Effects of sprouted fenugreek seeds on blood glucose level in type 2 diabetic patients with/without hepatitis C virus

***Adel AA Badr[1]; Abdel-Naser AA Gadallah[2]; Mohammed ZA Nooh[2]; Alia AF Atia[3] and Maymona AE El-Khlefa[3]**

1. Department of Nutrition, Menoufia University Hospitals.
2. Department of Internal Medicine, Faculty of Medicine, Menoufia University.
3. Therapeutic Nutrition Department, National Liver Institute, Menoufia University.

*** Corresponding author:** Adel AA Badr, Email: dr.badr2001@gmail.com - Mobil: +201271425995

ABSTRACT:

Trigonella foenum-graecum, the plant that is commonly recognized for fenugreek, has antibacterial, antinociceptive, and hypocholesterolemia benefits. Thus, the purpose of the current research was to form an opinion of the outcome of sprouted fenugreek seeds on glycosylated hemoglobin (HbA1C) and blood glucose levels (BGLs) in those with type 2 diabetes (T2D) with and without viral hepatitis C (HCV). Three categories were randomly assigned from among ninety male and female T2DPs who had been diagnosed for toward minimum of six months and were receiving insulin and oral medication treatment: group 1 (control), category 2 (T2D with HCV), and denomination 3 (T2D without HCV). After the second month, group 2's fast blood sugar (FBS) values were substantially dropped according to statistical analysis (P = 0.0485) and the 3rd month (P = 0.0207). Following the third month, Group 3's FBS concentrations substantially dropped (P = 0.0362). However, HbA1C values significantly reduced in both set 2 (P = 0.0252) and collection3 (P = 0.0481) after the 3rd month. In diabetics with hepatitis C, sprouted fenugreek seeds substantially reduced FBS levels, but there was no discernible difference in FBS and HbA1C levels between the two groups. Body mass index (BMI) values decreased in all groups throughout the study, although the changes were not statistically significant. In conclusion, individuals with Type 2 diabetes, whether or not they have HCV, may benefit from adding sprouted fenugreek seeds to their treatment program in addition to meal modification and physical activity.

Keywords: *Fenugreek seeds, T2DPs, Hepatitis C virus, FBS, HbA1c*

INTRODUCTION:

Type 2 diabetes mellitus (T2DM) and hepatitis C virus (HCV) stand as significant global health challenges, imposing substantial health and economic burdens across the globe. T2DM and insulin reluctance (IR) are intimately associated with HCV, acknowledged as the leading cause of liver insufficiency globally **(Nizamuddin et al., 2023).**

The progression of diabetes can lead to complications in multiple organs over an extended period before receiving adequate treatment. Insulin amounts and performance are dysregulated as part of the pathophysiology of T2DM **(Solis-Herrera and Collogues 2015).** Insulin secretion and tissue responsiveness to insulin are essential for maintaining the body's glucose homeostasis. Insulin administration is necessary for cellular uptake of glucose because it causes glucose transporter-4 (GLUT-4) to relocate to the plasma membrane. Insulin resistance prevents muscle and sebaceous tissue from absorbing glucose into their cells, which impedes the removal of glucose **(Avalos-Soriano and Anthers, 2016).** Insulin promotes GLUT-4 translocation from an internal compartment to the cell wall, which increases cellular glucose uptake in individuals suffering from T2D **(Jaiswal et al., 2012).** The involvement of peroxisome proliferators activated receptor (PPAR), especially PPAR gamma, in lipid metabolism and adipogenesis is crucial in T2DM, **(Wafer et al., 2017).** According to **Sirsikar and Copartners (2016),** glycosylated hemoglobin is an important indicator of continued glycemic management.

In low-income countries, limited access to appropriate diabetes medications due to financial constraints is a prevailing issue **(Smith-Spangler and Others 2012).**

Fenugreek, the herb utilized both in culinary practices and as a cure for diabetes across various regions, including China, India, Egypt, and the Middle East, has garnered attention for its therapeutic properties **(Wang and Wylie-Rosett, 2018; Thadiyan and Else 2022).**

A member of the Fabaceae family, fenugreek is cultivated as an herb in Mediterranean Europe, Asia, and Africa. Its seeds are used in traditional medicine **(Petropoulos, 2002).**

According to **Suresh-kumar and Coworkers (2018),** the Food and Drug Authority (FDA) approved fenugreek for use by people. Fenugreek has been employed for centuries in Indian, Arabic, and Chinese traditional medicine for treating conditions such as colds, coughs, bronchitis, arthritis, and menstrual pain **(Younesy et al., 2014; Herrera and Workers, 2019).** Fenugreek seeds, which are high in phytochemicals, have health advantages **(Khlifi and Others 2016).** Additionally, they are a commercial source of diosgenin, a chemical that is used in the synthesis of steroids **(Bahmani and Fellow workers 2016).**

Among the beneficial elements of fenugreek that have been linked to hypoglycemic properties include soluble fiber, saponin, trigonelline, diosgenin, and 4-hydroxy isoleucine **(Neeraja and Rajyalakshmi, 2021; Sauvaire and Colleagues 2012; Lu and workmates 2018; Moorthy and Associates 2020; Debebe and Nguse, 2019)**, but its effectiveness in glycemic mana-gement is still unknown, particularly when it comes to T2DM with or without HCV.

Therefore, the goal of this search was to assess how fenugreek seed sprouting affected FBG and HbA1C levels in T2DM patients receiving insulin treatment, diet, exercise, oral hypoglycemic agents (OHAs) medications, or all four, with or without HCV.

Settings and Design:

A prospective, single-center randomized control experiment was used in this investigation.

SUBSTANCES AND PROCEDURES:

Plant Material:

Fresh *Trigonella foenum-graecum* seeds were procured from the district emporium in Shebeen El-Kom City, Egypt. Dr. K. A. Yosef, an expert in crops from Menoufia University, assessed the seeds' purity and quality.

Fenugreek Seed Soaking and Germination (SFS):

50g of fenugreek seeds were disinfected by keeping them for 15 minutes at room temperature in a 70% ethanol solution. After washing the seeds with tap water, they were immersed in distilled water (1:10 w/v) for 12 hours. Next, presoaked seeds were allowed to sprout for four days in the dark, on flat trays covered with aluminum foil. To prevent additional germination, sprouted seeds were refrigerated every day **(El-Shimi and Teammates, 1984; Chen, 2009).**

Study Design and Period:

Ninety T2DM patients who were seen in the outpatient department of Menoufia University Hospital participated in the prospective study. With their informed agreement, participants who had been diagnosed with low six months earlier and were using insulin or OHA medication were enlisted. Under the direction of Menoufia University Hospitals, with approval from the Institutional Review Board (IRB) Ethics Committee number (4-2023 INT M2), the three-month study was conducted.

Experimental Groups:

Participants in the study were 90 T2DM (56 females and 34 males) who had their height and weight measured to calculate their BMI. Measurements of FBS and data on the most recent HbA1C, a glycemic management sign, were also included in the assessments. Data were also collected regarding age, educational background, degree of physical activity, and diabetic drugs used. To ensure ideal matching in terms of gender, age, education, exercise habits, controlling their glycemic index, type of diabetes medication, and BMI, participants were randomly assigned into three groups.

The categorization of groups is delineated as follows:

Group 1 (Control/ normal Group): Comprising 30 diabetic patients utilizing anti-diabetic drugs, this group adhered to the standard treatment protocol, diet, and exercise for 3 months (90 days). Sprouted fenugreek seeds were excluded from their regimen during this period. Group 2

(Treatment group A): Consisting of 30 diabetic patients with HCV, this group followed the standard treatment protocol, diet, and exercise for the initial month (30 days). Subsequently, they were introduced to an additional regimen of 25g sprouted fenugreek seeds (SFS) administered orally twice daily before breakfast and before dinner for the subsequent 2 months (60 days). Group 3 (Treatment group B): Encompassing 30 diabetic patients without HCV, this group underwent the standard treatment protocol, diet, and exercise for the first month (30 days). Following this period, they were introduced to 25g sprouted fenugreek seeds (SFS) orally twice daily before breakfast and before dinner for the ensuing 2 months (60 days).

The dietary and physical activity parameters specified in the American Diabetic Association **(ADA, 2015)** protocols were strictly followed by all groups. First visits were used for the initial measurement (IM) of demographic profiles. Over the next three months, levels of HbA1C) and FBS were measured. The recommended daily dosage was for ingesting 50g of sprouted fenugreek seeds, which were to be split into two doses of 25g before breakfast and 25g before dinner.

Statistical Analysis:

The confounding variables' distribution was analyzed using the Chi-square test. Means of SD were subjected to ANOVA for a completely randomized design and means comparisons were estimated by the LSD procedure of SAS. A T-test between the 2 groups was utilized to reckon the P value, with significance declared at $p<0.05$ **(Steel and Fellow workers, 1997).**

RESULTS:

Seven participants were excluded due to personal reasons or loss to follow-up, leaving a total of 83 patients: 28 in Group 1, 29 in Group 2, and 26 in Group 3. The demographic distribution included 44 women and 39 men, with mean ages of 54.8±1.3, 56.4±1.6, and 55.1±1.4 for Groups 1, 2, and 3, respectively (Table 1).

Baseline characteristics across all groups, encompassing gender, physical activity levels, education, and therapeutic approaches, were evenly distributed with no significant changes during the study (Table 1).

BMI for all participants was computed both at the baseline (the trial's initiation) and at the conclusion (after three months), as detailed in **Table 2**. Calculations of BMI at baseline and three months later showed a trend toward decline in all groups, albeit not to the point of statistical significance (p=0.155). This observation is consistent with the rigorous food and exercise regimens followed during the experiment following ADA standards. Figure 1 visually compares BMI among all groups at both the trial's initiation and its conclusion. While the BMI scale is commonly utilized to assess an individual's nutritional status, determining whether they are overnourished or undernourished, it is acknowledged as imperfect in clinical practice **(Cook and Others 2005)**.

Table 3 delineates the mean ± SD (standard deviation) values of BGL, as indicated by the FBS and HbA1c test across all groups. Blood glucose measurements were obtained on four occasions for analysis: initially before the commencement of the experiment and subsequently every month for three months.

Table 4 illustrates the impact of sprouted fenugreek seeds (SFS) on BGL in patients with T2DM and HCV (group 2). The initial FBS level in group 2 was 164.22 ± 30.31, while in group 1, it was 163.11 ± 28.11, showing no expression of *P* amount (0.681) upon enrollment in the study. A comparable pattern was noted for HbA1C values, with a non-significant *P* value (0.570) at the study's commencement. Set 2 showed a trend toward lower glucose levels during the trial, as measured by monthly evaluations of FBS and HbA1C levels. However, this trend was statistically unimportant after one month (P = 0.108). FBS in category 2 was measured at the end of the second month at 128 ± 23.80, whereas it was 155.65 ± 24.84 in normal patients. When P = 0.0485, it indicates that a substantial variance between groups 1 and 2, was found. Nonetheless, there was not a significant disparity (P =

0.149) between the HbA1C values, which were 6.94 ± 2.35 in group 2 and 7.40 ± 2.79 in group non-treatment, respectively. Upon comparing data at the trial's conclusion (after three months), a statistically significant difference was evident in both FBS and HbA1C values, indicating variations in absolute and *P* values. Statistical appreciates exhibited FBS of 121.91 ± 21.25 in group 2 and 153.96 ± 22.37 in group 1 with *P* = 0.0207. HbA1C levels also displayed a similar trend after the third month, where the HbA1C of set 2 was 5.82 ± 1.98 and that of group 1 was 6.54 ± 2.72, showing *P* = 0.0252. These indicators are visually represented in Figures 2, 3, and 4.

The initial FBS level in set 3 was 158.34 ± 28.77, whereas, in group 1, it was 163.11 ± 28.11, displaying no significance *P* value was 0.506 upon enrollment in the study. A parallel pattern was observed for HbA1C values, with a non-significant (*P* = 0.783) at the study's commencement, as indicated in **Table 5**. Throughout the study duration, when monthly assessments of FBS and HbA1C levels were conducted, group 3 demonstrated a declining trend in BSL. However, statistically, it was not significant in the initial month and the second month *P* = (0.146) and (0.0815), respectively. At the end of the third month, FBS in group 3 measured 128.66 ± 23.84, whereas it was 153.96 ± 22.37 in the control group. A noteworthy difference emerged between groups 1 and 3 with *P* = 0.0362. A comparable trend in HbA1C values between categories 1 and 3 was observed, which was not significant in the initial month and the second month, with ***P*** values of (0.311) and (0.204), respectively. However, significance was achieved at the trial's conclusion with *P* = 0.0481. These indicators are visually represented in Figures 5, 6, 7, and 8.

Table 6 illustrates a comparative analysis between group 2 (DM with HCV) and treatment group B (DM without HCV) concerning the impact of sprouted fenugreek seeds on BGL, as indicated by the *P*-value. Although there was a gradual decrease in FBS values observed in group 2, surpassing the changes in group 3, the reduction was not statistically significant. The mean ± SD values for treatment group A were 164.22±30.31, 150.06±26.32, 128±23.80, and 121.91±21.25, while those for the third group were 158.34 ± 28.77, 151.46 ± 26.51, 133 ± 24.12, and 128.66 ± 23.84. Notably, the results for group 2 and the last set did not differ significantly, with corresponding P values of (0.543, 0.481, 0.216, and 0.185). The HbA1C levels showed a similar trend, with group 2 showing a slow decline that was not statistically notable. In group 2, the mean ± SD values were 7.6±3.09, 7.5±3.08, 7.26±2.61, and 6.07±1.93. In the third group, the mean ± SD values were 7.6±3.09, 7.4 ± 3.07, 6.94 ± 2.35, and 5.82 ± 1.98. Once more, group 2 and the third category did not differ significantly, with corresponding *P* values of (0.708, 0.563, 0.377, and 0.249). Visual representations of these metrics are elucidated in Figures 9 and 10.

DISCUSSION:

The outcomes of this investigation reveal that groups treated with sprouted fenugreek seeds, coupled with dietary guidelines, exhibited a noteworthy reduction in BGL, as evidenced by FBS and (HbA1c). Consequently, this approach demonstrated positive effects in the management of T2DM. The study conducted by **Verma and Collaborator Allies (2016)** corroborates these outcomes, focusing on T2DM patients. The research indicated a substantial decrease in FBG, with 83% of the *Fenfuro*-treated group (a proprietary product derived from Fenugreek seeds) experiencing lowered levels compared to a 62% decrease in the placebo category. The same trend was observed in postprandial plasma glucose levels, with ratios of 89% and 72%, respectively. Similar favorable results were also noted for HbA1c. Additionally, **Nayak and Bhakta's trial in 2005,** involving 38 diagnosed T2DM aged 30-45 years, suggested that the inclusion of fenugreek seeds, rich in fiber, ameliorated FBS levels in patients.

In a study led by **Roberts (2011),** it was uncovered that the hypoglycemic impact of fenugreek seeds is attributed to the rich components, particularly dietary fiber, comprising 45.4% (13.3% soluble and 32% insoluble) and galactose. Fiber creates a viscous solution that slows down or prevents the gastrointestinal tract from absorbing glucose, which lowers the body's postprandial BSL **(Gharib, 2016; Srinivasan, 2019).**

The levels of FBG and fiber intake among patients may vary based on some characteristics, including age groups, weight-to-height ratios, BMI, and basal metabolic rates. An influential study identified an inverse relationship between body length and the extent of glucose tolerance in patients. This suggests that BMI plays a crucial role in determining the scope of glucose tolerance, potentially influencing FBG as well as macro- and microvascular complications in individuals with diabetes **(Anderwald and workers, 2011; Janghorbani and Amini, 2018).**

The same interpretation was pictorial in a meta-analysis conducted by **Gong and Copartners (2016),** involving 12 randomized controlled trials to assess its overall impact on individuals with T2DM. Insufficient insulin or insulin resistance may lead to the evolution of T2DM. Weight reduction aids in decreasing insulin resistance, which, in turn, contributes to a reduction in random blood sugar levels. The study found that hyperglycemia is associated with insulin resistivity, emphasizing the importance of addressing this issue to control glucose levels **(Jackness et al., 2013; Klein and Coworkers 2019).**

Al-Rowais, (2002) when analysis of HbA1C serves to gauge the average glucose levels over the past three months, providing an overarching perspective on glucose status. The outcomes of the inquiry highlight considerably lower HbA1c levels among participants undergoing treatment with fenugreek seeds.in HbA1c levels among participants undergoing treatment with fenugreek seeds**.** The primary objective of this study was to assess the impact of fenugreek seeds in promoting insulin production while maintaining cellular and immune function. Concerns about potential hypoglycemic events may be heightened due to prior experiences with hypoglycemia. The use of medications can further complicate this situation.

It is emphasized that hypoglycemia can lead to lower target HbA1c values, particularly in patients who have not previously encountered hypoglycemic episodes. The study underscores the interconnected nature of glycemia risk and the target level of HbA1c. A reduction of 46% in the probability of achieving the target HbA1c level is associated with an increased risk of hypoglycemia by up to 17%. The finding that patients who reach goal HbA1c values are more vulnerable to the danger of hypoglycemia could aid in clarifying this association. Intensive insulin titration, however, may also increase the risk of hypoglycemia in those receiving it. To fully understand the intricate mechanisms behind the association between hypoglycemia and HbA1c, more research is necessary **(Li and others, 2014).** Numerous researchers have conducted evaluations of fenugreek's impact on blood glucose control, with a majority demonstrating significant improvements in diabetes management, particularly in terms of FBS rates **(Gupta et al., 2011; Raghuram and Colleagues, 2023).** These studies have delved into various mechanisms, offering a comprehensive understanding of fenugreek's effects. Scientific investigations have revealed that the amino acid 4-hydroxy isoleucine (4-OH Ile) in fenugreek seeds enhances glucose-induced insulin release in human and rat pancreatic islet cells in vitro **(Sauvaire and Another 2017).**

Additionally, other researchers have shown that fenugreek seed extract phosphorylates particular proteins in 3T3-L1 adipocytes and human hepatoma cells (HepG2), including the insulin receptor, insulin receptor substrate 1, and the p85 subunit of PI3-K **(Vijayakumar and Colleagues 2022)**. One prominent free amino acid that is a major active component influencing blood glucose regulation is 4-OH Ile **(Flammang and Teammates 2021).** Addressing the challenge of T2D involves stimulating insulin production and enhancing its action in metabolizing glucose.

To further meet the body's needs, a healthy lifestyle and eating an adequate meal full of vital nutrients are needed. Since obesity is a major factor in the appearance of T2D, the best way to manage it is to consume fewer sweets and sweetened beverages and engage in physical activity to reach and maintain a healthy weight.

The limitations of prior research may arise from the impact of variations in diet and exercise on blood sugar levels, making it challenging to attribute the reduction solely to the studied herb (sprouted fenugreek seeds). These uncontrolled factors can introduce bias into the results. In contrast, the current study excels in addressing this issue. Researchers rigorously regulated the dietary and exercise patterns of participants, leveraging specific guidelines outlined by **ADA, (2015).** This careful monitoring implies that the observed variations in HbA1C and sugar levels can be ascribed to the herb under study as secondary effects, offering a stronger basis for conclusions.

CONCLUSION:

In summary, this investigation establishes that the hypoglycemic impact of sprouted fenugreek seeds on T2D patients, irrespective of their hepatitis C virus status, surpasses the benefits derived from dietary regimes and physical activity alone. The findings suggest that incorporating sprouted fenugreek seeds into the treatment regimen holds promise as an adjunctive therapeutic option for diabetes management, com-plementing conventional appro-aches such as nutrition, exercise, and medication therapy. This integration may potentially reduce the dependence on pharmaceutical interventions, enhance blood glucose parameters, and contribute to effective diabetes control. As a result, it emerges as a promising supportive measure in averting long-term morbidity associated with diabetes.

REFERENCES

Al-Rowais NA (2002): Herbal medicine in the treatment of diabetes mellitus. *Saudi Medical Journal*, 23(11), 1327-1331.

American Diabetes Association (ADA) (2015):
Standards of medical care in diabetes. *Diabetes Care,* 38: S1–94.

Anderwald C; Gastaldelli A; Tura A; Krebs M; Promintzer-Schifferl M; Kautzky-Willer A; Stadler M; DeFronzo RA; Pacini G and Bischof MG (2011):
Mechanism and effects of glucose absorption during an oral glucose tolerance test among females and males. *The Journal of Clinical Endocrinology and Metabolism,* 96 (2), 515-524.

Avalos-Soriano A; Cruz-Cordero RD; Rosado JL and GarciaGasca T (2016):
4-Hydroxyisoleucine from fenugreek *(Trigonella foenum-graecum):* Effects on insulin resistance associated with obesity. *Molecules*, 21:15-26.

Bahmani M; Shirzad H; Mirhosseini M; Mesripour A and Rafieian-Kopaei M. (2016):
A review on ethnobotanical and therapeutic uses of fenugreek (Trigonella foenum graceum L). *J Evid. Based Complementary Altern. Med;* 21: 53-62.

Chen LH (2009):
Germination of seeds for human consumption *J Food Sci*, 87:193–197.

Cook Z; Kirk S; Lawrenson S and Sandford S (2005):
Use of BMI in the assessment of undernutrition in older subjects: reflecting on practice. *The Proceedings of the Nutrition Society*, 64(3), 313-317.

Debebe YG and Nguse NA (2019):
Antidiabetic Effect of Fenugreek Seed Powder Solution (Trigonella foenum-graecum L.) on Hyperlipidemia in Diabetic Patients. *Journal of Diabetes Research,* vol. 8, Article ID 8507453,

El-Shimi NM; Damir AA and Ragab M (1984):
Changes in some nutrients of fenugreek seeds during germination. *Food Chemistry,* Vol. 14, Issue 1, Pages 11-19.

Flammang AM; Cifone MA; Erexson GL and Stankowski LF (2021):
Genotoxicity testing of a fenugreek extract. *Food Chem Toxicol*, 132: 669–675.

Gharib MA (2016):
Glycemic reaction of glimepiride combined with popular Egyptian anti-diabetic drinks of fenugreek and coffee in diabetic rats. *Pakistan Journal of Nutrition,* 15(2), 194-202.

Gong J; Fang K; Dong H; Wang D; Hu M and Lu F (2016):
Effect of fenugreek on hyperglycemia and hyperlipidemia in diabetes and Prediabetes: a meta-analysis. *Journal of Ethnopharmacology*, 194, 260-268.

Gupta A; Gupta R and Lal B (2011):
Effect of Trigonella foenum-graecum (fenugreek) seeds on glycemic control and insulin resistance in type 2 diabetes mellitus: A double-blind placebo-controlled study. *J ASSOC Physicians India,* 49:1057–1061.

Herrera T; Hierro JND; Fornari T; Reglero G and Martin D (2019):
Inhibitory effect of quinoa and fenugreek extracts on pancreatic lipase and α-amylase under in vitro traditional conditions or intestinal simulated conditions. *Food Chem*; 270: 509-517.

Jackness C; Karmally W; Febres G; Conwell IM; Ahmed L; Bessler M; McMahon DJ and Korner J (2013):
A very low-calorie diet mimics the early beneficial effect of Roux-en-Y gastric bypass on insulin sensitivity and β-cell function in type 2 diabetic patients. *Diabetes,* 62(9), 3027-3032.

Jaiswal N; Maurya CK; Venkateswarlu K; Sukanya P; Srivastava AK and Narender T (2012):
4-Hydroxyisoleucine stimulates glucose uptake by increasing surface GLUT4 levels in skeletal muscle cells via phosphatidylinositol-3-kinase-dependent pathway. *Eur. J Nutr*; 51:893-898.

Janghorbani, M and Amini M (2018):

Effects of gender and height on the oral glucose tolerance test: the Isfahan diabetes prevention study. The Review of Diabetic Studies; *RDS*, 5(3), 163-170.

Khlifi S; Jemaa HB; Hmad HB; Abaza H; Karmous I and Abid A. (2016):
Antioxidant, anti-diabetic, and antihyperlipidemic effects of *Trigonella foenum-graecum* seeds. *Inter. J Pharmacol*; 12: 394-400.

Klein P; Tyrlikova I; Pirolli N; Barber A; Tyrlik M and Goldman L (2019):
A pilot study of "classic" 3:1 ketogenic diet complete meal replacement treatment of obesity-related type 2 diabetes. *Journal of Obesity and Chronic Diseases,* 3(01), 19-27.

Li L; Shen J; Bala MM; Busse JW; Ebrahim S; Vandvik PO; Rios LP; Malaga G; Wong E; Sohani Z; Guyatt GH and Sun X (2014):
Incretion treatment and risk of pancreatitis in patients with type 2 diabetes mellitus: systematic review and meta-analysis of randomized and non-randomized studies. *BMJ*, 348(2), 53 - 66.

Lu F; Shen L; Qin Y; Gao L; Li H and Dai Y (2018):
Clinical observation on Trigonella Foenum-graecum L. total Saponins in combination with sulfonylureas in the treatment of type 2 diabetes mellitus. *Chin J Integr Med*, 14:56–60.

Mathern JR; Raatz SK; Thomas W and Slavin JL (2019):
Effect of fenugreek fiber on satiety, blood glucose and insulin response and energy intake in obese subjects. *Phytother Res*, 13:154–159.

Moorthy R; Prabhu KM and Murthy PS (2020):
Anti-hyperglycemic compound (GII) from fenugreek (*Trigonella foenum-graecum Linn*) seeds, its purification, and effect in diabetes mellitus. *Indian J Exp Biol*, 48:1111–1118.

Nayak S and Bhaktha G (2005):
Relationship between sialic acid and metabolic variables in Indian type 2 diabetic patients. *Lipids in Health and Disease,* 4(1), 15.

Neeraja A and Rajyalakshmi P (2021):
Hypoglycemic effect of processed fenugreek seeds in humans. *J Food Sci Technol*, 33:427–430.

Nizamuddin; Ghaffar T; Kanwal S; Jan B; Aamir M; Haq T; Rahman A and Ali M (2023):
Frequency of diabetes mellitus in patients with chronic Hepatitis C Infection: *Pakistan Journal of Health Sciences*, 4(05), 69–72.

Petropoulos GA (2002):
Fenugreek: the genus Trigonella (Medicinal and aromatic plants – industrial profiles) ISBN 0-415-29657-9 (hbk.) 1. Fenugreek. I. Petropoulos, George A. II. Series. SB317.F44 F45 2002 633.88—dc21 British Library of Congress Cataloging in Publication Data.

Raghuram TC; Sharma RD; Sivakumar B and Sahay BK (2023):
Effect of fenugreek seeds on intravenous glucose disposition in non-insulin-dependent diabetic patients. *Phytother Res*, 72:83–86.

Roberts KT (2011):
The potential of fenugreek (*Trigonella foenum-graecum*) as a functional food and nutraceutical and its effects on glycemia and lipidemia. *Journal of Medicinal Food,* 14(12), 1485-1489.

Sauvaire Y; Baissac Y; Leconte O; Petit P and Ribes G (2012):
Steroid saponins from fenugreek and some of their biological properties. *Adv Exp Med Biol*, 405:37–46.

Sauvaire Y; Petit P; Broca C; Manteghetti M; Baissac Y and Fernandez-Alvarez J (2017):
4-hydroxyisoleucine: A novel amino acid potentiator of insulin secretion. *Diabetes*, 139: 226–230.

Sirsikar M; Supriya MS and Pinnelli VBK (2016):
Role of glycosylated hemoglobin (HbA1c) as a dual marker to predict glycemic status and dyslipidemia in type II diabetes mellitus. *Int. J Res. Medical Sci*; 36: 124-129.

Smith-Spangler CM; Bhattacharya J and Goldhaber-Fiebert JD (2012):
Diabetes, its treatment, and catastrophic medical spending in 35 developing countries. *Diabetes Care*, 35:319–326.

Solis-Herrera C; Triplitt C; Reasner C; De Fronzo RA and Cersosimo E (2015):
Classification of Diabetes Mellitus. Book from MD Text.com, Inc., South Dartmouth (MA), 24 Apr; *PMID*: 25905343

Steel R; Torrie J and Dickey DJI (1997):
Principals and procedures of statistics: a biometrical approach (3rd Ed.). New York: McGraw Hill.

Sureshkumar D; Begum S; Johannah NM; Maliakel B and Krishnakumar IM (2018):
Toxicological evaluation of a saponin-rich standardized extract of fenugreek seeds : Acute, sub-chronic and genotoxicity studies. *Toxicol. Rep*; 5: 1060- 1068.

Thadiyan PI; Varughese G and Palpu P (2022):
History of Research on Medicinal Plants in India: *Medicinal and Aromatic Plants of India* Vol. 1 pp 35–61

Verma N; Usman K; Patel N; Jain A; Dhakre S; Swaroop A; Bagchi M; Kumar P; Preuss HG and Bagchi D (2016):
A multicenter clinical study to determine the efficacy of a novel fenugreek seed (*Trigonella foenum-graecum*) extract (*Fenfuro* ™) in patients with type 2 diabetes. *Food & Nutrition Research,* 60 (1), 32382.

Vijayakumar MV; Singh S; Chhipa RR and Bhat MK (2022):
The hypoglycemic activity of fenugreek seed extract is mediated through the stimulation of an insulin signaling pathway. *Br J Pharmacol*, 286: 61–68.

Wafer R; Tandon P and Minchin JEN (2017):
The role of peroxisome proliferator-activated rece-ptor gamma (PPARG) in adipogenesis: applying knowledge from the fish aquaculture industry to

biomedical research. *Front. Endocrinology* (Lausanne); 8:102.

Wang E and Wylie-Rosett J (2018):
Review of selected Chinese herbal medicines in the treatment of type 2 diabetes. *Diabetes Educ*, 34:645–654.

Younesy S; Amiraliakbari S; Esmaeili S; Alavimajd H and Nouraei S (2014):
Effects of fenugreek seed on the severity and systemic symptoms of dysmenorrheal. *J Reprod. Infertil*; 15: 41-48.

Table 1: Distribution of demographic and health-related variables between the control group and the experimental groups.

Variable	Group1 (control) (N=28)	Group2-SFS (DM+HCV) (N=29)	Group3-SFS (DM only) (N=26)	(P) Value
Gender: n (%)				
Males	13 (46 %)	14 (48%)	12 (46%)	(0.24)
Females	15 (54%)	15 (52%)	14 (54%)	(0.24)
Age (Mean years ± S.E*)	54.8±1.3	56.4±1.6	55.1±1.4	(0.58)
Education: n (%)				
Illiterate	7 (24%)	11 (38 %)	8 (31 %)	(0.21)
High school	12 (44%)	13 (45%)	11 (42%)	(1.00)
College degree	9 (32%)	5 (17%)	7 (27%)	(0.17)
Physical Activity: n (%)				
Active (leisure physical activity)	6 (21%)	3 (10%)	6 (23%)	(0.20)
Sedentary (activities of typical day-to-day life)	22 (79%)	26 (90%)	20 (77%)	(0.20)
BMI: n (%)				
Underweight (<18.5)	0 (0%)	1 (3%)	0 (0%)	(0.60)
Normal (18.5-24.9)	4 (14%)	6 (21%)	5 (19%)	(0.18)
Overweight (25-29.9)	18(64%)	17 (59%)	12 (46%)	(0.67)
Obese (≥ 30)	6 (22%)	5 (17%)	9 (35%)	(0.19)
Medication: n (%)				
Insulin	12 (40%)	11 (39%)	10 (38%)	(0.85)
Oral hypoglycemic drugs	13 (48%)	16 (54%)	15 (58%)	(0.27)
Combination therapy	3 (12%)	2 (7%)	1 (4%)	(0.13)
Glycemic control [50]				
Fair control (HbA1C ≤8)	16 (58%)	17 (59%)	17 (64%)	(0.80)
Poor (HbA1C >8)	12(42%)	12 (41%)	9 (36%)	(0.56)

***S.E**. = standard error **SFS** = sprouted fenugreek seeds

Table 2: The comparison of body mass index between all groups at the initial and the finish of the period

Study parameters	Group1 (control)	Group2-SFS (DM+HCV)	Group3-SFS (DM only)	P value
BMI (kg/m^2) Initial	29.38 ± 4.59	29.31 ± 4.90	30.06 ± 4.89	0.155
BMI (kg/m^2) End	27.16 ± 3.92	27.67 ± 3.96	27.94 ± 4.01	

BMI= Body mass index, Values of mean ± SD (standard deviation), P-values were calculated by t-test, SFS = sprouted fenugreek seeds

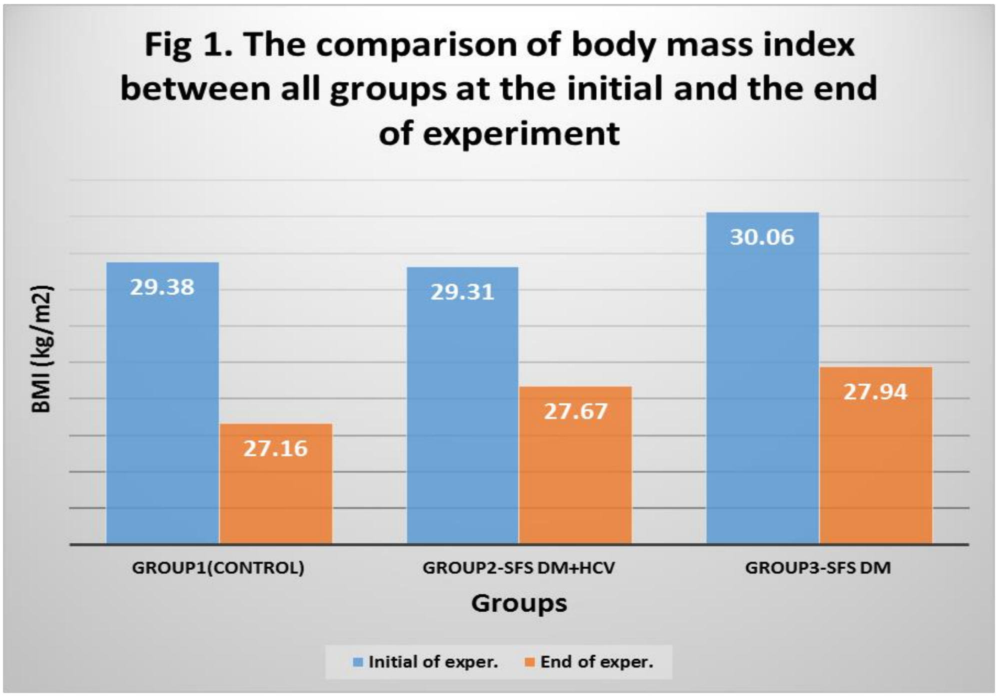


Table 3: BGL values represented in FBS (mg/dl) **and HbA1c** (%) **in all groups**

Study parameters	Group1 (control)	Group2-SFS (DM+HCV)	Group3-SFS (DM only)
FBS (mg/dl) (IM)	163.11 ±28.11	164.22 ±30.31	158.34 ±28.77
HbA1c (%) (IM)	7.6 ±3.11	7.5 ±3.54	7.6 ±3.09
FBS (mg/dl) (M1)	156.11 ±26.72	150.06 ±26.32	151.46 ±26.51
HbA1c (%) (M1)	7.8 ±3.09	7.4 ±3.07	7. 5±3.08
FBS (mg/dl) (M2)	155.65 ±24.84	128 ±23.80	133 ±24.12
HbA1c (%) (M2)	7.4 ±2.79	6.94 ±2.35	7.26 ±2.61
FBS (mg/dl) (M3)	153.96 ±22.37	121.91 ±21.25	128.66 ±23.84
HbA1c (%) (M3)	6.54 ±2.72	5.82 ±1.98	6.07 ±1.93

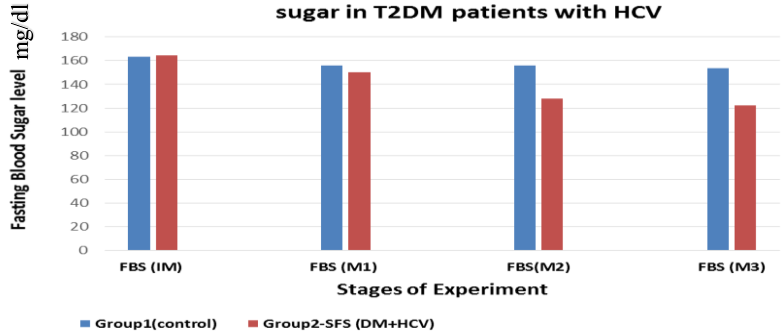
SFS: sprouted fenugreek seeds, FBS: Fasting blood sugar level, HbA1 c: Glycosylated hemoglobin level, (IM): Initial Measurement before starting the experiment, M1: First month, M2: Second month, M3: Third month. Values of mean ± SD (standard deviation).

Table 4: Effect of sprouted fenugreek seeds on BGL (mg/dl) in T2DM patients with HCV

Study parameters	Group1 (control)	Group2-SFS (DM+HCV)	P value
FBS (mg/dl) (IM)	163.11 ±28.11	164.2 2±30.31	0.681
HbA1c (%) (IM)	7.6 ±3.11	7.5 ±3.54	0.570
FBS (mg/dl) (M1)	156.11 ±26.72	150.06 ±26.32	0.108
HbA1c (%) (M1)	7.8 ±3.09	7.4 ±3.07	0.233
FBS (mg/dl) (M2)	155.65 ±24.84	128.0 ±23.80	0.0485*
HbA1c (%) (M2)	7.4 ±2.79	6.94 ±2.35	0.149
FBS (mg/dl) (M3)	153.96 ±22.37	121.91 ±21.25	0.0207*
HbA1c (%) (M3)	6.54 ±2.72	5.82 ±1.98	0.0252*

SFS: sprouted fenugreek seeds, FBS: Fasting blood sugar level, HbA1 c: Glycosylated hemoglobin level, (IM): Initial Measurement before starting the experiment, M1: First month, M2: Second month, M3: Third month. Values of mean ± SD (standard deviation).
** Significant differences (P-Value ≤0.05)*

Fig. 2. Effect of sprouted fenugreek seeds on fasting blood sugar in T2DM patients with HCV



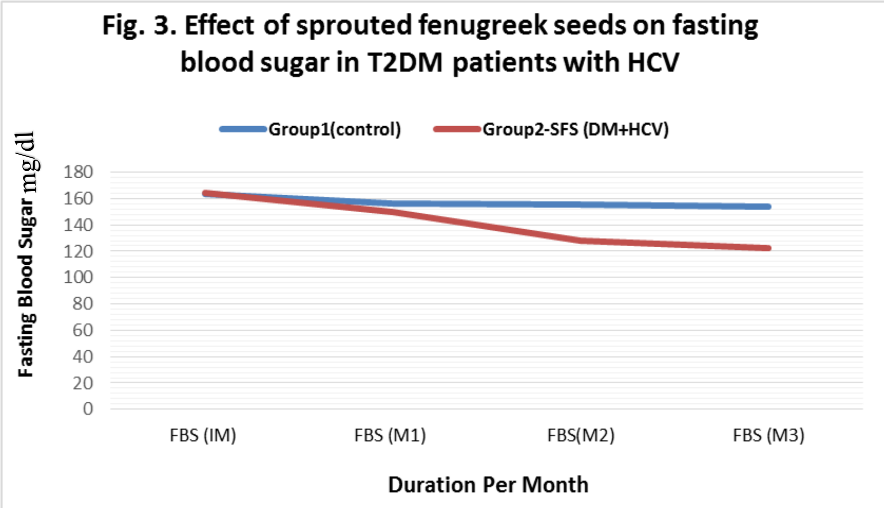


Fig. 3. Effect of sprouted fenugreek seeds on fasting blood sugar in T2DM patients with HCV
Group1(control)
Group2-SFS (DM+HCV)
Fasting Blood Sugar mg/dl
180
160
140
120
100
80
60
40
20
0
FBS (IM)
FBS (M1)
FBS(M2)
FBS (M3)
Duration Per Month

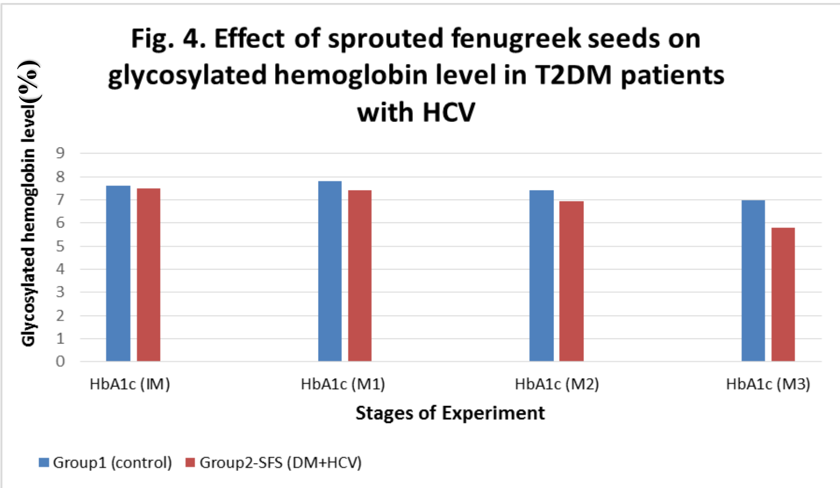


Fig. 4. Effect of sprouted fenugreek seeds on glycosylated hemoglobin level in T2DM patients with HCV
Glycosylated hemoglobin level(%)
9
8
7
6
5
4
3
2
1
0
HbA1c (IM)
HbA1c (M1)
HbA1c (M2)
HbA1c (M3)
Stages of Experiment
Group1 (control)
Group2-SFS (DM+HCV)

Table 5: Effect of sprouted fenugreek seeds on blood glucose level in T2DM patients without HCV

Study parameters	Group1 (control)	Group3-SFS (DM only)	P value
FBS (mg/dl) (IM)	163.11 ±28.11	158.34 ±28.77	0.506
HbA1c (%) (IM)	7.6 ±3.11	7.6 ±3.09	0.783
FBS (mg/dl) (M1)	156.11 ±26.72	151.46 ±26.51	0.146
HbA1c (%) (M1)	7.8±3.09	7.5 ±3.08	0.311
FBS (mg/dl) (M2)	155.65 ±24.84	133.0 ±24.12	0.0815
HbA1c (%) (M2)	7.4 ±2.79	7.26 ±2.61	0.204
FBS (mg/dl) (M3)	153.96 ±22.37	128.66 ±23.84	0.0362*
HbA1c (%) (M3)	6.54 ±2.72	6.07 ±1.93	0.0481*

SFS: sprouted fenugreek seeds, FBS: Fasting blood sugar level, HbA1 c: Glycosylated hemoglobin level, (IM): Initial Measurement before starting the experiment, M1: First month, M2: Second month, M3: Third month. Values of mean ± SD (standard deviation).
** Significant differences (P-Value ≤0.05)*

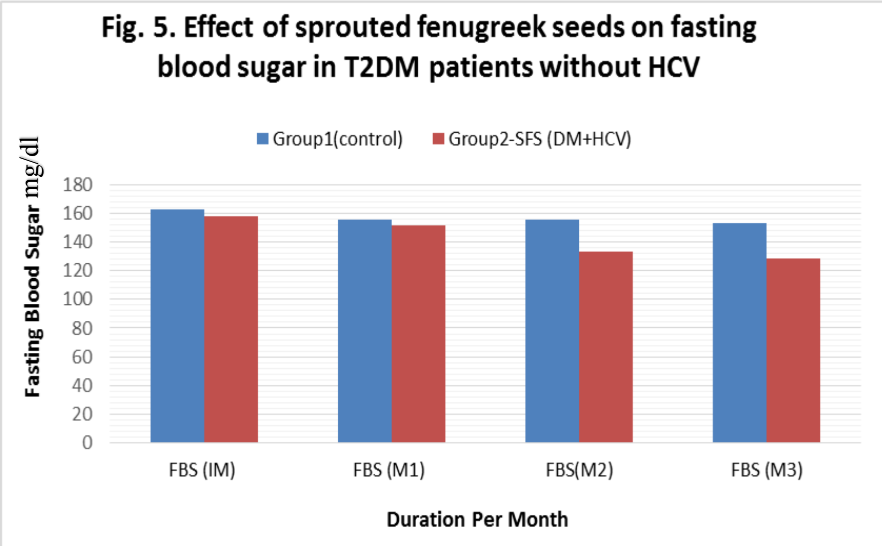


Fig. 5. Effect of sprouted fenugreek seeds on fasting blood sugar in T2DM patients without HCV
Group1(control)
Group2-SFS (DM+HCV)
Fasting Blood Sugar mg/dl
180
160
140
120
100
80
60
40
20
0
FBS (IM)
FBS (M1)
FBS(M2)
FBS (M3)
Duration Per Month

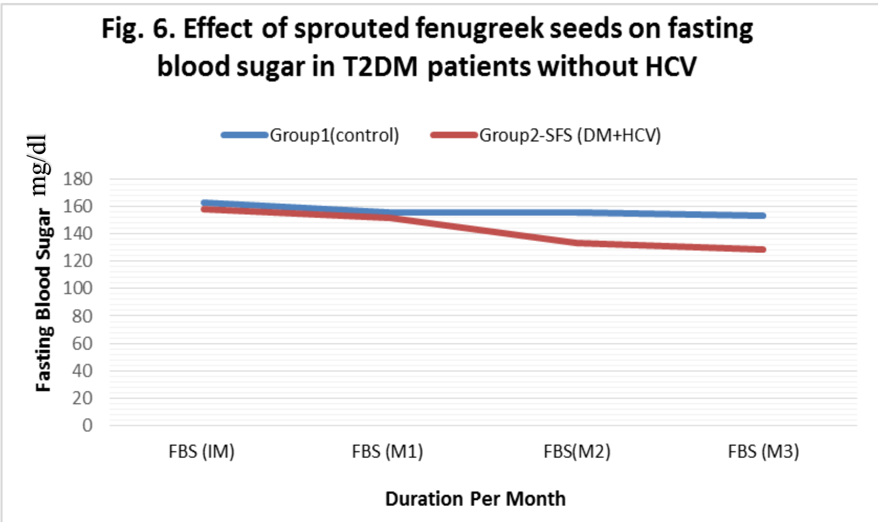


Fig. 6. Effect of sprouted fenugreek seeds on fasting blood sugar in T2DM patients without HCV
Group1(control)
Group2-SFS (DM+HCV)
Fasting Blood Sugar mg/dl
180
160
140
120
100
80
60
40
20
0
FBS (IM)
FBS (M1)
FBS(M2)
FBS (M3)
Duration Per Month

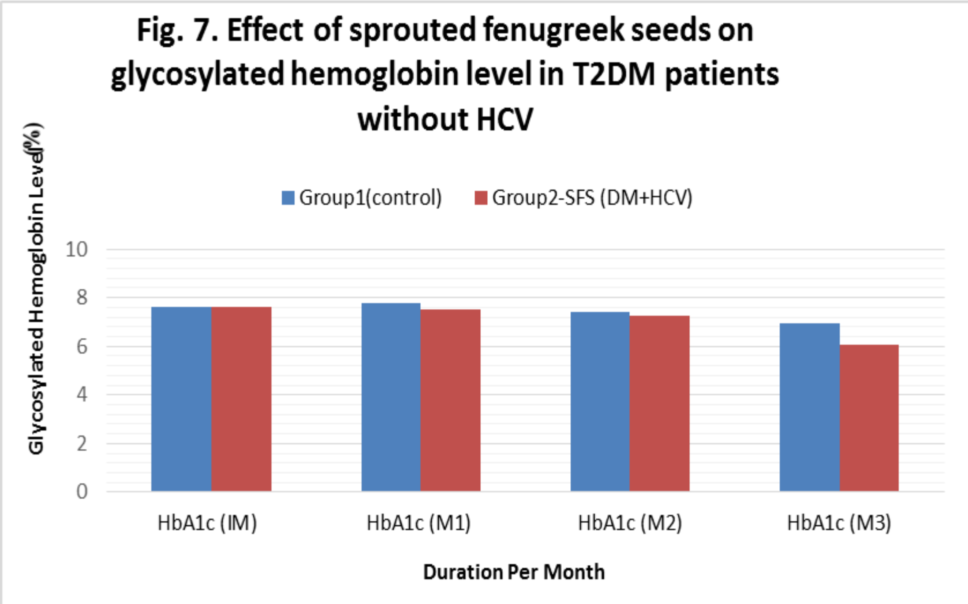


Fig. 7. Effect of sprouted fenugreek seeds on glycosylated hemoglobin level in T2DM patients without HCV
Group1(control)
Group2-SFS (DM+HCV)
Glycosylated Hemoglobin Level(%)
10
8
6
4
2
0
HbA1c (IM)
HbA1c (M1)
HbA1c (M2)
HbA1c (M3)
Duration Per Month

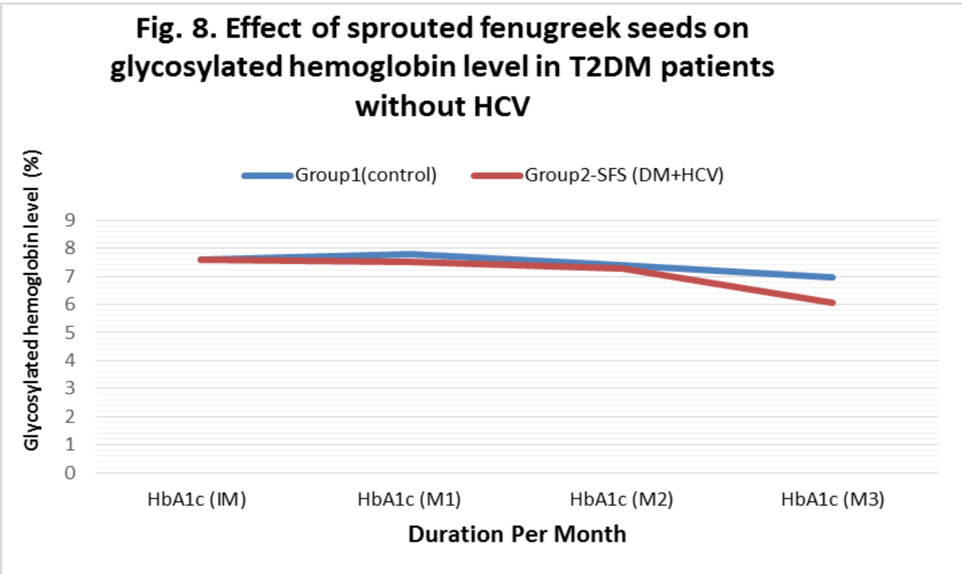


Fig. 8. Effect of sprouted fenugreek seeds on glycosylated hemoglobin level in T2DM patients without HCV
Group1(control)
Group2-SFS (DM+HCV)
Glycosylated hemoglobin level (%)
9
8
7
6
5
4
3
2
1
0
HbA1c (IM)
HbA1c (M1)
HbA1c (M2)
HbA1c (M3)
Duration Per Month

Table 6: Comparison of the effect of SFS on BGLs between (group 2 and group 3) using P- value

Study parameters	Group2-SFS (DM+HCV)	Group3-SFS (DM only)	P value
FBS (mg/dl) (IM)	164.22 ±30.31	158.34 ±28.77	0.543
HbA1c (%) (IM)	7.5 ±3.54	7.6 ±3.09	0.708
FBS (mg/dl) (M1)	150.06 ±26.32	151.46 ±26.51	0.481
HbA1c (%) (M1)	7.4 ±3.07	7.5 ±3.08	0.563
FBS (mg/dl) (M2)	128.0 ±23.80	133.0 ±24.12	0.216
HbA1c (%) (M2)	6.94 ±2.35	7.26 ±2.61	0.377
FBS (mg/dl) (M3)	121.91 ±21.25	128.66 ±23.84	0.185
HbA1c (%) (M3)	5.82 ±1.98	6.07 ±1.93	0.249

SFS: sprouted fenugreek seeds, FBS: Fasting blood sugar level, HbA1 c: Glycosylated hemoglobin level, (IM): Initial Measurement before starting the experiment, M1: First month, M2: Second month, M3: Third month. Values of mean ± SD (standard deviation).
** Significant differences (P-Value ≤0.05)*

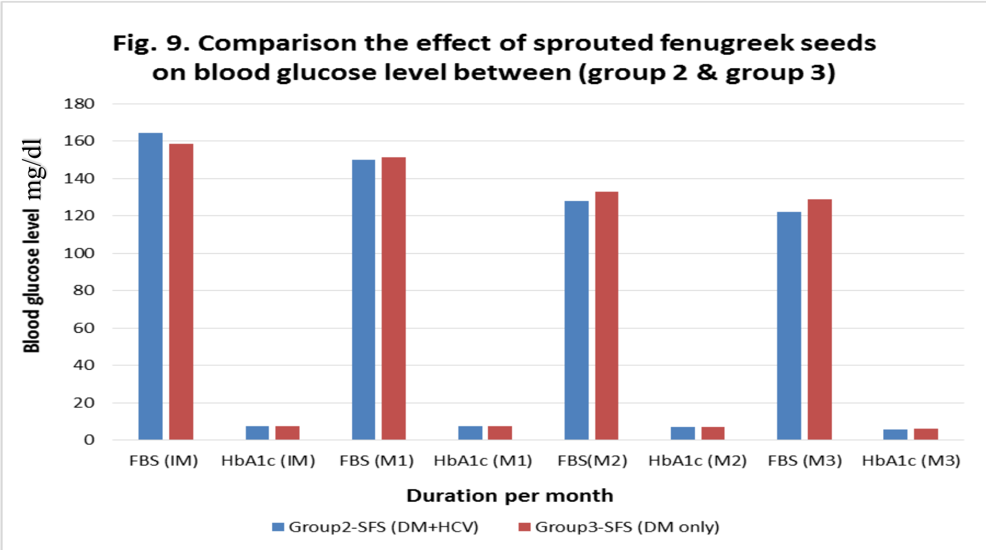


Fig. 9. Comparison the effect of sprouted fenugreek seeds on blood glucose level between (group 2 & group 3)
Blood glucose level mg/dl
180
160
140
120
100
80
60
40
20
0
FBS (IM)
HbA1c (IM)
FBS (M1)
HbA1c (M1)
FBS(M2)
HbA1c (M2)
FBS (M3)
HbA1c (M3)
Duration per month
Group2-SFS (DM+HCV)
Group3-SFS (DM only)

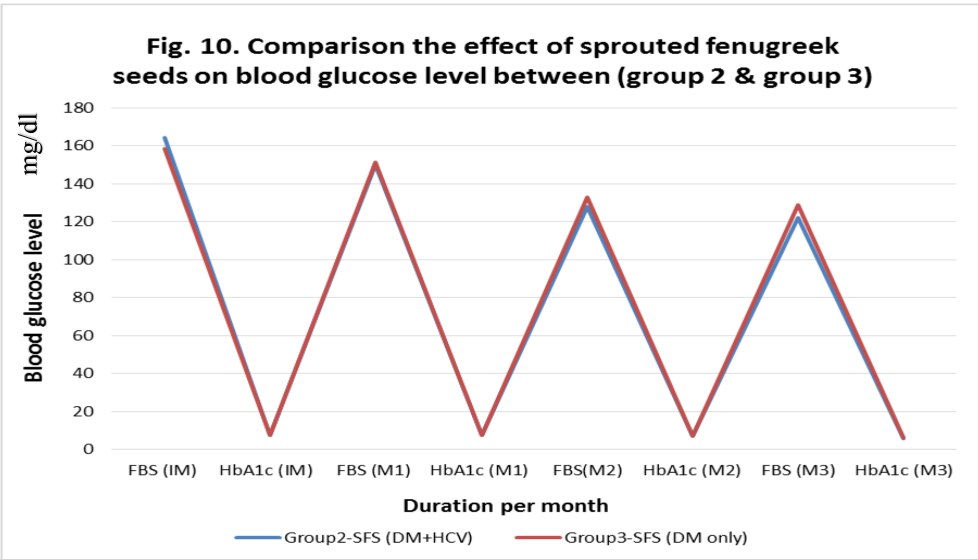


Fig. 10. Comparison the effect of sprouted fenugreek seeds on blood glucose level between (group 2 & group 3)
mg/dl
Blood glucose level
180
160
140
120
100
80
60
40
20
0
FBS (IM)
HbA1c (IM)
FBS (M1)
HbA1c (M1)
FBS(M2)
HbA1c (M2)
FBS (M3)
HbA1c (M3)
Duration per month
Group2-SFS (DM+HCV)
Group3-SFS (DM only)

تأثير براعم بذور الحلبة المنبتة على مستوى السكر في الدم لدى مرضى السكري من النوع الثاني المصابين بفيروس التهاب الكبد الوبائي (ج) وغير المصابين به

عادل عبدالرسول عبدالوهاب بدر1 ، عبدالناصر عبدالعاطي عبدالرحمن جاد الله 2 ، محمد زكريا أحمد نوح 2 ، عليه عاطف فتح الله عطيه 3 ، ميمونه عبدالواحد محمد الخليفه 3

1. قسم التغذية - مستشفيات جامعة المنوفية.
2. قسم الطب الباطني- كلية الطب- جامعة المنوفية.
3. قسم التغذية العلاجية. معهد الكبد القومي – جامعة المنوفية.

الملخــص العربـــــي :

تتمتع الحلبة بخصائص علاجية مثل كونها مضاد للبكتيريا، ومضاد للألم، وعامل خفض كولستيرول الدم. لذلك ، تم تصميم هذه الدراسة لتقييم تأثير بذور الحلبة المنبتة على مستوى السكر في الدم لدى مرضى السكري من النوع الثاني المصابين بفيروس التهاب الكبد الوبائي (ج) وغير المصابين به . تم اختيار تسعين مريضًا بالسكري من النوع الثاني من كلا الجنسين تم تشخيصهم قبل 6 أشهر على الأقل ويتعاطون أدوية السكر الفموية والأنسولين. تم تقسيم المرضى لثلاث مجموعات : المجموعة 1 (الضابطة) ، والمجموعة 2 (مجموعة الدراسة A وتمثل مرضى السكر المصابون بفيروس ج) ، والمجموعة 3 (مجموعة الدراسة B وتمثل مرضى السكر غير مصابون بفيروس ج). أظهر التحليل الإحصائي وجود انخفاض معنوي في مستويات السكر الصائم (FBS) بعد الشهر الثاني (P = 0.0485) والشهر الثالث (P = 0.0207) على التوالي في مجموعة الدراسة 2 ، في حين حدث هذا الإنخفاض المعنوي في مجموعة الدراسة 3 بعد الشهر الثالث (P = 0.0362). على الجانب الآخر لم تكن معدلات الإنخفاض في قيم (HbA1C) مشابهة لذلك تماما حيث أظهرت انخفاضًا معنويا بعد الشهر الثالث للمجموعة 2 (P = 0.0252) والمجموعة 3 (P = 0.0481) على التوالي. على الرغم من أن تأثير براعم الحلبة في خفض مستوى سكر الدم في مرضى السكر المصابون بالتهاب الكبد الوبائي ج أعلى من تأثيره في مرضى السكر غير المصابون به إلا أنه لم يكن فرقا معنويا بين المجموعتين لكل من قيم FBS ، HbA1C .أظهرت الدراسة أن هناك قيم متناقصة لمؤشر كتلة الجسم في جميع المجموعات ولكنها انخفاضات غير معنوية. ***الاستنتاج*** *، وجدت هذه الدراسة أنه يمكن استخدام الحلبة كعامل مساعد في السيطرة على مرضى السكري من النوع الثاني سواء المصابين بفيروس التهاب الكبد الوبائي ج وغير المصابين به ، وذلك على شكل براعم منبتة مع التحكم في النظام الغذائي وممارسة الرياضة.*

الكلمات المفتاحية: *براعم بذور الحلبة المنبته، سكري النوع الثاني، فيروس التهاب الكبد الوبائي ج ، سكر الدم الصائم ، الجلوكوز التراكمي.*