Jundishapur J Nat Pharm Prod. 2024 February; 19(1):e143074. https://doi.org/10.5812/jjnpp-143074.

Published online 2024 January 23. **Research Article**

Okra (*Abelmoschus esculentus*) Intake Improves Lipid Profile and Liver Transaminases in Pre-diabetic Adults: A Randomized Double-blinded Trial

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Received 2023 November 14; **Revised** 2023 December 27; **Accepted** 2023 December 27.

Abstract

Background: Okra (*Abelmoschus esculentus*) has garnered scientific attention for its beneficial effects on various chronic disorders, including type 2 diabetes mellitus.

Objectives: The current study was designed and conducted to assess the influence of whole okra fruit powder on the serum levels of specific biochemical parameters in individuals with pre-diabetes.

Methods: Seventy pre-diabetic patients, aged 30 - 55 years, were divided into two groups: The okra group (n = 35, fasting plasma glucose: 116.26 ± 6.02) and the placebo group (n = 35, fasting plasma glucose: 112.26 ± 5.8). The okra group received 3000 mg of okra capsules daily for eight weeks, while the placebo group received placebo capsules. Liver function, renal markers, and lipid profiles were assessed at both the baseline and the end of the experiment using a spectrophotometer. The impact of the okra intervention on biochemical parameters was determined using parametric or non-parametric analysis of covariance (ANCOVA).

Results: The serum levels of total cholesterol, low-density lipoprotein cholesterol, liver transaminases, and uric acid were significantly lower in the okra group compared to the placebo group. Conversely, the high-density lipoprotein cholesterol levels were significantly higher in the okra group than in the placebo group. However, there were no statistically significant differences between the two groups regarding triglycerides, creatinine, blood urea nitrogen, and alkaline phosphatase levels.

Conclusions: The consumption of okra effectively improved the lipid profile and certain serum parameters (alanine transaminase, aspartate transaminase, and uric acid) related to liver and kidney health in pre-diabetic participants.

Keywords: Pre-diabetes, Okra, Lipid Profiles, Liver Function Test

1. Background

Diabetes remains a significant public health concern in modern society, imposing a substantial economic burden on both individuals and societies (1). In 2021, approximately 537 million adults worldwide were living with diabetes, a number predicted to increase to about 643 million by 2030 and 783 million by 2045 (2). In Iranian adults, the incidence of diabetes was reported to be 14.15% in 2021 (3, 4). Over 90% of diabetes cases are classified as type 2 diabetes mellitus (T2DM) (5). Prolonged hyperglycemia in T2DM predisposes patients to the development of microvascular and macrovascular complications. Alarmingly, nearly half of all individuals with T2DM are unaware of their condition, leading to subsequent severe complications. Evidence increasingly indicates that pre-diabetes is a risk state preceding T2DM, characterized by pathophysiological abnormalities in various tissues and organs, including insulin resistance and β-cell dysfunction (6). Pre-diabetes is typically defined as a state of impaired glucose metabolism in which blood glucose levels are elevated but not yet high enough to warrant a T2DM diagnosis (7, 8). Individuals with pre-diabetes are at a higher risk of developing T2DM,

especially without proper treatment (6).

In recent decades, several herbal supplements rich in flavonoids have garnered special scientific attention due to their potential beneficial effects on diabetic complications (9-11). *Abelmoschus esculentus* (L.), commonly known as okra, is a tropical plant belonging to the Malvaceae family. It is widely used as a food and also as an herbal remedy for various chronic diseases (12). Okra is a rich source of polyphenols and flavonoids, which exhibit notable anti-cancer, lipid-lowering, and anti-diabetic properties, providing scientific support for the medicinal value of this plant (13, 14). Although multiple in vivo and in vitro studies have reported that okra may improve lipid profiles and mitigate diabetes-related complications, there is a limited number of clinical studies on this topic (15, 16). Therefore, more clinical trials are necessary to substantiate the protective role of okra in individuals with pre-diabetes or T2DM.

2. Objectives

This clinical trial aimed to investigate the efficacy of okra on liver enzymes, lipid profiles, and kidney biochemical markers in pre-diabetic patients.

3. Methods

Prior to recruiting participants, the study design was approved by the Ethics Committee of Golestan University of Medical Sciences, Gorgan, Iran (IR.GOUMS.REC.1399.229). This trial was registered at the Iranian Registry of Clinical Trials (IRCT20201026049154N1). The ethical principles adhered to the Declaration of Helsinki, and each participant provided informed consent by signing a consent form.

The current research was categorized as a randomized, double-blinded, placebo-controlled clinical trial conducted between 2020 and 2022. In summary, a total of 70 Iranian participants aged 30 to 55 years were recruited from newly diagnosed pre-diabetic individuals referred to Shushtar health and treatment centers in Iran. Table 1 displays information regarding the average age and gender distribution of the two groups, as well as the initial fasting plasma glucose (FPG) levels of the patients. Common inclusion criteria for this research encompassed not being pregnant or lactating and having no history of cardiovascular diseases, renal failure, thyroid diseases, chronic inflammatory diseases, mental health issues, allergies, etc. Participants exhibiting any of the aforementioned physiological or pathological conditions were excluded from the study. Additionally, individuals using specific medications, such as nonsteroidal anti-inflammatory drugs (NSAIDs) or steroid drugs were excluded.

Table 1. Baseline Characteristics of the Study Population [a]

Variables	Okra Group (n = 35)	Placebo Group (n = 35)
Age (y)	45.81 ± 6.59	45.61 ± 7.80
Gender		
Male	15	15
Female	20	20
Fasting blood sugar	116.26 ± 6.02	112.26 ± 5.80

[a] Values are expressed as mean ± SD or No. (%).

In this study, approximately 100 kg of okra was sourced from okra farms in Shushtar city, Khuzestan province, Iran. The plant material was deposited in the herbarium of the Tabriz University of Medical Science with voucher number 5001 TBZFPH. Subsequently, the whole okra fruit was meticulously rinsed, air-dried in the shade, and finely ground to obtain okra powder. The okra powders were then blended with magnesium stearate powder at a 10: 1 ratio to produce 500 mg okra capsules. The 500 mg placebo capsules were composed of carboxymethyl cellulose (CMC) and magnesium stearate (used as a lubricant) in a 10: 1 ratio. The chosen dosage of okra was determined based on a pilot study involving 10 pre-diabetic subjects over an 8-week period.

Patients were randomized into the okra and placebo groups using a 4-item randomized block design (RBD). Allocation to the intervention and placebo groups was indicated by either “A” or “B”, which were determined by the epidemiologist consultant. The color, size, and shape of all capsules were identical for both the intervention and placebo groups, and their contents were concealed from both the patients and the principal investigators.

Subjects in the placebo group ingested placebo capsules, while those in the okra group received capsules containing 500 mg of okra powder for 8 weeks. All participants were instructed to take 2 capsules three times a day, 30 minutes before meals (6 capsules per day). The capsules were distributed every two weeks at Noor Laboratory, Shushtar, Iran. Simultaneously with the distribution of capsules, possible side effects were also assessed.

Blood samples were collected at the beginning and end of the study. In brief, a 10-mL fasting blood sample was obtained from all the patients using a serum separator tube, then centrifuged for 10 minutes at 3000 rpm, and the resulting serum samples were stored at -80°C. Lipid profiles (total cholesterol (TC), high-density lipoprotein

cholesterol (HDL-C), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-C)), liver enzymes [alkaline phosphatase (ALP), alanine transaminase (ALT), and aspartate transaminase (AST)], and renal markers [blood urea nitrogen (BUN), creatinine (Cr), and uric acid (UA)] were assessed using commercially available diagnostic kits provided by Pars Azmun (Tehran, Iran). These biochemical tests were conducted using an auto-analyzer following the protocols outlined in the kit's manual.

The findings were analyzed using SPSS software version 26 (SPSS Inc., Chicago, IL) and presented as mean ± standard deviation. Data normality was assessed using the Shapiro-Wilk test. The comparison of differences between the 2 groups was performed using either an independent *t*-test or the Mann-Whitney U test. The impact of okra intervention on biochemical parameters was assessed through parametric and non-parametric covariance analysis (ANCOVA). A significance level of $P \leq 0.05$ was considered statistically significant.

4. Results

4.1. Lipid Profiles

The consumption of okra ameliorated TC ($P < 0.001$) and LDL-C ($P < 0.001$) compared to the placebo group. The levels of HDL-C ($P < 0.001$) were substantially elevated in the okra group compared to the placebo group. We did not detect any considerable influence of okra on serum TG ($P = 0.923$) (Table 2).

4.2. Liver Function Enzymes

The okra group showed a decrease in the serum concentrations of AST ($P = 0.008$) and ALT ($P < 0.001$) compared to the placebo group. We did not detect any meaningful impact of okra on ALP serum levels ($P = 0.155$) (Table 3).

4.3. Renal Markers

We observed that treatment with okra substantially reduced UA ($P < 0.001$) relative to the placebo group. We did not detect any meaningful influence of okra consumption on Cr ($P = 0.555$) and BUN ($P = 0.877$) (Table 4).

5. Discussion

The current investigation suggests that the intake of okra for eight weeks could effectively improve TC, LDL-C, HDL-C, UA, ALT, and AST levels in pre-diabetic individuals. Okra did not reveal any remarkable impact on ALP, BUN, Cr, and TG.

Observational evidence illustrates the association of pre-diabetes with a high risk of developing overt T2DM and its related complications, such as nephropathies (17). Pre-diabetes presents a time window of opportunity that can be targeted to prevent or delay the progression of T2DM. Effective interventions for reversing pre-diabetes may prevent or delay further medical complications, like renal failure and cardiovascular diseases (18, 19). This calls for more research into novel, impressive therapies with fewer adverse effects. Herbal medicine can effectively be used as an alternative remedy for lowering diabetes-induced complications. As a result, several natural plants have received special attention due to their ameliorative effects against T2DM and pre-diabetes (10, 20).

Multiple pre-clinical studies have implied that okra could protect the pancreas, kidneys, and liver. For instance, Aleissa et al. described that okra consumption for 30 days had favorable effects on liver function markers and serum lipids in streptozotocin-induced diabetes in rat models (15). Another study on diabetic rats showed that an 8-week administration of okra powder could significantly lower serum lipids and improve renal function and liver index in T2DM rats (21). Nguekouo et al. also observed a substantial decline in the serum levels of TG, LDL-C, liver transaminases, Cr, and UA in T2DM rats treated with okra for 28 days (22).

Further, the anti-diabetic impact of okra has also been mentioned in several clinical trials. Saatchi et al. studied the anti-hyperglycemic effect of okra whole fruit on patients with T2DM. Their findings showed that fasting blood sugar and HbA1c were significantly lower in the okra group compared to the placebo group (23). In another study, Moradi et al. reported that 8 weeks of okra consumption led to a substantial reduction in serum TC, FPG, TG, homeostasis model assessment of insulin resistance (HOMA-IR), and LDL-C levels (24). Also, in a clinical trial on diabetic nephropathy patients, Nikpayam et al. found a significant reduction in energy intake and carbohydrate consumption after 10 weeks of okra supplementation (25). The effectiveness of okra in FPG and TC in individuals with T2DM was also reported by Haryati and Rahmawati in 2019 (26). According to the current study, there was an improvement in TC, LDL-C, HDL-C, UA, and liver transaminases following 8 weeks of okra administration. However, we did not observe any meaningful influence of okra on ALP, BUN, Cr, and TG, which could be due to the dosage of okra consumption.

Various mechanisms have been suggested for the impact of okra on glycemic regulation in patients with prediabetes or T2DM. Okra promotes the synthesis of hepatic glycogen and the regeneration of Langerhans'

Table 2. The Impact of Okra on Lipid Profiles [a]

Variables and Time Point	Okra Group	Placebo Group	P-Value	P-Value [b]
TG				0.923
Before	173.8 ± 53.4	146.3 ± 54.1	0.036 [c]	
After	168.3 ± 53.3	152.4 ± 60.2	0.934 [d]	
TC				< 0.001
Before	193.2 ± 26.8	184.8 ± 31.4	0.238 [d]	
After	177.80 ± 27.00	187.1 ± 31.2	0.191 [c]	
LDL-C				< 0.001
Before	115.1 ± 26.8	110.9 ± 32.7	0.556 [c]	
After	102.3 ± 26.6	110.7 ± 30.6	0.118 [d]	
HDL-C				< 0.001
Before	43.2 ± 5.6	44.51 ± 6.31	0.363 [c]	
After	45.8 ± 5.9	43.8 ± 5.5	0.144 [c]	

Abbreviations: HDL-C, high-density lipoprotein cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol.
[a] Values are expressed as mean ± SD.
[b] P-value was acquired by ANCOVA.
[c] P-value was acquired by an independent *t*-test.
[d] P-value was acquired by the Mann-Whitney U test.

Table 3. The Impact of Okra on Liver Function Tests [a]

Variables and Time Point	Okra Group	Placebo Group	P-Value	P-Value [b]
AST				0.008
Before	23.34 ± 8.70	21.26 ± 7.80	0.285 [c]	
After	20.3 ± 6.9	23.9 ± 11.0	0.132 [c]	
ALT				< 0.001
Before	26.3 ± 10.9	26.4 ± 10.8	0.919 [c]	
After	19.6 ± 8.8	28.40 ± 11.00	0.000 [c]	
ALP				0.155
Before	189.7 ± 52.8	187.0 ± 48.7	0.481 [c]	
After	199.3 ± 44.6	186.7 ± 46.4	0.978 [d]	

Abbreviations: HDL-C, high-density lipoprotein cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol.
[a] Values are expressed as mean ± SD.
[b] P-value was acquired by ANCOVA.
[c] P-value was acquired by the Mann-Whitney U test.
[d] P-value was acquired by an independent *t*-test.

islets. Another suggested mechanism is the suppression of the peroxisome proliferator-activated receptors (PPAR)-dependent pathway, which plays a significant role in lipid and glucose homeostasis (27, 28).

However, participants in our investigation observed no adverse effects associated with okra intake. Overall, this vegetable is a safe dietary component that is extensively used in cooking. Nevertheless, when co-administered with metformin, okra can interfere with metformin absorption. Therefore, interactions between herbs and pharmacological remedies should be considered when okra is used as an adjuvant therapy alongside common antidiabetic medications (29).

However, the current study has some limitations. First, the duration of this study was relatively short, and it is possible that eight weeks were insufficient to observe the full favorable impact of okra on certain parameters, such as kidney serum markers. Second, we were unable to examine all active constituents in different parts of okra separately. Hence, further research is recommended to determine the optimal dosage of okra required to achieve the most favorable results against pre-diabetes and T2DM.

Table 4. The Effect of Okra on Kidney-Related Markers [a]

Variables and Time Points	Okra Group	Placebo Group	P-Value	P-Value [b]
Cr				0.555
Before	0.83 ± 0.17	0.90 ± 0.15	0.041 [c]	
After	0.83 ± 0.15	0.90 ± 0.15	0.035 [c]	
BUN				0.877
Before	12.57 ± 4.00	14.49 ± 4.30	0.199 [c]	
After	12.31 ± 3.20	13.74 ± 4.30	0.119 [d]	
UA				< 0.001
Before	5.37 ± 1.10	4.87 ± 1.00	0.054 [d]	
After	4.81 ± 1.00	4.93 ± 0.99	0.642 [d]	

Abbreviations: Cr, creatinine; BUN, blood urea nitrogen; UA, uric acid.
[a] Variables are presented as mean ± SD.
[b] P-value was acquired by ANCOVA.
[c] P-value was acquired by the Mann-Whitney U test.
[d] P-value was acquired by an independent *t*-test.

Although we made efforts to control the influence of potential confounders, there may still be other factors beyond our control that could have interfered with our findings.

In conclusion, the current investigation revealed that okra could improve serum levels of lipid profiles (TC, LDL-C, HDL-C), as well as liver transaminases and UA, among pre-diabetic individuals. Okra supplementation was found to be safe, with no reports of side effects in the current clinical trial. However, further investigations are needed to confirm the validity of our results.

Acknowledgments

The data of this article were derived from MR's Ph.D. thesis.

Footnotes

Authors' Contribution: MR. A. contributed to the data collection and writing the first draft of the manuscript. AR. M. contributed to the study conception and advised the project. M. SJ. contributed to the manuscript's methodology, review, and editing. S. Gh. contributed to preparing okra and placebo capsules and reviewing the edited manuscript. S. E. contributed as a nutritional consultant and reviewed and edited the manuscript. N. B. contributed to data analysis, review, and manuscript editing. SM. J. contributed to the study conception and design, project supervision, and manuscript review and editing.

Clinical Trial Registration Code: IRCT20201026049154N1.

Conflict of Interests: The authors declared that they have no conflicts of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: The study design was confirmed by the Ethics Committee of Golestan University of Medical Sciences, Gorgan, Iran (IR.GOUMS.REC.1399.229).

Funding/Support: This study was funded by a grant from the Golestan University of Medical Sciences (grant number: 111265).

Informed Consent: An informed consent form was signed by each participant.

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