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The efficacy of bitter gourd (*Momordica charantia* L.) in reducing oxidative stress in diabetic patients

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Abstract
This study aims to evaluate the efficacy of bitter gourd (*Momordica charantia* L.) in reducing oxidative stress in diabetic patients. A total of 50 diabetic patients participated in a randomized, controlled trial. The intervention group received bitter gourd extract, while the control group received a placebo. Biomarkers of oxidative stress, including malondialdehyde (MDA) levels and superoxide dismutase (SOD) activity, were measured before and after the intervention. The results indicated a significant reduction in MDA levels and an increase in SOD activity in the intervention group compared to the control group, suggesting that bitter gourd has potential as a natural antioxidant therapy for diabetic patients.

Keywords: Bitter gourd, *Momordica charantia* L., reducing oxidative stress, diabetic patients

Introduction
Diabetes mellitus is a prevalent chronic disease characterized by elevated blood glucose levels, which result from defects in insulin secretion, insulin action, or both. This metabolic disorder is associated with long-term damage to various organs, particularly the eyes, kidneys, nerves, heart, and blood vessels. One of the critical factors contributing to the complications of diabetes is oxidative stress, which arises when there is an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defenses. Persistent hyperglycemia in diabetic patients leads to increased production of ROS, causing oxidative damage to cells and tissues, and exacerbating diabetic complications. Bitter gourd (*Momordica charantia* L.), commonly known as bitter melon, is a tropical and subtropical vine belonging to the family Cucurbitaceae. It is widely cultivated and consumed in Asia, Africa, and the Caribbean for its distinctive bitter taste and medicinal properties. Bitter gourd has been traditionally used in various cultures to manage diabetes and other health conditions. The vegetable is rich in essential nutrients, including vitamins A and C, iron, and potassium. Additionally, it contains bioactive compounds such as charantin, momordicin, and polypeptide-p, which are believed to contribute to its therapeutic effects. Research has shown that bitter gourd possesses significant hypoglycemic properties, making it an effective natural remedy for diabetes management. The bioactive compounds in bitter gourd are known to mimic insulin, enhance glucose uptake, and improve insulin sensitivity. Beyond its anti-diabetic properties, bitter gourd is also recognized for its antioxidant potential. Antioxidants are crucial in neutralizing ROS, thereby reducing oxidative stress and preventing cellular damage. The antioxidant effects of bitter gourd are primarily attributed to its high content of phenolic compounds and flavonoids, which have been shown to scavenge free radicals and enhance the activity of endogenous antioxidant enzymes. Given the critical role of oxidative stress in the progression of diabetic complications, there is growing interest in exploring natural antioxidant therapies that can mitigate these effects. This study aims to evaluate the efficacy of bitter gourd in reducing oxidative stress in diabetic patients. By measuring biomarkers of oxidative stress, such as malondialdehyde (MDA) levels, and antioxidant enzyme activity, such as superoxide dismutase (SOD), this research seeks to provide evidence of the therapeutic potential of bitter gourd in managing diabetes-related oxidative stress. Previous studies have highlighted the beneficial effects of bitter gourd on blood glucose levels and overall health. However, there is limited research specifically focusing on its impact on oxidative stress in diabetic patients. This study aims to fill this gap by providing a detailed analysis of how bitter gourd supplementation can influence oxidative stress markers in individuals with diabetes. By doing so, it hopes to contribute to the growing body of evidence supporting the use of bitter gourd as a complementary therapy in diabetes management.

Main objective

The main objective of this study is to evaluate the efficacy of bitter gourd (*Momordica charantia* L.) in reducing oxidative stress in diabetic patients.

Materials and Methods

This study was designed as a randomized, double-blind, placebo-controlled trial to evaluate the efficacy of bitter gourd (*Momordica charantia* L.) in reducing oxidative stress in diabetic patients. Fifty participants diagnosed with type 2 diabetes mellitus, aged between 30 and 60 years and with HbA1c levels between 7% and 10%, were recruited. Exclusion criteria included the use of antioxidant supplements, presence of severe diabetic complications, and other chronic illnesses. Participants were randomly assigned to either the intervention group (n=25) or the control group (n=25) using a computer-generated random number sequence. Both participants and researchers were blinded to the group assignments. The intervention group received a daily dose of 1000 mg of bitter gourd extract in capsule form for 12 weeks, standardized to contain consistent levels of bioactive compounds, including charantin, momordicin, and polypeptide-p. The control group received a placebo capsule identical in appearance to the bitter gourd capsules but containing an inert substance. Blood samples were collected from all participants at baseline and after the 12-week intervention period. The primary biomarkers measured were malondialdehyde (MDA) levels and superoxide dismutase (SOD) activity. MDA levels, indicative of lipid peroxidation and oxidative stress, were measured using the thiobarbituric acid reactive substances (TBARS) assay, with plasma MDA levels quantified by spectrophotometry at 532 nm. SOD activity, reflective of the body's antioxidant defense mechanisms, was measured using a commercially available SOD assay kit, with erythrocyte SOD activity quantified according to the manufacturer's instructions. Data were analyzed using SPSS software (version 25.0). Continuous variables were expressed as mean±standard deviation (SD). The paired t-test was used to compare baseline and post-intervention values within groups, and the independent t-test was used to compare differences between the intervention and control groups. A *p*-value of <0.05 was considered statistically significant. The study protocol was approved by the Institutional Review Board (IRB) of the participating institution. Written informed consent was obtained from all participants prior to their inclusion in the study, which was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. The sample size of 50 participants (25 in each group) was determined based on a power analysis to detect a significant difference in oxidative stress markers with a power of 80% and a significance level of 0.05. The effect size was estimated from previous studies examining the impact of natural antioxidants on oxidative stress in diabetic patients.

Results

Table 1: Baseline characteristics of study participants

Characteristic	Intervention group (n=25)	Control group (n=25)	p-value
Age (years)	45.2±7.1	46.3±6.8	0.64
Gender (M/F)	14/11	13/12	0.79
Duration of diabetes (years)	5.3±2.4	5.1±2.7	0.82
HbA1c (%)	8.2±0.6	8.3±0.7	0.77
BMI (kg/m²)	27.5±3.2	27.7±3.1	0.84

Table 1 presents the baseline characteristics of the participants in both the intervention and control groups. The data show no significant differences between the two groups regarding age, gender distribution, and duration of diabetes, HbA1c levels, and BMI. This indicates that the participants were well-matched at the start of the study, ensuring that any observed effects can be attributed to the intervention rather than pre-existing differences.

Table 2: Changes in malondialdehyde (MDA) levels (nmol/L)

Time point	Intervention group (Mean±SD)	Control group (Mean±SD)	p-value
Baseline	6.5±0.8	6.6±0.7	0.71
After 12 weeks	4.2±0.6	6.4±0.8	< 0.01
Change from baseline	-2.3±0.4	-0.2±0.3	< 0.01

Table 2 shows the changes in malondialdehyde (MDA) levels, a marker of oxidative stress, over the 12-week intervention period. At baseline, MDA levels were similar between the intervention group (6.5±0.8 nmol/L) and the control group (6.6±0.7 nmol/L). After 12 weeks, the intervention group experienced a significant reduction in MDA levels to 4.2±0.6 nmol/L, while the control group showed no significant change (6.4±0.8 nmol/L). The significant reduction in MDA levels in the intervention group suggests that bitter gourd effectively reduces oxidative stress in diabetic patients.

Table 3: Changes in Superoxide Dismutase (SOD) activity (U/mg protein)

Time point	Intervention group (Mean±SD)	Control group (Mean±SD)	p-value
Baseline	1.2±0.3	1.3±0.4	0.55
After 12 weeks	2.4±0.4	1.3±0.3	< 0.01
Change from baseline	1.2±0.3	0.0±0.2	< 0.01

Table 3 details the changes in superoxide dismutase (SOD) activity, an important antioxidant enzyme, over the 12-week period. Initially, SOD activity was similar between the intervention (1.2±0.3 U/mg protein) and control groups (1.3±0.4 U/mg protein). After the intervention, the SOD activity in the intervention group significantly increased to 2.4±0.4 U/mg protein, while it remained unchanged in the control group (1.3±0.3 U/mg protein). The significant increase in SOD activity in the intervention group indicates that bitter gourd enhances the body's antioxidant defense system.

Discussion

The findings from this study provide compelling evidence for the efficacy of bitter gourd (*Momordica charantia* L.) in reducing oxidative stress among diabetic patients. The study

enrolled 50 diabetic patients who were randomly assigned to either an intervention group, which received bitter gourd extract, or a control group, which received a placebo. The primary biomarkers measured were malondialdehyde (MDA) levels, indicative of lipid peroxidation and oxidative stress, and superoxide dismutase (SOD) activity, reflective of the body's antioxidant defense mechanisms.

The baseline characteristics of the participants, including age, gender distribution, duration of diabetes, HbA1c levels, and BMI, were comparable between the intervention and control groups. This uniformity ensured that any observed differences in the biomarkers could be attributed to the intervention rather than pre-existing disparities.

After 12 weeks, the intervention group showed a significant reduction in MDA levels from 6.5±0.8 nmol/L to 4.2±0.6 nmol/L, while the control group showed no significant change. This reduction in MDA levels indicates that bitter gourd effectively decreases oxidative stress by reducing lipid peroxidation. This finding aligns with previous research highlighting the antioxidative properties of bitter gourd, which are attributed to its rich content of bioactive compounds such as charantin, momordicin, and polypeptide-p.

Furthermore, the intervention group exhibited a significant increase in SOD activity from 1.2±0.3 U/mg protein to 2.4±0.4 U/mg protein. In contrast, the control group showed no significant change in SOD activity. The increase in SOD activity in the intervention group suggests that bitter gourd enhances the body's endogenous antioxidant defenses, providing greater protection against oxidative damage. This enhancement of SOD activity is particularly significant as SOD plays a crucial role in catalyzing the dismutation of superoxide radicals into oxygen and hydrogen peroxide, thereby mitigating the harmful effects of reactive oxygen species.

The observed benefits of bitter gourd in reducing oxidative stress and enhancing antioxidant defenses are consistent with its traditional use in managing diabetes and other oxidative stress-related conditions. These results are promising as oxidative stress is a major contributor to the complications associated with diabetes, including cardiovascular diseases, neuropathy, and retinopathy. By reducing oxidative stress, bitter gourd may help mitigate these complications, improving overall health outcomes for diabetic patients.

The study's findings are also supported by other research that has demonstrated the antioxidative and anti-inflammatory effects of bitter gourd. For instance, Fang and Ng (2011) [3] reported that bitter gourd extract could inhibit the growth of cancer cells by disrupting their metabolic processes and signalling pathways, further emphasizing its potential as a therapeutic agent.

In conclusion, this study underscores the significant therapeutic potential of bitter gourd in reducing oxidative stress and enhancing antioxidant defenses in diabetic patients. The significant reduction in MDA levels and increase in SOD activity observed in the intervention group highlight the effectiveness of bitter gourd as a natural antioxidant therapy. These findings support the incorporation of bitter gourd into the diet of diabetic patients as a complementary approach to managing oxidative stress and its associated complications. Further research with larger sample sizes and longer follow-up periods is warranted to confirm these findings and explore the long-term benefits and mechanisms of action of bitter gourd supplementation.

Conclusion

This study demonstrates that bitter gourd (*Momordica charantia* L.) significantly reduces oxidative stress and enhances antioxidant defenses in diabetic patients. The findings reveal a notable reduction in malondialdehyde (MDA) levels and a significant increase in superoxide dismutase (SOD) activity in the intervention group compared to the control group. These results indicate that bitter gourd is effective in lowering lipid peroxidation and boosting the body's endogenous antioxidant mechanisms. Incorporating bitter gourd into the diet of diabetic patients could serve as a valuable complementary approach to managing oxidative stress and potentially mitigating complications associated with diabetes. Further research with larger cohorts and extended follow-up periods is needed to substantiate these findings and fully elucidate the long-term benefits and mechanisms of action of bitter gourd supplementation.

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