

Therapeutic Potential of Neem (*Azadirachta Indica*) in Combating Food-Induced Diabetes Addiction: An Investigative Study in Patna

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ABSTRACT

This randomized controlled trial (RCT) investigated the therapeutic potential of Neem (*Azadirachta indica*) in managing Type 2 Diabetes Mellitus (T2DM) and food addiction. Conducted over six months in Patna, Bihar, the study included 50 diabetic patients aged 30–60 years with a history of food cravings. Participants were randomly assigned to the Neem group (500 mg Neem extract twice daily) or the placebo group, both following a standard diabetic diet. Metabolic and behavioral outcomes were assessed at baseline and after six months. The Neem group showed significant reductions in fasting blood glucose (FBG) by **22.3%**, postprandial blood glucose (PPBG) by **26.4%**, and HbA1c by **21.2%**, compared to minimal improvements in the placebo group (**2.9%**, **4.4%**, and **3.6%**, respectively). Insulin resistance, measured via HOMA-IR, decreased by **39.6%** in the Neem group, while the placebo group achieved only a **6.4%** reduction. The Neem group exhibited a **42.8%** reduction in Yale Food Addiction Scale (YFAS) scores, indicating decreased food cravings, compared to **6.6%** in the placebo group. The findings suggest that Neem extract significantly improves glycemic control, reduces insulin resistance, and mitigates food addiction tendencies, offering dual metabolic and behavioral benefits. Neem's efficacy highlights its potential as a natural adjunct therapy for T2DM management.

Keywords: *Neem; Diabetes Mellitus; Food Addiction; Insulin Resistance; Antidiabetic Activity*

INTRODUCTION

Food addiction has emerged as a major contributor to the rising prevalence of Type 2 Diabetes Mellitus (T2DM). The excessive consumption of refined carbohydrates and sugar-laden foods disrupts insulin function, leading to insulin resistance and metabolic disorders (Gearhardt et al., 2011). This growing crisis is further exacerbated by the highly palatable nature of modern diets, which stimulate reward pathways in the brain, reinforcing addictive eating patterns similar to substance dependence (Schulte et al., 2015). Consequently, managing food addiction is crucial for diabetes control and overall metabolic health.

Neem (*Azadirachta indica*), a traditional medicinal plant widely used in Ayurveda, has gained significant attention for its antidiabetic potential. Its bioactive compounds, including nimbidin, azadirachtin, flavonoids, and limonoids, contribute to its hypoglycemic effects by enhancing insulin sensitivity, promoting glucose uptake, and reducing oxidative stress (Chattopadhyay, 1999). In addition to its direct antidiabetic action, Neem has also shown potential in modifying addictive behaviors by influencing neurotransmitter pathways related to food addiction (Niveditha et al., 2020). This study aims to analyze the therapeutic role of Neem in regulating blood glucose levels and modifying addictive food behaviors in diabetic patients in Patna, Bihar. Given the high burden of diabetes in the region and the cultural significance of Neem in traditional medicine, this research seeks to explore its efficacy as a complementary approach to diabetes management.

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Food Addiction and Type 2 Diabetes Mellitus

Food addiction, characterized by compulsive overeating of unhealthy foods, shares neurological similarities with drug addiction. Research has shown that hyperpalatable foods activate the brain's dopamine reward system, leading to increased cravings and loss of control over food intake (Volkow et al., 2013). This dysregulated eating behavior contributes to obesity, insulin resistance, and the progression of T2DM. Highly processed foods, rich in refined sugars and unhealthy fats, have been linked to chronic hyperglycemia and beta-cell dysfunction, accelerating the onset of diabetes (Lustig et al., 2012). Many individuals with T2DM struggle with persistent cravings for sugary and high-calorie foods, making dietary modifications challenging. Effective interventions targeting both metabolic and neurobehavioral aspects of food addiction are necessary to break this cycle.

Therapeutic Potential of Neem in Diabetes Management

Neem has long been recognized in traditional medicine for its antidiabetic properties. Various studies have demonstrated its effectiveness in reducing blood glucose levels and improving insulin function. The key bioactive compounds in Neem, such as flavonoids, glycosides, and tannins, exert antidiabetic effects through multiple mechanisms:

- a. **Enhancing Insulin Sensitivity:** Neem leaf extracts have been found to improve insulin sensitivity by modulating glucose transporters and enhancing glucose uptake by cells. Studies suggest that Neem can restore insulin receptor function, thereby reducing insulin resistance, a hallmark of T2DM (Khosla et al., 2000).
- b. **Regulating Glucose Metabolism:** Neem extracts inhibit key enzymes involved in carbohydrate metabolism, such as alpha-amylase and alpha-glucosidase, reducing postprandial hyperglycemia (Bhat et al., 2019). By slowing down carbohydrate digestion and absorption, Neem helps maintain stable blood sugar levels.
- c. **Reducing Oxidative Stress and Inflammation:** Chronic hyperglycemia leads to oxidative stress, contributing to pancreatic beta-cell damage and insulin resistance. Neem's antioxidant properties help neutralize free radicals, protecting pancreatic cells and enhancing their function (Ganguly et al., 2020).
- d. **Neurobehavioral Effects and Food Addiction Modification:** Emerging research suggests that Neem may influence neurochemical pathways involved in addiction. Its bioactive compounds modulate dopamine and serotonin levels, which play key roles in reward-seeking behavior and appetite regulation (Niveditha et al., 2020). By modulating these neurotransmitters, Neem may help reduce cravings for sugary and high-calorie foods, aiding in the management of food addiction in diabetic patients.

Study Relevance to Patna, Bihar

Patna, the capital of Bihar, has witnessed a sharp rise in diabetes cases due to dietary shifts towards processed foods, sedentary lifestyles, and urbanization. Traditional dietary practices, once rich in fiber and whole grains, are being replaced by refined and sugar-laden foods, increasing the risk of metabolic disorders (Kumar et al., 2018). Given the widespread availability and cultural acceptance of Neem in this region, investigating its role in diabetes management could offer an accessible and cost-effective intervention. This study will assess the effects of Neem supplementation on diabetic patients in Patna, focusing on both metabolic parameters and changes in food addiction tendencies. By integrating traditional medicine with modern therapeutic approaches, this research aims to provide evidence-based recommendations for diabetes management.

LITERATURE REVIEW

The potential of Neem (*Azadirachta indica*) in managing diabetes and food addiction has been explored in various studies. This review highlights existing research on Neem's antidiabetic properties and its role in modifying addictive food behaviors, with a focus on its relevance to managing Type 2 Diabetes Mellitus (T2DM) in Patna, Bihar.

Neem and Its Antidiabetic Properties

Several studies have demonstrated the antidiabetic potential of Neem due to its rich bioactive compounds such as nimbidin, azadirachtin, and flavonoids. Chattopadhyay (1999) reported that Neem leaf extract significantly reduced blood glucose levels in diabetic models by enhancing insulin sensitivity and improving pancreatic beta-cell function. Similarly, Khosla et al. (2000) found that Neem extract lowered fasting blood glucose in alloxan-induced diabetic rabbits, suggesting its potential in improving glucose metabolism.

Bhat et al. (2019) observed that Neem leaf extract inhibited alpha-amylase and alpha-glucosidase enzymes, which are responsible for carbohydrate digestion. This mechanism effectively reduces postprandial blood glucose levels, highlighting Neem's role in glycaemic control.

Neem and Food Addiction Management

Emerging research suggests that Neem may influence neurobehavioral pathways involved in food addiction. Niveditha et al. (2020) found that Neem extract modulates dopamine and serotonin levels, reducing cravings for high-calorie, sugar-rich foods. This modulation of reward pathways could help address compulsive eating behaviors commonly seen in diabetic patients.

Neem's Antioxidant and Anti-inflammatory Effects

Neem's antioxidant properties further contribute to its antidiabetic effects. Ganguly et al. (2020) reported that Neem extract reduces oxidative stress and protects pancreatic beta-cells from damage, which is critical for maintaining insulin secretion. The anti-inflammatory properties of Neem also help mitigate chronic inflammation, a key factor in insulin resistance and diabetes progression.

Relevance to Patna, Bihar

The high prevalence of T2DM in Patna, Bihar, has been linked to dietary shifts toward highly processed foods. Kumar et al. (2018) highlighted that urbanization and changing lifestyles have contributed to an increased intake of refined carbohydrates and sugary foods, exacerbating the diabetes epidemic. Given the cultural familiarity and accessibility of Neem in this region, integrating Neem-based interventions could provide a cost-effective and sustainable approach to managing diabetes and food addiction.

MATERIALS AND METHODS

Study Design

A randomized controlled trial (RCT) was conducted from July 2024 to December 2024 in three hospitals and two wellness centers in Patna, Bihar. The trial aimed to evaluate the efficacy of Neem (*Azadirachta indica*) extract in managing food-induced diabetes addiction. Participants were randomly assigned to one of two groups: the Neem group, which received capsules containing Neem extract, and the placebo group, which received identical capsules without Neem extract. The study followed a double-blind design to ensure that neither the participants nor the researchers knew which treatment was being administered, minimizing bias and enhancing the reliability of results.

Participant Selection

A total of 50 patients with Type 2 Diabetes Mellitus (T2DM) and a history of food cravings for sugar and refined carbohydrates were selected for the study. Participants were divided equally into the Neem group (n=25) and the placebo group (n=25). The inclusion criteria required participants to be between 30 and 60 years old and have a confirmed diagnosis of T2DM. Exclusion criteria included pregnant women, individuals with Type 1 Diabetes Mellitus (T1DM), and patients with severe comorbidities. These criteria ensured a homogenous study population, improving the validity of the findings regarding Neem's potential benefits in managing food cravings and glycemic control.

Intervention

The intervention phase of the study was designed to assess the impact of Neem extract on diabetes management and food addiction tendencies. Participants in the Neem group received 500 mg Neem extract capsules twice daily—once in the morning and once in the evening. The extract was standardized to ensure consistency in active compounds, particularly nimbin and azadirachtin, which are known for their anti-diabetic and anti-inflammatory properties. The placebo group received identical-looking capsules containing inert ingredients to maintain blinding. Both groups were advised to continue their prescribed diabetes medications, if any, and follow a standard diabetic diet curated by a certified nutritionist. This diet emphasized low glycemic index foods, high fiber intake, and balanced macronutrients to stabilize blood sugar levels. Participants were monitored monthly for adherence to the intervention and dietary guidelines, with regular follow-ups to record any adverse effects or deviations from the protocol.

Parameters Measured

To evaluate the effectiveness of Neem extract in managing Type 2 Diabetes Mellitus (T2DM) and reducing food addiction tendencies, several metabolic and behavioral parameters were assessed at baseline and after six months. Fasting Blood Glucose (FBG) and Postprandial Blood Glucose (PPBG) levels were measured using a glucometer to track changes in blood sugar control. FBG was recorded after an overnight fast of at least eight hours, while PPBG was measured two hours post-meal to assess the body's ability to manage glucose intake. A significant reduction in these values would indicate improved glycemic control due to Neem supplementation.

HbA1c levels, representing glycated hemoglobin, were measured to evaluate long-term glucose management. This parameter reflects average blood glucose levels over the past two to three months and was calculated using the standard formula:

$$HbA1c(\%) = \frac{\text{Average Blood Glucose (mg/dL)} + 46.7}{28.7}$$

A lower HbA1c percentage would signify better glucose regulation and reduced risk of diabetes-related complications.

Another critical parameter assessed was Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), an indicator of insulin sensitivity. HOMA-IR was calculated using the equation:

$$HOMA - IR = \frac{\text{Fasting Insulin } (\mu U/mL) \times \text{Fasting Glucose (mg/dL)}}{405}$$

Higher HOMA-IR values indicate greater insulin resistance, which is a hallmark of T2DM. A decrease in HOMA-IR scores after six months would suggest enhanced insulin sensitivity and improved metabolic function in the Neem group compared to the placebo group.

Lastly, Yale Food Addiction Scale (YFAS) scores were recorded to assess the severity of food addiction symptoms, particularly cravings for sugar and refined carbohydrates. The YFAS questionnaire evaluates behavioral patterns such as loss of control over eating, withdrawal symptoms, and continued consumption of unhealthy foods despite adverse health effects. A higher score reflects stronger food addiction tendencies. By comparing pre- and post-intervention YFAS scores, the study aimed to determine whether Neem extract had a therapeutic effect in reducing compulsive eating behaviors associated with diabetes.

These comprehensive metabolic and behavioral assessments provided a multi-dimensional analysis of Neem's potential benefits in diabetes management, offering insights into its role in improving glycemic control, reducing insulin resistance, and mitigating food addiction tendencies among individuals with T2DM.

RESULTS

Change in Blood Glucose and HbA1c

The study demonstrated significant improvements in blood glucose levels and HbA1c among participants in the Neem group compared to the placebo group. At the end of the six-month intervention, the Neem group exhibited a notable reduction in fasting blood glucose (FBG) from 165.2 ± 10.1 mg/dL to 128.3 ± 9.8 mg/dL, marking a considerable improvement in fasting glucose control. Similarly, their postprandial blood glucose (PPBG) decreased from 245.4 ± 12.3 mg/dL to 180.6 ± 11.2 mg/dL, reflecting better glucose regulation after meals. The Neem group's HbA1c levels dropped from $8.5 \pm 0.4\%$ to $6.7 \pm 0.3\%$, indicating a significant improvement in long-term glycemic control.

In contrast, the placebo group showed minimal improvements. Their FBG reduced slightly from 162.8 ± 9.5 mg/dL to 158.1 ± 9.2 mg/dL, and PPBG decreased from 240.7 ± 11.5 mg/dL to 230.2 ± 10.8 mg/dL. The placebo group's HbA1c levels declined only marginally from $8.4 \pm 0.3\%$ to $8.1 \pm 0.4\%$, highlighting the limited impact of the standard diabetic diet alone. The Neem group showed significant reductions in FBG, PPBG, and HbA1c levels compared to the placebo group after six months.

Table 1: Changes in Blood Glucose and HbA1c Levels (Before and After Intervention)

Group	FBG (mg/dL) Before	FBG (mg/dL) After	PPBG (mg/dL) Before	PPBG (mg/dL) After	HbA1c (%) Before	HbA1c (%) After
Neem Group	165.2 ± 10.1	128.3 ± 9.8	245.4 ± 12.3	180.6 ± 11.2	8.5 ± 0.4	6.7 ± 0.3
Placebo Group	162.8 ± 9.5	158.1 ± 9.2	240.7 ± 11.5	230.2 ± 10.8	8.4 ± 0.3	8.1 ± 0.4

HOMA-IR Index (Insulin Resistance)

The Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) results further demonstrated the efficacy of Neem extract in improving insulin sensitivity. The Neem group experienced a significant reduction in HOMA-IR from 4.8 ± 0.5 to 2.9 ± 0.4 , a 39.6% decrease, indicating improved insulin sensitivity and reduced insulin resistance.

On the other hand, the placebo group showed only a slight reduction from 4.7 ± 0.6 to 4.4 ± 0.5 , with a modest 6.4% decrease. These results underscore the potential of Neem extract in addressing insulin resistance, a key factor in the progression of Type 2 Diabetes Mellitus (T2DM). Neem supplementation showed a significant impact on insulin sensitivity compared to the placebo.

Table 2: HOMA-IR Index Before and After Intervention

Group	HOMA-IR Before	HOMA-IR After	% Reduction
Neem Group	4.8 ± 0.5	2.9 ± 0.4	39.6%
Placebo Group	4.7 ± 0.6	4.4 ± 0.5	6.4%

Food Addiction Reduction (YFAS Scores)

Behavioral assessments using the Yale Food Addiction Scale (YFAS) revealed that Neem extract also played a role in reducing food addiction tendencies. The Neem group exhibited a significant decrease in YFAS scores from 18.2 ± 1.3 to 10.4 ± 1.1 , marking a 42.8% reduction in food addiction symptoms, including cravings for sugary and refined carbohydrate-rich foods. In contrast, the placebo group showed only a slight decrease in YFAS scores from 18.1 ± 1.2 to 16.9 ± 1.3 , a modest 6.6% reduction. Neem extract significantly reduced food cravings and addiction tendencies, as measured by YFAS scores.

Table 3: YFAS Scores Before and After Intervention

Group	YFAS Score Before	YFAS Score After	% Reduction
Neem Group	18.2 ± 1.3	10.4 ± 1.1	42.8%
Placebo Group	18.1 ± 1.2	16.9 ± 1.3	6.6%

The trial outcomes strongly indicate the therapeutic potential of Neem extract in managing Type 2 Diabetes Mellitus and associated food addiction. Compared to the placebo group, the Neem group achieved:

- **Better glycemic control** (significant reductions in FBG, PPBG, and HbA1c)
- **Improved insulin sensitivity** (marked reduction in HOMA-IR)
- **Reduced food cravings** (significant decline in YFAS scores)

Table 4 summarizes the percentage improvements across all parameters for both groups, highlighting the superior efficacy of Neem extract over placebo.

Table 4: Percentage Improvements in Key Parameters

Parameter	Neem Group (Improvement %)	Placebo Group (Improvement %)
Fasting Blood Glucose (FBG)	22.3%	2.9%
Postprandial Blood Glucose (PPBG)	26.4%	4.4%
HbA1c (%)	21.2%	3.6%
HOMA-IR (Insulin Resistance)	39.6%	6.4%
YFAS (Food Addiction Score)	42.8%	6.6%

These results suggest that Neem extract, when combined with a standard diabetic diet, could serve as a promising adjunct therapy for patients with T2DM, not only improving metabolic parameters but also addressing food addiction, a common barrier to effective diabetes management.

DISCUSSION

The findings of this randomized controlled trial (RCT) demonstrate the significant therapeutic potential of Neem (*Azadirachta indica*) in managing Type 2 Diabetes Mellitus (T2DM) and food addiction. The Neem group showed substantial improvements in glycemic control, with notable reductions in fasting blood glucose (FBG), postprandial blood glucose (PPBG), and HbA1c levels compared to the placebo group. This outcome aligns with previous studies highlighting Neem's antihyperglycemic properties, attributed to its bioactive compounds, including flavonoids, triterpenoids, and polyphenols, which enhance insulin secretion and improve glucose uptake. The marked reduction in HOMA-IR scores (39.6%) in the Neem group indicates a significant improvement in insulin sensitivity, further supporting Neem's role in mitigating insulin resistance—a major contributor to T2DM. In contrast, the placebo group showed only minimal improvements, underscoring the limited effect of a standard diabetic diet alone without adjunct therapy.

This study also highlights Neem's potential in addressing food addiction, as evidenced by a 42.8% reduction in Yale Food Addiction Scale (YFAS) scores in the Neem group. The reduction in food cravings, particularly for sugary and refined carbohydrates, suggests that Neem may influence reward pathways linked to addictive eating behaviors, potentially through its antioxidant and anti-inflammatory effects on the brain. Such improvements in food addiction are crucial for better diabetes management, as unhealthy eating patterns are common barriers to glycemic control. The placebo group, which showed only a 6.6% reduction in YFAS scores, reinforces Neem's distinct impact beyond dietary adjustments alone. These findings collectively indicate that Neem extract, when combined with a standard diabetic diet, offers a dual benefit—improving both metabolic parameters and behavioral factors contributing to poor diabetes management.

CONCLUSION

This randomized controlled trial highlights the significant potential of Neem (*Azadirachta indica*) as an adjunct therapy for managing Type 2 Diabetes Mellitus (T2DM) and food addiction. The Neem group demonstrated remarkable improvements in glycemic control, with fasting blood glucose (FBG) reduced by 22.3%, postprandial blood glucose (PPBG) by 26.4%, and HbA1c levels by 21.2% compared to minimal reductions in the placebo group (2.9%, 4.4%, and 3.6%, respectively). Additionally, the Neem group achieved a 39.6% reduction in HOMA-IR scores, indicating improved insulin sensitivity, while the placebo group showed only a 6.4% reduction. These results suggest that Neem's bioactive compounds, such as flavonoids and polyphenols, effectively enhance insulin function and glucose metabolism, supporting its use as a natural therapeutic alongside standard diabetic management. Neem extract showed a significant impact on reducing food addiction tendencies. Participants in the Neem group experienced a 42.8% reduction in Yale Food Addiction Scale (YFAS) scores, indicating decreased cravings for sugary and refined carbohydrates, compared to only 6.6% in the placebo group. This dual benefit—improving both metabolic and behavioral outcomes—is crucial for better diabetes management, as food addiction often hinders glycemic control. Overall, Neem extract, when combined with a standard diabetic diet, proved highly effective in managing both T2DM and food cravings.

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