prescribed sugar-free, low-fat diet. Additionally, biochemical tests were performed to measure blood glucose and HbA1C levels, using standardized methods to evaluate the effectiveness of the intervention. RBG and FBG were measured using the Accu-Chek Active Blood Glucose Meter (05046452160). HbA1C levels were measured using the D-10 Hemoglobin Testing System with the D-10 Hemoglobin A1c Reorder Pack (220-0101).

Sample dose

Bitter melon powder was consumed in early morning (pre breakfast) for 6 months. 1/2 teaspoon of powder was recommended daily.

Diet

Participants were instructed to follow a sugar-free, low-fat diet tailored to their ideal body weight. Daily calorie intake was maintained at an average of 1500±200 kcal, including approximately 50–60 g of protein. The dietary plan was closely monitored on a weekly basis to ensure adherence.

Physical activity measurement

Physical activity was measured using self-reported questionnaires, where participants recorded type, duration, and frequency of their physical activities. Physical activity was also

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monitored through periodic assessments to ensure that it did not interfere with the study results.

Biochemical estimation

Individual patients were assessed for blood variables RBG, FBG and HbA1C was estimated and the participants were classified as pre-diabetic and diabetic.

RBG: This test was performed after 2 hours of meal to check the RBG levelof the patient. This is a blood test which can be performed at home by using glucometer by pinching a needle on finger and can test the blood by using sugar strips which depicts the RBG level of patient (Rao *et al.*, 2018).

FBG: This test was performed at least 8-10 hours before meals. This test is normally done when the individual is at fasting stage for at least 8 hours. It is a simple blood test which diagnoses the fasting blood glucose level of the body (Inzucchi, 2012).

HbA1C: This blood test is the mean blood glucose level of 3 months of the patient. It is considered as the most authentic and valid test for the verification of blood glucose level within the body (Goldstein *et al.*, 2004).

Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, ensuring that all participants provided informed consent before participation. Ethical approval for the study was obtained from the hospital ethics committee. Patients from the OPD in Benazir Bhutto Hospital Rawalpindi were selected after obtaining their consent. Both male and female between the age group of 35-60 years were taken from upper- and lower-class family. IRCT registration ID for the study is IRCT20240305012345N1.

Data analysis

A one-way analysis of variance (ANOVA) was conducted using SPSS version 25 to evaluate differences in mean values, with a statistical significance threshold set at P-value<0.05. Results were expressed as mean ± standard deviation (SD) for all measured variables (Steel, 1997).

Results

Baseline characteristics of participants

To ensure the validity of the findings and to confirm the comparability of the treatment and control groups, baseline characteristics of the participants were assessed. These characteristics included demographic variables (age, gender, socioeconomic status), clinical variables (initial RBG, FBG), and HbA1C levels), and lifestyle factors (dietary habits and physical activity levels). The mean age of participants in the treatment group was 47.5±6.3 years, while the control group had a mean age of 48.1±5.9 years, with no statistically significant difference (P>0.05). The mean RBG level on day 1 was 244.43 mg/dl for the treatment group and 246.63 mg/dl for the control group (P>0.05). The mean FBG level at baseline was 11.21 mg/dl for both groups, with no significant difference (P>0.05). Mean HbA1C level was 8.09% for the treatment group and 8.02% for the control group, showing no significant baseline differences (P>0.05). Both groups followed similar dietary patterns and reported comparable physical activity levels, monitored through questionnaires and weekly follow-ups.

RBG

At the beginning of the study (day 1), the mean RBG value was 244.43 mg/dl for the treatment group and 246.63 mg/dl for the control group. By day 150, the treatment group RBG mean value dropped to 201.20 mg/dl, while the control group mean value increased to 275.10 mg/dl. This change highlights the significant positive effect of bitter melon on managing blood glucose levels.

The standard deviation of RBG levels in the treatment group was 24.33 at day 1, compared to 19.57 in the control group. By day 150, the standard deviation in the treatment group reduced to 20.97, while the control group showed a slight reduction to 17.67. This result further emphasizes the effectiveness of bitter melon powder in reducing glucose variability over time in the treatment group.

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Graphical representations of the data (**Figure 1**) demonstrated a steady decrease in RBG levels in the treatment group, while the control group levels remained relatively higher. The results from the ANOVA table confirmed that the decrease in blood glucose levels in the treatment group was statistically significant. This indicated that RBG levels reduced to possible extent and the efficacy of bitter melon powder was proved.

The mean RBG levels for the treatment group at day 1 and day 30 were 244.43 mg/dl and 236.77 mg/dl, respectively, demonstrating a slight reduction in blood glucose within the first month of treatment. Similarly, at day 60, the treatment group mean glucose value was 221.60 mg/dl, and by day 90, it had dropped further to 206.90 mg/dl. These values showed that with continuous use of bitter melon powder, there was a gradual and consistent reduction in blood glucose levels.

At day 120, the mean RBG level in the treatment group was 205.57 mg/dl, compared to 273.80 mg/dl in the control group. By day 150, the treatment group mean level decreased further to 201.20 mg/dl, while the control group mean value increased to 275.10 mg/dl. This result further confirms the positive impact of bitter melon powder in lowering blood glucose levels, as the control group did not show any such a reduction.

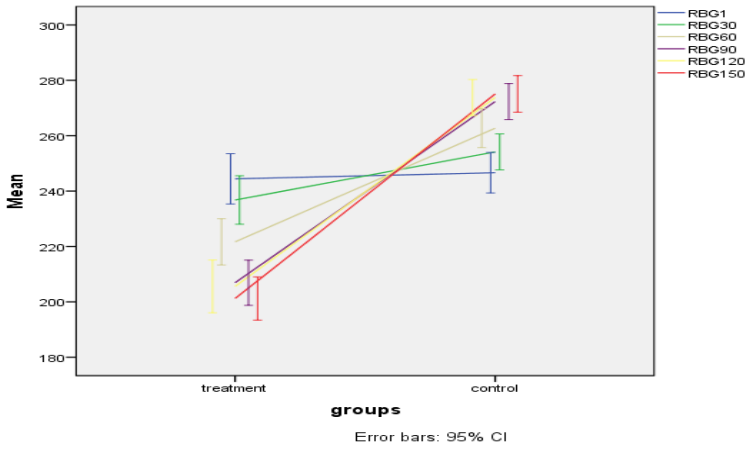

Figure 1. Mean of random blood glucose levels in treatment and control groups analyzed using one-way ANOVA.

FBG

This study investigated the role of bitter melon powder administered on FBG of the treatment group and control group after 150 days. Overall, it revealed that the first group that consumed bitter melon had better and improved FBG level than the second group (control group).

The mean FBG level at the beginning of the study was 11.21 mg/dl in both treatment and control group. Then, on day 150, treatment group mean value of FBG reduced to 10.43 mg/dl, while control group mean value increased to 11.26. There is evidence that bitter melon powder played a role in lowering the FBG level in treatment group. The standard deviation for the treatment group of participants also reduced slightly over 150 days, being 0.80 on day 1 and reducing to 0.79 on day 150, thus showing a consistent decrease in FBG levels of participants. The standard deviation of control group, on the other hand, raised only slightly from 0.45 mg/dl on day 1 to 0.47 mg/dl on day 150.

The graphical analysis of the data in terms of mean value of FBG (**Figure 2**) for the treatment group depicted a progressive decrease from a value of 11.21 mg/dl at baseline to a value of 10.43 mg/dl at the end of 30 days and thereafter at an interval of 30 days up to day 150. The control group, on the other hand, increased slightly FBG mean value from 11.21 mg/dl on day 1 to 11.26 mg/dl on day 150.

At all the following periods, treatment group

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FBG showed further enhancement as well. For example, FBG mean value on day 30 was 11.08 mg/dl (treatment) and 11.17 mg/dl (control). At the end of Day 60, treatment group FBG reached to 10.91 mg/dl, while that of the control group reached to 11.16 mg/dl. The decline of FBG in treatment group continued until day 90 (125.10±8.56 *vs.* 129.53±8.82 in the control group) and day 120 (123.46±7.94 *vs.* 127.39±7.52 in the control group), with statistically significant differences observed at each interval.

The final comparison at day 150 further emphasized the effectiveness of bitter melon powder in reducing FBG levels. Treatment group mean value decreased to 10.43 mg/dl, while the control group mean value increased slightly to 11.26 mg/dl. This significant difference supports the conclusion that bitter melon powder has a positive and measurable impact on managing FBG levels in patients with diabetes.

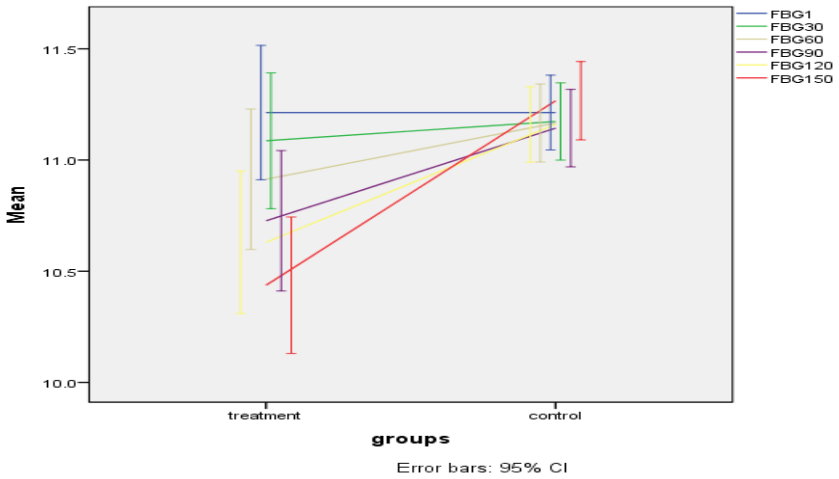

Figure 2. Mean of fasting blood glucose levels across treatment and control groups analyzed using one-way ANOVA.

HbA1C

At baseline (day 1), treatment group had HbA1C mean value of 8.09% compared to HbA1C mean value of 8.02% for control group. As the study progressed, several changes were recorded in both groups. At day 150, HbA1C mean value of treatment group patients was 7.62% and that of the control group patients was 8.14%, suggesting that bitter melon powder greatly reduced HbA1C levels in treatment group. The two groups standard deviation also enriched these outcomes. At day 1, in treatment group, standard deviation primary outcome upper limit was 0.31 and in control group, it was 0.27. Further development of standard deviation at day 150 of treatment group was 0.37, while that of control group dropped slightly to 0.27. This implies greater fluctuations in HbA1C levels throughout the study period in treatment group, probably contributing to the consumption of bitter melon powder.

When results of HbA1C levels were graphically compared with time (**Figure 3**), mean values decreased in treatment group. Finally, the results after 150 days revealed that HbA1c mean values decreased in treatment group compared to the control, which proved that bitter melon had long-term cure for diabetes. The capsule dose in form of powder and HbA1C was found to have a ratio that was consistent with a corresponding increase in capsule dose. Interaction was significant with increase in number of days.

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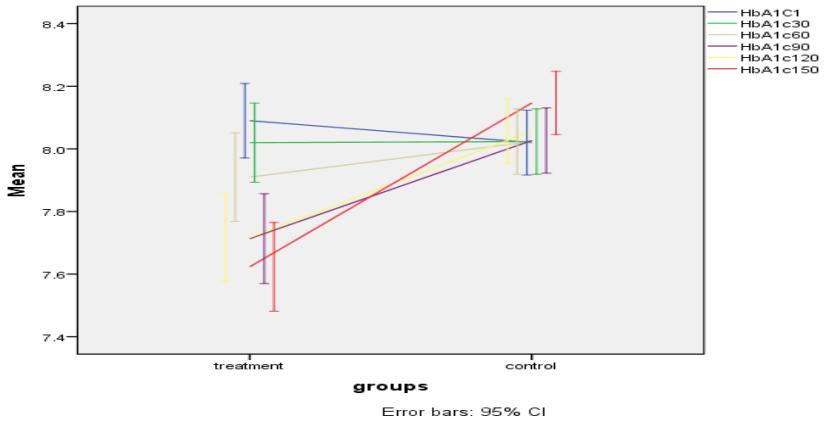

Figure 3. Glycosylated hemoglobin A1c mean levels across treatment and control groups analyzed using one-way ANOVA.

Discussion

Bitter melon has been shown to exert its hypoglycemic effects through multiple biochemical pathways. One of the most effective facts is its capacity to boost the uptake of glucose in peripheral tissues especially skeletal muscles possessing great impact on reduction of blood glucose level. This is rather similar to the action of drugs such as metformin used in sensitizing insulin; thus, bitter melon can be included in diabetes treatment regimes.

The previous study indicated a reduction in blood glucose levels in both normal conditions and after fasting, following the intake of bitter melon supplements. The reduction of RBG mean value in treatment group reflected the results of such a study, where the treatment group showed a significant reduction in blood glucose. This decrease was explained by hypoglycemic properties of bitter melon suggesting an increase in insulin sensitivity and efficient glucose transport in peripheral tissues by bitter melon (Patel *et al.*, 2022).

Studies have suggested that bitter melon may help decrease FBG by increasing insulin secretion and improving the body ability to utilize glucose. This mechanism is also supported by the data presented in the current study, where the treatment group exhibited a significant decrease in two types of blood glucose measurements, namely FBG and RBG (Clouatre *et al.*, 2011).

Previous studies have focused on the effects of bitter melon powder on HbA1C levels in adult and male type 2 diabetic patients. The present study found that after 12 weeks of supplementation, the treatment group showed a significant reduction in HbA1C, indicating that bitter melon effectively helps improve long-term blood glucose control. This decrease in HbA1C was as per the findings of the current study where the treatment group showed a noticeable decrease in HbA1C during the entire 150 days of treatment period. The reduction in HbA1C levels indicated that bitter melon may contribute to maintaining chronic hyperglycemia and preventing common diabetes complications (Kim *et al.*, 2020).

Studies have suggested that bitter melon increases the activity of AMP-activated protein kinase (AMPK) pathway, which enhances glucose transport into cells by increasing the number of glucose transporter proteins (GLUT4) on cell surface. This mimics the insulin-signaling pathway and thus contributes to improved glycemic control in diabetic individuals (Petersen *et al.*, 2017)

Bitter melon ability to inhibit intestinal glucose absorption and suppress gluconeogenic enzymes in the liver plays a crucial role in reducing both postprandial and fasting hyperglycemia, which are critical aspects of managing type 2 diabetes. Research also indicates that bitter melon has antioxidant properties that can protect pancreatic β-cells from oxidative stress. Since oxidative

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damage significantly contributes to β-cell dysfunction, bitter melon protective effect may help preserve the insulin-secreting capacity of these cells, improving both insulin sensitivity and secretion over time (Malik *et al.*, 2021). This dual role of enhancing insulin secretion and sensitivity enables bitter melon to address two key pathological features of diabetes including insulin resistance and β-cell failure.

Beyond its impact on glycemic control, bitter melon also demonstrates potential anti-obesity effects, which are highly relevant, given that obesity is a major risk factor for type 2 diabetes. By reducing fat accumulation, bitter melon indirectly supports glycemic management. Mechanistically, it is believed to inhibit adipogenesis (the formation of new fat cells) while promoting lipolysis (the breakdown of fats). This leads to a reduction in adipocyte hyperplasia and hypertrophy, both of which contribute to chronic inflammation and insulin resistance associated with obesity (Bao *et al.*, 2013).

Bitter melon potential to reduce low-grade inflammation associated with obesity further underscores its value in metabolic syndrome management. Chronic inflammation, often induced by excess adipose tissue, exacerbates insulin resistance and contributes to the progression of type 2 diabetes (Zatterale *et al.*, 2020). Therefore, bitter melon dual role in managing both hyperglycemia and obesity could offer a more holistic approach to metabolic health, providing a two-pronged defense against complications of diabetes.

By increasing the prevalence of diabetes, particularly in low- and middle-income countries, there is a growing demand for cost-effective and accessible management strategies. Bitter melon, a naturally occurring and widely available vegetable, presents a potential solution for diabetes management, especially in resource-limited settings. Unlike conventional antidiabetic medications, which can be expensive and may cause side effects, bitter melon offers an affordable, natural alternative with minimal risks when consumed in appropriate doses.

In many Asian regions, bitter melon has long been a part of traditional medicine, used to address a range of ailments, including diabetes. Incorporating bitter melon into diet, either as a fresh vegetable, juice, or dried powder, provides a practical and culturally familiar method for regulating blood sugar levels without depending solely on costly pharmaceuticals.

The growing interest in integrative medicine, which combines traditional remedies with modern treatments, highlights the potential of bitter melon to complement existing antidiabetic therapies. In the face of rising healthcare costs, natural interventions like bitter melon may alleviate financial burdens on individuals and healthcare systems, particularly in low- and middle-income countries, where access to advanced medical facilities is often limited.

While bitter melon shows promise, further research is necessary to establish standardized dosages, appropriate forms of consumption, and its long-term safety profile. It is also important to exercise caution; as bitter melon may lead to hypoglycemia when used in conjunction with other antidiabetic medications. Healthcare providers should monitor blood sugar levels carefully when patients use bitter melon alongside prescribed treatments to prevent adverse effects. This approach emphasizes the need for personalized medical strategies, where dietary and natural interventions like bitter melon are tailored to the individual's unique requirements and responses.

Conclusion

The results of this study support the hypothesis that bitter melon powder is effective in managing type 2 diabetes by significantly reducing RBG, FBG, and HbA1C levels. The strong correlations between predicted and actual values, along with the interaction effects between dosage and time, underscore the potential of bitter melon as a natural therapeutic option for improving glycemic control. The desirability score of 1 further validates the robustness of the experimental design and suggests that bitter melon powder can be optimally used in a controlled manner to manage diabetes.

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Authors' contributions

All the authors designed and conducted the research and involved equally in writing the manuscript and finalized it.

Conflict of interests

The authors declare no conflict of interests.

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