

Effects of Ladies' Finger Water with Calorie Restriction on Type 2 Diabetes Mellitus

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Abstract

BACKGROUND: Diabetes mellitus is a chronic metabolic disorder¹ characterized by elevated hyperglycemia, insulin resistance, and relative insulin deficiency² which can lead to various health complications if left untreated. Dietary fibre plays a crucial role in the management and prevention of diabetes. ^{6, 7, 8} Ladies' fingers, also known as okra, are a widely cultivated vegetable that has been used in traditional medicine for its potential health benefits, including its effects on blood glucose regulation. This study aims to investigate the effect of ladies' finger water on diabetes mellitus, specifically focusing on its impact on blood glucose levels and glycated haemoglobin A1c (HbA1C), a marker of long-term glucose control.

METHODOLOGY: A randomised controlled trial was conducted on 30 subjects aged 30-50 years over 3 months, with participants randomly assigned to 2 groups (15 per group) to evaluate the antidiabetic effects of ladies' finger water. The intervention group received ladies' finger water four times daily along with a calorie-restricted diet, while the control group followed only a calorie-restricted diet. Glycemic parameters, including glycated haemoglobin (HbA1c), fasting blood sugar (FBS), post-prandial blood sugar (PPBS), body weight, and body mass index (BMI), were assessed before and after the intervention period.

RESULTS After three months, the intervention group showed a greater reduction in HbA1c, FBS, and PPBS compared with the control group. Both groups exhibited reductions in weight and BMI; however, the decrease was more pronounced in the intervention group.

Conclusion: The study suggests that ladies' finger water, when combined with a calorie-restricted diet, may help improve glycemic control in individuals with type 2 diabetes mellitus and may serve as a supportive dietary intervention in diabetes management and phenolic acids. Ladies' finger water with a calorie-restricted diet is more effective than just a calorie-restricted diet on HbA1C and blood glucose levels in type 2 diabetes mellitus subjects.

Keywords: - HbA1C (Glycated haemoglobin A1C), FBS (Fasting Blood Sugar), PPBS (Post Prandial Blood Sugar) and BMI (Body mass index).

BACKGROUND

Type 2 Diabetes Mellitus (T2DM) is one of the most common metabolic disorders, characterised by elevated hyperglycemia, insulin resistance, and relative insulin deficiency. It's primarily caused by a combination of two main factors: defective insulin secretion by pancreatic β -cells and the inability of insulin-sensitive tissues to respond to insulin³. Insulin release and action must precisely meet metabolic demand.

Elevated hyperglycemia, insulin resistance, and relative insulin deficiency² which can lead to various health complications if left untreated.⁴

Lady's fingers/okra (*Abelmoschus esculentus* L) is packed with high dietary fiber¹⁰ that helps stabilise blood sugar levels by regulating the rate of absorption of sugar from the digestive tract⁹ and thereby decreases postprandial hyperglycemia. It is also shown to increase satiety, resulting in weight loss. The anti-diabetic property of okra is also attributed to its ability to inhibit enzymes metabolising carbohydrates, enhance the production of insulin, regenerate the beta cells of the pancreas and increase the secretion of insulin.¹¹ Dietary Fibre fermentation by certain microbes in the intestinal colon, and they have anti-inflammatory actions on both gut epithelial and immune cells.^{6,7,8} A fibre-rich diet improves glycemic control, reduces glucose spikes, decreases hyperinsulinemia, improves plasma lipid concentrations and weight management in T2DM patients.⁵

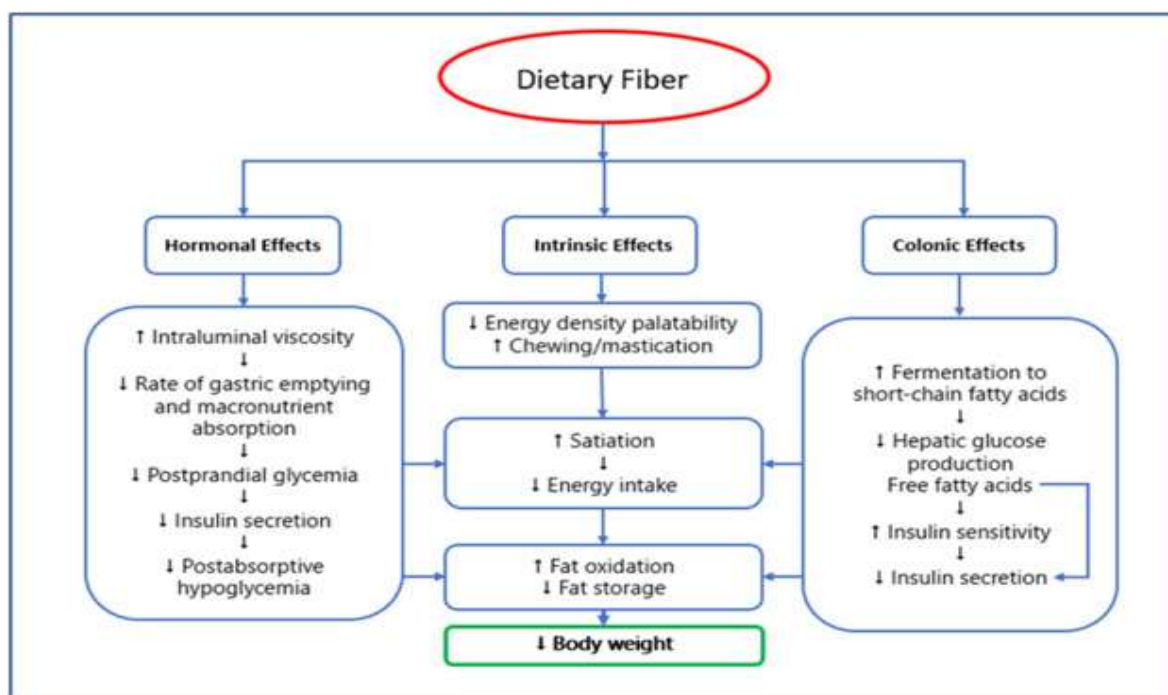
The nutritional constituents of ladies' finger include carbohydrate, protein, phosphorus, calcium, magnesium, iron, vitamin A and C, with traces of vitamin B [1, 2, and 3]¹². Phytochemical Screening of ladies' finger water includes phenols, flavonoids, alkaloids, terpenoids, flavonoids¹⁴, steroids, tannins, saponins, and cardiac glycoside¹³.

The therapeutic properties of ladies finger water, it has high content of soluble fiber and polysaccharides, which modulate carbohydrate absorption in the intestine.^{9,10} Studies suggest that the infusion of okra work synergistically to enhance insulin sensitivity in the individual enhances insulin sensitivity, thereby facilitating better glucose uptake by cells, a mechanism resonant with findings related to traditional treatments for diabetes^{9,10,11,12,13}. Antioxidants present in ladies' fingers water combat oxidative stress, a significant contributor to insulin resistance and diabetes progression.¹⁴

Ladies' finger has various bioactive compounds, including soluble fibres, flavonoids, and phenolic acids, which work synergistically to enhance insulin sensitivity in the individual. The soluble fibre present in okra has been shown to slow down the absorption of sugar in the intestines, which directly contributes to lower postprandial glucose levels and modulates glucose metabolism. Additionally, the flavonoids and phenolic compounds exhibit antioxidant properties, reducing oxidative stress, which is often exacerbated in diabetic conditions.^{9,10,11,12,13 and 14.}

A high-calorie diet is the main contributor to the development of obesity, which results in Type 2 diabetes mellitus, as obesity or increased intra-abdominal adipose tissue is related to insulin resistance.¹⁵ calorie restriction produced substantial decreases in fasting plasma glucose, hepatic glucose production, and fasting plasma triglyceride and increases in insulin sensitivity and secretion.¹⁶

The effect of dietary fibre FIG-1⁵



Hence, in this proposal, we were interested in understanding the benefit of ladies' finger water on blood glucose levels and Glycated hemoglobin A1C (HbA1C) in subjects with diabetes mellitus.

MATERIALS AND METHODS

Objectives

To evaluate the effect of ladies' finger water with calorie restriction on HbA1C, FBS, PPBS, BMI and weight in type 2 diabetes mellitus subjects.

Subjects

30 subjects aged between 30 and 50 years participated in this study. They were screened through a routine medical check-up, and those satisfying diagnostic criteria for type 2 diabetes mellitus were recruited in this study.

Selection criteria for the study

Inclusion criteria

1. Age - 30-50 yrs.
2. FBS-110- 140 mg/dl
3. PPBS- 140-180 mg/dl
4. HbA1C- 6.5-7.5%
5. BMI - >25 <34.9 kg/m²
6. History of pre diabetes
7. Medicine – only plain metformin(500mg).

Sample size (n=30)

The sample size is taken at our convenience

Group -1 (n=15)

Received a calorie-restricted diet with ladies' finger water

Group-2(n=15)

Received a calorie-restricted diet only

Study Design

Randomised controlled study

Randomisation

Patients were randomised using a computerised randomisation table and were allocated into two groups of 15 each.

Study intervention chart

Total 3 months study plan for each subject in this present study: Okra, lady's finger (*abelmoschus esculentus*) is put in the water over night or 4-5 hrs of soaking & taken in with empty stomach 3 times a day (between each dose of 5-6 hrs gap had been given) Totally = 4 glass (800 ml) of ladies' finger water was given in a day 200ml- 200ml- 200ml- 200ml.

PROCEDURE FOR MAKING LADIES' FINGER WATER

Okra (Ladies fingers) should be washed thoroughly, and the okra's top & bottom are cut & thrown away; 2-3 okra are cut into small pieces. About 4-5 pieces of okra are added to 200ml of water and left as it is for over a night or 4-5 hrs of soaking & taken on an empty stomach. Then take the okra out of the water and drink the water.



Time of giving ladies' finger water

Sedentary (Men- 2110 Kcal and women- 1660 Kcal) and moderate (Men- 2710 Kcal and women- 2130 Kcal) category adults, and the balanced diet concept has been followed in this study.

7 am -8 am - 200ml of ladies' finger water

9 am -10 am- Breakfast-Calories restriction to 350-500kcal (women) and 500- 650kcal (men)

12 pm-12:30 pm – 200ml of ladies' finger water

1 pm – 2 pm- Lunch - Calorie restriction to 500-700kcal (women) and 600- 800kcal (men)

5:30 pm- 6 pm- 200ml of ladies' finger water

7 pm-8 pm – Dinner- Calorie restriction to 300- 350kcal (women) and 400- 550kcal (men)

9:30 pm - 10 pm- 200ml of ladies' finger water.

List of food items followed due to low glycaemic index and low glycaemic load.

1. Complex carbohydrate (carbohydrate with fibres) – like Brown rice, Oats, Whole grains, Lentils, leafy vegetables- spinach, Nuts and seeds.
2. Low-fat meal- unsaturated fats- like Nuts and seeds, Avocado, vegetable oils, and seeds.
3. Moderate levels of protein- plant sources of protein – soy and soy products (complete protein means all nine essential amino acids have been given).

4. Vitamins and minerals - Vitamin A, D, C, E, B12 and 9, Zinc, magnesium, calcium and Selenium. Sources- fruits like papaya, orange, Guava, Pulses, Dairy products, Eggs, fish, Broccoli, ladies' finger, Peas, etc.
5. Water – 3 litres- 4 litres of water per day.
6. Probiotics and prebiotics - Yogurt, Buttermilk, cabbage, soy, whole grains, legumes, onion, garlic, barley, fruits-apples, avocados and green leafy vegetables.

Note: - Avoided all the following food items due to high glycaemic index and high glycaemic load

1. Simple carbohydrates like refined rice, white flour, cake, and cookies.
2. Saturated fats like high-fat dairy products and animal proteins- red meat.
3. Trans fats are found in processed snacks, baked food items, and butter.
4. Cholesterol is found in high-fat dairy products and high-fat animal proteins, egg yolks, liver, and other organ meats.
5. No extra added Sodium
6. Fruits- Mango, Ripe banana, dried fruits, Grapes, and Watermelon.
7. Soft drinks, sodas, sugar-filled coffee.

Methods

Blood sugar levels are measured by FBS, PPBS, and HbA1C. All the parameters like FBS, PPBS, HbA1C and Anthropometer measurements were taken pre (1st day) and post (90 days) of the intervention.

Blood was drawn from an cubital vein in the morning after 12 hours of overnight fasting for FBS & HbA1C, and 2 hours after breakfast, again blood was drawn for PPBS and sent for analysis within 2 hours of blood collection. HbA1C levels were measured by High-performance liquid chromatography (HPLC), FBS & PPBS were measured by reducing methods by a biochemical auto-analyser at the district hospital, Mysore.

Anthropometric measurements were obtained from the complete physical examination. Weight and height were measured with the subject's shoeless and wearing light clothing. BMI was derived from the formula, $\text{weight (kg)} \div \text{height (m)}^2$.

Statistical analyses were conducted using GraphPad Prism 10.0. Data are presented as mean $\pm$ standard error of the mean (SEM). Pre- and post-intervention values were compared using paired t-tests, and the Wilcoxon signed-rank test was applied as a non-parametric confirmatory analysis. A two-tailed p-value < 0.05 was considered statistically significant.

Results

The present study included 30 participants, divided equally into an intervention group (n = 15) and a control group (n = 15). The parameters analysed were HbA1c, Fasting Blood Sugar (FBS), Post Prandial Blood Sugar (PPBS), Weight, and Body Mass Index (BMI).

All the parameters were compared between 2 groups. There was a significant decrease in HbA1C, FBS, PPBS, weight, and BMI.

Variable	Pre-intervention	Post-intervention
HbA1C (%)	7.04 $\pm$ 0.08	5.94 $\pm$ 0.09
FBS (mg/dl)	124.40 $\pm$ 2.48	93.33 $\pm$ 1.74
PPBS (mg/dl)	157.60 $\pm$ 2.74	137.87 $\pm$ 1.48

Table: Shows mean $\pm$ SEM the glycaemic parameters (HbA1C, FBS and PPBS) pre- and post-intervention

Statistical analyses were conducted using GraphPad Prism 10.0. Data are presented as mean $\pm$ standard error of the mean (SEM). Pre- and post-intervention values were compared using paired t-tests, and the Wilcoxon signed-rank test was applied as a non-parametric confirmatory analysis. A two-tailed p value < 0.05 was considered statistically significant

Variable	Mean Difference (Post – Pre)	t-value	df	p-values
HbA1C (%)	-1.10	-18.58	14	p < 0.001
FBS (mg/dl)	-31.07	-10.95	14	p < 0.001
PPBS (mg/dl)	-19.73	-7.36	14	p < 0.001

Table: Shows the paired t-test results. Significant reductions were observed in HbA1C, FBS, and PPBS levels following the intervention (p < 0.001 for all variables).

Normality of the data was assessed using the Shapiro–Wilk test and Normal QQ plots. Since the data did not follow normal distribution in some variables, both parametric (Paired t-test) and non-parametric tests (Wilcoxon signed-rank test and Mann–Whitney U test) were used.

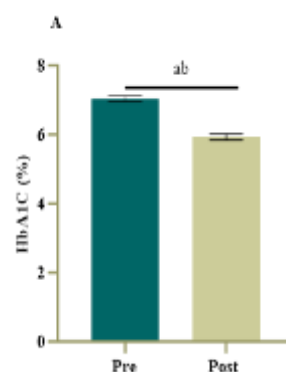
In the intervention group, comparison between pre- and post-intervention values using the paired t-test showed a statistically significant reduction in all parameters. The results showed significant decreases in HbA1c (t = 18.57, p < 0.001), FBS (t = 10.95, p < 0.001), PPBS (t = 7.36, p < 0.001), Weight (t = 23.5, p < 0.001) and BMI (t = 17.00, p < 0.001). The large Cohen’s d effect sizes also indicated a strong effect of the intervention.

Similarly, the Wilcoxon signed-rank test for the intervention group also showed statistically significant differences between pre and post-values (p < 0.05) for all variables, indicating improvement after the intervention.

In the control group, paired comparisons showed minimal or less significant changes in most parameters compared with the intervention group.

Further, the Mann–Whitney U test was applied to compare the change between intervention and control groups. The analysis showed a statistically significant difference between groups for HbA1c (p = 5.54×10^{-6}), Weight (p = 2.84×10^{-6}), and BMI (p = 5.99×10^{-6}), indicating that the intervention group had greater improvement compared to the control group. However, FBS (p = 0.0838) and PPBS (p = 0.884) did not show statistically significant differences between the groups.

Overall, the results indicate that the intervention significantly improved glycemic parameters and anthropometric measurements, especially HbA1c, weight, and BMI, compared to the control group.



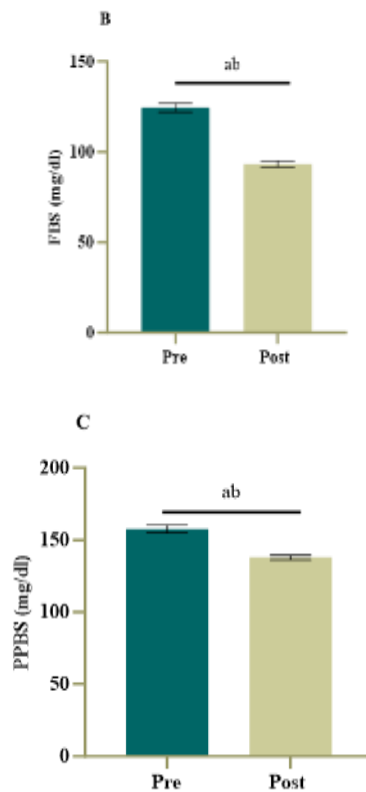


Figure: Shows HbA1C (A), FBS (B) and PPBS (C) pre- and post-intervention. The data represented the mean $\pm$ SEM with a significant level of $p < 0.05$. ab- significant and aa- not significant

Discussion

The present study was conducted to evaluate the effect of ladies' finger (*Abelmoschus esculentus*) water on glycemic parameters and anthropometric measurements among individuals with diabetes. The results of the study demonstrated a significant improvement in HbA1c, Fasting Blood Sugar (FBS), Post-Prandial Blood Sugar (PPBS), weight, and Body Mass Index (BMI) among participants in the intervention group after the intervention period. The paired t-test results indicated highly significant differences between the pre- and post-intervention values ($p < 0.001$), suggesting that the consumption of ladies' finger water may play a beneficial role in improving glycemic control.

These findings are consistent with previous research that highlights the antidiabetic potential of ladies' finger. A study conducted by **Sabitha et al. (2011)** reported that extracts of *Abelmoschus esculentus* significantly reduced blood glucose levels and improved lipid metabolism in diabetic animal models. The authors suggested that the hypoglycemic activity may be due to the presence of polysaccharides and flavonoids that help regulate carbohydrate metabolism.

Similarly, **Khatun et al. (2018)** observed that okra consumption contributed to improved glycemic control by reducing fasting blood glucose levels in individuals with type 2 diabetes. The researchers explained that the high soluble fibre content present in ladies' fingers slows glucose absorption in the intestine, thereby preventing sudden spikes in blood glucose levels after meals.

The reduction in HbA1c observed in the present study also supports the findings of **Fan et al. (2014)**, who reported that the polysaccharides extracted from *Abelmoschus esculentus* improved long-term glycemic

control by enhancing insulin sensitivity and promoting glucose uptake in peripheral tissues. HbA1c is an important indicator of long-term glycemic status, and a reduction in HbA1c suggests improved overall glucose regulation.

In addition to glycemic improvement, the present study also showed a significant reduction in weight and BMI in the intervention group. Weight reduction plays a crucial role in diabetes management, as it helps improve insulin sensitivity and reduce insulin resistance. This observation is supported by **Gemedede et al. (2015)**, who reported that the high dietary fibre and low-calorie content of okra contribute to satiety, improved digestion, and better weight management.

The Wilcoxon signed-rank test further confirmed the effectiveness of the intervention, demonstrating significant differences between the pre- and post-intervention values for all parameters in the intervention group. These findings indicate that the consumption of ladies' finger water may positively influence metabolic parameters associated with diabetes.

However, when the intervention group was compared with the control group using the Mann–Whitney U test, significant differences were observed only in HbA1c, weight, and BMI, while FBS and PPBS did not show statistically significant differences between the two groups. This variation may be attributed to short-term dietary fluctuations, individual metabolic responses, and the relatively small sample size. Similar observations were reported by **Liu et al. (2015)**, who noted that short-term interventions may not always produce consistent changes in fasting and post-prandial glucose levels due to physiological variability.

The beneficial effects observed in this study may be attributed to the nutritional composition of ladies' fingers. Ladies' fingers are rich in soluble fibre, mucilage, flavonoids, antioxidants, and polysaccharides, which are known to delay carbohydrate digestion, reduce glucose absorption, and enhance insulin activity. These components may contribute to improved glycemic regulation and metabolic health.

Overall, the findings of the present study suggest that regular consumption of ladies' finger water may serve as a simple and cost-effective dietary intervention for improving glycemic control and reducing anthropometric parameters among individuals with diabetes. However, further studies with larger sample sizes and longer intervention durations are required to confirm these findings and to explore the long-term therapeutic potential of ladies' finger in diabetes management.

Limitation

The present study has certain limitations that should be considered while interpreting the results. The sample size was relatively small, which may limit the generalizability of the findings to the wider diabetic population. In addition, the intervention period was short, whereas glycemic indicators such as HbA1c usually reflect long-term glucose control. Dietary intake, physical activity, and lifestyle habits of participants were not strictly monitored throughout the study, which may have influenced fasting and post-prandial glucose levels. Furthermore, the study mainly assessed glycemic and anthropometric parameters and did not include additional biochemical markers such as insulin levels, lipid profile, or inflammatory markers.

Strength of the study

Despite these limitations, the study has notable strengths. It evaluates a simple, natural, and cost-effective dietary intervention using ladies' finger water. The assessment of multiple parameters, including HbA1c, FBS, PPBS, weight, and BMI, along with appropriate statistical analyses, provides a comprehensive understanding of its potential role in improving glycemic control.

Conclusion

The present study was conducted to evaluate the effect of ladies' finger (*Abelmoschus esculentus*) water on glycemic parameters and anthropometric measurements among individuals with diabetes. The findings of the study demonstrated a significant reduction in HbA1c, fasting blood sugar (FBS), post-prandial blood sugar (PPBS), body weight, and body mass index (BMI) in the intervention group after the consumption of ladies' finger water. The statistical analysis confirmed significant improvements between the pre- and post-intervention values, indicating that the intervention had a positive impact on glycemic control and metabolic health.

The observed improvements may be attributed to the high dietary fibre, mucilage, antioxidants, and bioactive compounds present in ladies' finger, which help slow glucose absorption, enhance insulin sensitivity, and support better metabolic regulation. The reduction in weight and BMI may further contribute to improved insulin function and glycemic control.

Overall, the findings suggest that regular consumption of ladies' finger water may serve as a simple, natural, and cost-effective supportive dietary approach for improving glycemic control in individuals with diabetes. However, further studies with larger sample sizes and longer intervention periods are recommended to confirm these findings and to better understand the long-term therapeutic potential of this dietary intervention.

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