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# THE HYPOGLYCEMIC EFFECT OF FENUGREEK SEEDS IN TYPE 2 DIABETES

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## ABSTRACT

The present study was conducted to evaluate the effect of Fenugreek seed powder on blood glucose along with nutritional status, Knowledge, Attitude and Practice in Type 2 Diabetic patients.50 subjects were divided into group I (Standard Conventional Treatment) and group II (Standard Conventional Treatment and Fenugreek seed powder 25 g per day for a period of 3 weeks). **Results:** The mean age was 50.87±10.76 years in males and 50.69± 10.85 in females. The mean duration of the disease was 5.62 ±5.54 yrs. 95.65% females had raised BMI >23 kg/m² compared to 76.1% in males. Similarly, 76% of females had a WHR above the cut off value as compared 47.61% to males. The mean knowledge score was 7.85±1.21; attitude score was 35.75±4.07 and Practice score was 12.57±2.04. The Intervention group have shown significant reduction in FBS (P= 0.001) and PPBS (P=0.000). In the control group there was a significant reduction in the PPBS (P=0.007). However, the significance was more in the intervention group than control group. **Conclusion:** Our study has shown high prevalence of general and central obesity in type 2 diabetic patients with good knowledge with poor practice towards diabetes management. Fenugreek seed powder supplementation has shown a significant improvement in the fasting and post prandial blood glucose levels. Thus, indigenous and natural food based intervention like fenugreek seeds can be used as an adjuvant in the management of diabetes.

**KEYWORDS:** Diabetes Fenugreek, Knowledge Attitude and Practice, Blood Glucose.

## INTRODUCTION

Diabetes mellitus is described as a metabolic disorder of multiple etiology characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both.[1] According to the Indian Council of Medical Research-Indian Diabetes study[2] a national diabetes study, India currently has 62.4 million people with diabetes. Epidemiologic transition (from widely prevalent infectious diseases to a pattern of high prevalence of chronic lifestyle related NCDs), and socioeconomic transition (shift of people from low SES to high SES) Demographic transition (shift to low fertility, low mortality, and higher life expectancy) in developing countries have lead to shifts in dietary and physical activity patterns (nutrition and lifestyle transitions, and stress) affecting body composition and metabolism leading to increase in BMI, excess generalized and abdominal adiposity, and diabetes. Several studies has shown, an increase in prevalence of obesity in both urban and rural India[3,4] A prospective relation has been reported between blood glucose levels and abdominal adiposity.[5] The physiological effects of glycemic index of foods has been reviewed which argues for the need for controlled clinical trials of a low glycemic index diet in the treatment of obesity[6] and a clinical trial supported the beneficial effects of fenugreek seeds on glycemic control in persons with diabetes.[7]

Fenugreek seed commonly known as Methi seeds (*Trigonella foenum graecum* L.) is commonly cultivated and used as a condiment in India and North African countries. It has a long history of medical uses in Ayurvedic and Chinese medicine. The recent research has explored several health beneficial physiological benefits of fenugreek seeds using it as a folk medicine for its role in hyperglycemia, hypercholesterolemia, protection of liver, and many others.[8,9,10]

Fenugreek has been listed as one of the common medicinal plants having anti obesity potential.[11] Fenugreek seeds has shown to have an amino acid (2S, 3R, 4S) 4-hydroxyisoleucineenhancing insulin secretion under hyperglycaemic conditions, and increasing insulin sensitivity coupled with antioxidant potential against the oxidative damage induced by diabetes.[12] The Diabetes Control and Complications Trial Research Group[13] has suggested that tight glycaemic control is by far the most effective approach in the prevention of diabetic vascular complications. Despite such high prevalence, awareness,

on diabetes and its treatment still remain major challenges, particularly in the context of developing countries like India. A cross-sectional study revealed that the knowledge attitude and practices towards prevention and control of diabetes among majority of the respondents was poor.[14] Environmental factors, psychological factors, social and cultural factors. are the influencing factors for self- management of diabetes.[15] Regular inculcation of health education, making the patient aware regarding the disease and encouraging self care management during treatment will reduce health care burden and help achieve optimal control of the disease with minimal long term complications.[16]

Since food and dietary pattern of an individual have an important role to play in the prevention and management of type 2 diabetes, the present study attempted to assess the nutrient intake of the diabetic patients. Knowledge about diabetes mellitus, appropriate attitude and practices are vital to reduce the incidence and morbidity associated with DM. Hence the present study has also assessed the Knowledge, Attitude and Practices of the diabetic subjects towards diabetes. patients who were more self aware about the disease, having knowledge and regularly involved in self care practices achieve better glycemic control and better management of the disease. A meta-analysis.[17] on fenugreek clinical studies has supported the beneficial effects of fenugreek seeds on glycemic control in persons with diabetes. and only one study[18] with 25 g of fenugreek preparation for 15 days has reported an improvement in the peripheral glucose utilization which contributes to an improvement in glucose tolerance.

Despite of considerable progress in the management of diabetes mellitus by synthetic drugs, the prevalence and incidence of Diabetes is still on the rise. Review on Fenugreek seeds have shown a paucity in research related to human studies. Hence there is a need to search for an indigenous natural anti diabetic like Fenugreek seeds which is still in an experimental stage. Moreover, Fenugreek seeds abundantly available round the year with good shelf life without any acute toxicity.[19] In this regard Diabetics in developing countries like India could benefit from a low-risk, inexpensive, food-based intervention aimed at normalizing their metabolic milieu. Therefore the present study focused on direct consumption of fenugreek seeds powder which directly evaluates the effect of fenugreek seeds in Hyperglycemia. It will also convenient and easy for follow up as it is independent of food preparations.

## RESEARCH OBJECTIVES

1. To assess the Nutritional status and nutrient intake of type 2 diabetic patients.
2. To assess the Nutrition Knowledge, Attitude and Practices of type 2 diabetes subjects.
3. To assess the effect of Fenugreek Seed Powder on Fasting and Post Prandial Blood Glucose levels in type 2 diabetic patients.

## MATERIALS AND METHODS

The study was conducted in 2 stages. 365 subjects were screened for type 2 diabetes at OPD of V. A. Munshi Nature Cure Centre, Vallabh Vidyanagar, Anand (Gujarat). 67 were found to be eligible as per the inclusion and exclusion criteria. Nutrient intake, Knowledge Attitude Practices (KAP) and baseline assessment of FBS, PPBS, BP were recorded in the stage 1 of the study. 17 subjects dropped out as they were not willing to participate in stage 2 of the study. The remaining 50 subjects has participated in stage 2 of the study which is an intervention of Fenugreek seed for 3 weeks.

### Inclusion Criteria

- Age 35 – 65 yrs
- Gender-Both male and female
- Diagnosed cases of type 2 diabetes mellitus on oral hypoglycaemic drugs.
- Above high school level of education

### Exclusion Criteria

- Adults younger than 35 yrs and more than 70 yrs of age.
- Type 1 diabetes mellitus
- Type 2 diabetes with any associated diseases like Thyroid disorders, Endocrine disorders, Glaucoma, steroid therapy and other complications which can influence the outcome.
- Pregnancy / Lactation.

### Study Protocol

Subjects who were diagnosed cases of type 2 diabetes mellitus and eligible to participate in the study as per the inclusion and exclusion criteria were recruited into the study after obtaining voluntary consent. Demographic details, KAP using a self designed KAP questionnaire, and dietary intakes of the patients using Food Frequency questionnaires were recorded.

Subjects of group I were advised to continue Standard Conventional Treatment, whereas group 2 were given both Standard Conventional Treatment and Intervention of 25 g fenugreek seed powder per day to be taken in two equally divided dose, 15 minutes before lunch and dinner. Patients were asked to come on Fasting at the beginning of the study. Height, Weight, Waist and Hip circumference, and Blood Pressure were recorded. The Fasting and Post prandial Blood sugar from Finger Prick Blood sample was collected on Test Strips and analyzed using Contour TS Glucose meter by a Lab Technician who was blinded about the subjects groups. Fenugreek seed powder sachets were distributed at the beginning of the study to Group 2 and advised them to take Fenugreek seed powder, 25 g per day in two equally divided dosages (2 Sachets per day) 15 mts before lunch and dinner for a period of 3 weeks. Adherence to the intake of fenugreek seed powder was obtained from a diary given for Group 2. They were instructed to put a tick mark on the day and dose as per their intake. All the

subjects were asked to report once a week. The data collected at the beginning of the study was repeated after 3 weeks.

**Study Design:** Interventional study.

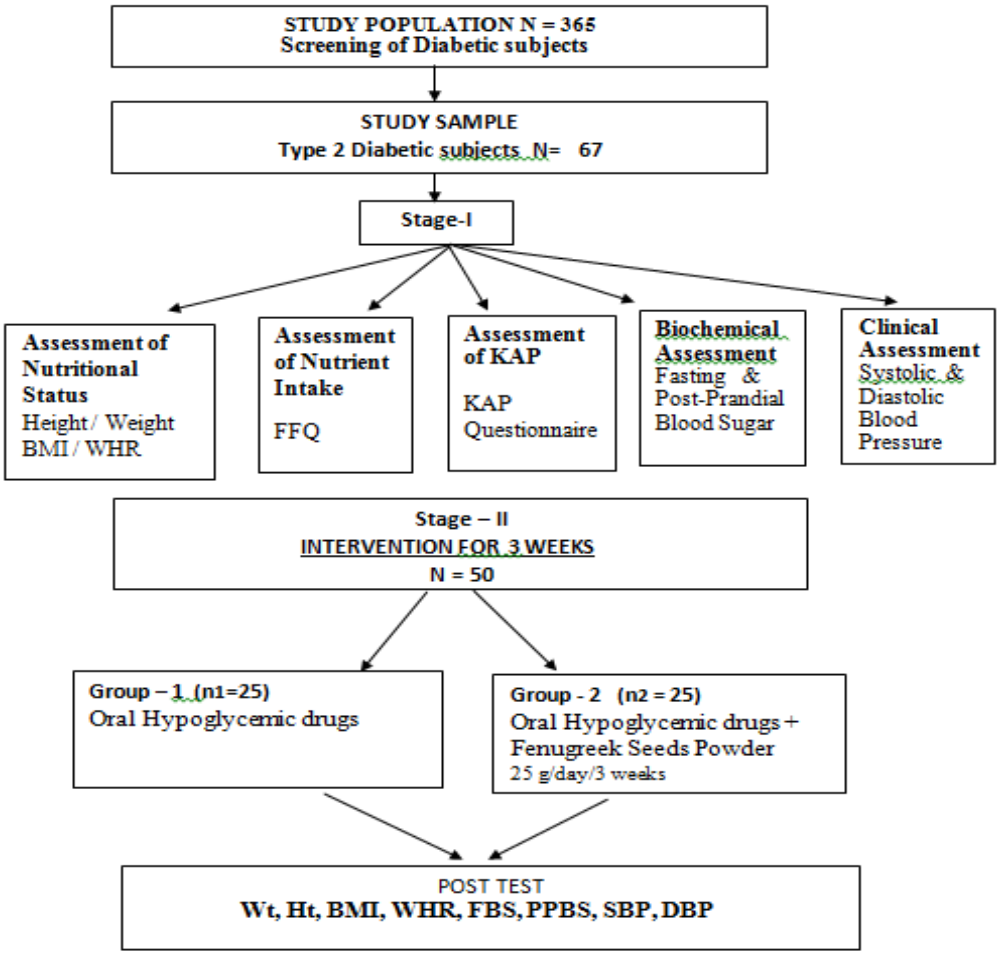


**Fig. 1: Schematic representation of study design.**

**Intervention**

Food Based Intervention - Fenugreek seeds powder

Preparation of Fenugreek seed powder Sachets: Fenugreek seeds were obtained from local market, ground to a powder. 12.5 g of powder was packed per Sachet.

**Distribution of Fenugreek Seeds Powder Sachets**

42 sachets were distributed to each subject at the beginning of study (2 sachets per day for 3 weeks)

Mode of intake: Oral intake.

Dosage: 25 g per day in two equally divided doses (2 sachets per day) 15 mts before lunch and dinner with water.

**Intervention period:** 3 weeks.

**Follow Up:** Adherence to the intake of fenugreek seeds powder was obtained from a dairy given for Group II at the beginning of the study. All the subjects reported every week

**DATA COLLECTION**

**Anthropometric measurements:** Height in cms, weight in kgs, Waist and Hip circumference in cms, Body Mass Index (Weight (Kg) / Height² (m) and Waist-to-Hip Ratio were recorded to assess the nutritional status of the study subjects.

**Food Frequency Questionnaire (FFQ)** was used to record the dietary intake of the subjects.[20]

**Calculation of food intakes**: Frequency of consumption of each food item in the FFQ was converted to intake in grams per day by multiplying the standard serving size of each food as specified in the FFQ by the values for each frequency of food intake option. FFQ was administered once at the beginning of the study. Information regarding the dietary intake of all subjects regarding the kinds of food eaten and the frequency of their consumption was recorded though a specially designed semi- quantitative, interviewer-administered appx 110 item Food Frequency questionnaire. It consists of 2 components viz Food List and Frequency Response Section.

Standard measuring cups and home based weighing balance were used for the estimation of Portion size to assess dietary intake of the diabetic subjects. Portion size estimation was undertaken using volume measures, circular measures, numbers and linear measures. A set of 5 plastic measuring cups and a steel glass was used as an aid to estimating volumes. In addition, two spoons were used to estimate very small quantities. For approximately circular items such as chapatti a set of printed images of chapattis was used to estimate the portion size of raw ingredients. Some items such as bread slices and salty snacks were recorded as integer multiples of standard portion sizes. Most fruits were recorded small or medium sizes.

**Knowledge Attitude Practice (KAP) Questionnaire**

KAP Questionnaire is a self-designed in a multiple choice format on Knowledge, Attitude and practice on type 2 diabetes mellitus administered at the beginning of the study to all the subjects. The 'Knowledge' section of questionnaire has 10 questions about diabetes and its risk factors and the role of diet on controlling diabetes. Each question had only one correct answer to be selected from the given 4 options. Each correct answer was assigned score 1 and wrong answer was assigned 0 (zero) with maximum attainable score of 10 and minimum of zero in knowledge section of the questionnaire. The level of knowledge was classified according to the score. Poor knowledge corresponded to score < 4, average knowledge to score between 4 and 7 and good knowledge referred to score > 7.

A likert scale which is a bipolar scaling method with five response levels was used to assess the attitude of the subjects towards diabetes and its management. The responses ranged from strongly agree to strongly disagree and the scoring assigned ranged from 5 – 0 [Strongly agree =5, agree = 4, Neither agree nor disagree = 3, disagree =2, strongly disagree =1] with a maximum attainable score of 50 and minimum of 10 in the attitude section of the questionnaire. The level of attitude was classified according to the score. Poor attitude corresponded to score < 20, average attitude to score between 20 and 40 and good attitude referred to score >40.

The Practice section of questionnaire has 10 questions related to their dietary choices and their implementation for the dietary management of diabetes. The scoring given ranges from 2, 1, 0 depending on the frequency and the food choices, with a maximum attainable score of 20 and minimum of 0 in the practice section of the questionnaire. The level of practice was classified according to the score. Poor practice corresponded to score <10, average practice to score between 10 and 20 and good practice referred to score >20.

The total score of the KAP questionnaire ranged from a maximum score of 80 to a minimum score of 10.

**Estimation of Blood sugar levels:** Capillary Finger Prick Blood sample was collected on Test Strips and analyzed using Contour TS Glucose meter for Fasting and Post Prandial Blood sugar at the beginning and at the end of the study.

**Principle**

The contour TS blood glucose test is based on measurement of electrical current caused by the reaction of glucose with the reagents on the electrode of the strip. The blood sample is drawn into the tip of the test strip through capillary action Glucose in the sample reacts with FAD glucose dehydrogenase (FAD-GDH) and potassium ferricyanide. Electrons are generated, producing a current that is proportional to the glucose in the sample. After the reaction time, the glucose concentration in the sample is displayed.[21,22]

**Blood Pressure:** Systolic and Diastolic Blood pressure will be recorded using the Mercury Sphygmomanometer and Stethoscope at the beginning and at the end of the study. The blood pressure was measured for each participant, using the auscultatory method with a standardized calibrated mercury column type sphygmomanometer and an appropriate sized cuff encircling at least 80% of the arm in the seated posture, with feet on the floor and arm supported at heart level. Systolic BP is the point at which the first of 2 or more sounds is heard and diastolic BP is the point before the disappearance of sounds.

## DATA ANALYSIS

The data analysis was done by using Statistical Package for Social Studies (SPSS 10). The measure of central tendency was calculated for all the variables. The within group pre post effect was evaluated by using Paired sample t test and between group effect was evaluated by using Independent sample t test. P value < 0.01 was considered as significant.

## RESULTS AND DISCUSSION

Out of the 67 patients, 21 were males and 46 were females. The mean age was 50.87±10.76 years in males and 50.69± 10.85 in females. The mean duration of the disease was 5.62 ±5.54 yrs. All the subjects were literates above the high school level of education.

**Nutritional status of type 2 diabetic subjects**

In view of the possible gender difference in the prevalence of obesity, the distributions of BMI and WHR were determined separately for men and women. The distribution of BMI, WHR has been shown in Table 1 and 2.

**Table 1: Prevalence of obesity in type 2 diabetic subjects.**

| BMI (Kg/m2) | Presumable diagnosis | Males (%) | Females (%) |
|---|---|---|---|
| <18 | Underweight | 0 | 0 |
| 18.5– 22.9 | Normal | 24 % | 4 % |
| 23 – 24.9 | Overweight | 5 % | 13 % |
| 25 – 29.9 | Obese grade I | 66 % | 35 % |
| >30 | Obese grade II | 5 % | 48 % |

**Table. 2: Distribution of WHR in type 2 diabetic Patients**

| Males [> 0.90] | Females [> 0.85] |
|---|---|
| **47.61 %** | **76 %** |

Results have shown 24% of males and 4% of females were maintaining normal BMI, 5% males and 13% females were overweight, 66% males and 35% females were Obese grade I, 5% males and 48% females were Obese grade II as per the ICMR recommendations of BMI.[23] Similarly, 76% of females had a WHR above the cut off value of as compared 47.61% to males.[24] A larger percentage of diabetic subjects having general obesity from raised BMI and central obesity was higher in females than males similar to previous Indian studies.[25,26,27]

**Macronutrient Intake of Diabetic Subjects**

The average daily intake of energy, carbohydrates, fats, protein and fibre is given in Table 3.

**Table. 3: Average daily intake of Energy, Carbohydrate, Protein, Fat and dietary fibre.**

| Nutrients | Average Daily Intake (Mean ± SD) |
|---|---|
| Energy (k cal) | 2269.1±260.0 |
| Carbohydrate (g) | 354.0± 55.3 |
| Protein (g) | 67.2±10.2 |
| Fat (g) | 64.1±14.9 |
| Fibre (g) | 23.7±3.9 |

The present study has shown the an average daily intake of 2269.1±260.0 kcal of Energy, 354.0± 55.3 g of Carbohydrate, 67.2±10.2 of Protein, 64.1±14.9 of Fat and 23.7±3.9 of dietary fibre by the diabetic subjects. The average percent contribution of dietary carbohydrate, Protein and fat to total energy is 62.4%, 10.9% and 25.5% respectively, and shown that the carbohydrate and fat intake in the diabetic subjects was higher than the dietary recommendations of the Indian Council for Medical Research for glycemic control.[28]

**KAP OF DIABETIC SUBJECTS**

Responses to KAP questionnaire by diabetic subjects has the mean scores of 7.85±1.21, 35.75±4.07 and 12.57±2.04 for Knowledge, Attitude and Practice respectively as shown in table 4.

46 of the subjects agreed that a diabetic patient should follow a controlled and planned diet along with medicines. 34 subjects disagreed that diabetic should restrict papads and pickles in their diet. 19 subjects agreed and 21subjects disagreed that good control of blood sugar levels would help in preventing diabetic complications. 32 subjects agreed that diabetic should restrict salt intake in their diet. 27 subjects strongly agreed that exercise will help in controlling the blood sugar levels.27 subjects strongly agreed but 28 subjects strongly disagreed that fibre supplements available in the market will help in diabetes.

58 subjects agreed that regular counselling from Diabetologist / dietician would help in easy follow up of the prescribed diet. 44 strongly agreed and 18 agreed that diet control would help in lowering your blood sugar level.51 subjects agreed that regular meal timings would help in Diabetes. 39 subjects agreed whereas 17 neither agreed nor agreed and 10 disagreed that diabetes is a serious disease.

**Table. 4: KAP Mean scores of the patients.**

| Variables | Average score (Mean ± SD) | Response levels |
|---|---|---|
| Knowledge | 7.85±1.21 | Poor knowledge < 4<br>average knowledge 4 - 7<br>good knowledge > 7 |
| Attitude | 35.75±4.07 | Poor attitude < 20<br>average attitude 20 - 40<br>good attitude > 40. |
| Practice | 12.57±2.04 | Poor practice < 10<br>average practice 10 - 20<br>good practice > 20 |

The results in this present study has evidenced good knowledge with low attitude and average Practice scores in diabetic patients. The good Knowledge score in the present study could be related to the formal diabetic education received by the subjects from their doctors during their visits and all the subjects were found to be literates. But that knowledge has not been translated into practice due to their poor attitude towards diabetes. Multiple factors plays a role in maintaining the glycemic control which was supported by a Malaysian study which has reported negative correlation between the KAP scores and HbA1C levels[29] indicating that social support, motivation and compliance for lifestyle and dietary modifications plays a vital role in glycemic control.

**Effect of Fenugreek seeds on anthropometric measurements:** The intervention of fenugreek seeds powder in this study did not find any significant change in weight, Body Mass Index, Waist Hip Ratio. However, some of the earlier studies[30,31] has suggested that Fenugreek fiber (8 g) significantly increased satiety and reduced energy intake at lunch, which may have short-term beneficial effects in obese subjects. The differences in the results are attributed to the selection of healthy obese subjects and isolated fenugreek seeds powder in the earlier studies. In this present study the patients' anthropometrical parameters did not change perceptively during the period of experimentation may be because we have not monitored their dietary intake during the experimentation period and has also not emphasized any active exercise intervention.

**Hypoglycemic Effect of Fenugreek:** The blood sugar profile during the study period of the control group I and the intervention group II was given in Table 5.

**Table. 5: Effect of Fenugreek Powder on Blood Glucose and Blood Pressure measures compared to control group.**

| S. No | Parameter | Control Group I | | Intervention Group II | |
|---|---|---|---|---|---|
| 1 | | Pre | Post | Pre | Post |
| 2 | FBS | 137.24±37.98 | 130.86± 30.33 | 134.74 ± 29.80 | 124.91±25.79* |
| 3 | PPBS | 196.24 ±52.35 | 184.62± 41.84* | 195.39± 48.03 | 170.00± 29.26* |
| 4 | Systolic BP | 127.52 ±7.64 | 127.24± 6.11 | 128.26 ± 9.33 | 127.83±6.85 |
| 5 | Diastolic BP | 84.00± 8.17 | 82.95± 5.61 | 83.83 ± 8.29 | 83.30 ± 4.42 |

* $p<0.01$ for within group using paired *t* test

Paired sample t – test was computed for within group effect showed significant reduction of FBS (t=3.97,p=0.001) and PPBS (t=5.71, p=0.000) whereas control group showed significant reduction in PPBS(t=3.04, p=0.007). But the reduction was more in intervention group compared to control group. Independent sample test was computed to compare between group effect did not show any significant reduction in PPBS (t =1.35,p =0.18).

These results were in agreement with the earlier studies. However there is a difference in the duration and dosages of fenugreek like 100 g of defatted fenugreek seeds powder[32] 10 grams/day powdered fenugreek seeds mixed with yoghurt or soaked in hot water for 8 weeks.[33] suggested that management of Type 2 Diabetes mellitus would be easier with therapeutic approach of fenugreek seeds. Treatment with a decoction of fenugreek seeds has reported to suppress glycosuria in mild diabetes and improvement in severe diabetic condition due to the water soluble alkaloid called Trigonelline, first reported by *Kinsky et al*. (*1967*). The probable mechanism by which fenugreek seeds induce a hypoglycemic effect may be due to an amino acid 4-hydroxy isoleucine found in it. This amino acid has shown to have both insulinotropic[35] and antidiabetic properties by the enhancement of insulin sensitivity and glucose uptake in peripheral tissue, Slowing carbohydrate absorption and inhibition of glucose transport from the fibre content as well as modulation of peripheral glucose utilization may be by exerting its hypoglycemic effect by acting at the insulin receptor as well as at the gastrointestinal level.[36] The Soluble Dietary Fibre fraction of *T. foenum-graecum* seeds exerts antidiabetic effects mediated through inhibition of carbohydrate digestion and absorption, and enhancement of peripheral insulin action.[37] An increased oxidative stress has been observed in diabetic patients as indicated by high free radical production[38] and studies show that majority of plasma antioxidants are depleted in T2DM and the oxidative stress plays an important role in diabetic complications.[39]

Therefore Fenugreek seeds can be incorporated in the diet as Some of the studies indicated that the extract of fenugreek seeds contains antioxidants and protects cellular structures from oxidative damage.[40]

## CONCLUSION

Our study has shown a significant improvement in the fasting and post prandial blood glucose with fenugreek seeds powder supplementation. Therefore, indigenous and natural food based intervention like fenugreek seeds can be used as an adjuvant in the management of diabetes. This study has also shown that good knowledge on diabetes could not be translated into good practice which suggests for more emphasis on the poor attitude for better practice towards diabetes management.

## LIMITATIONS OF THE STUDY

The sample size is less.

Though diabetes requires a lifetime management, long term effect of the fenugreek has not been evaluated.

We did not concentrate on exercise and individual diet prescription Micronutrient intake in the study was not calculated.

Blood sugar was estimated from capillary blood instead of venous blood.

## RECOMMENDATIONS

Due to high incidence and prevalence of diabetes in developing countries like India, further studies are recommended to evaluate the dose dependent hypoglycemic effect of fenugreek seeds.

The role of fenugreek seeds as an alternative therapy in pre diabetes are recommended.

While the results of this study are promising, clinical study with larger sample size and longer follow up duration may be undertaken to further validate the results of this study.

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## REFERENCES

1. World Health Organization. Global report on diabetes. World Health Organization, 2016.
2. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V, Unnikrishnan R, Bhansali A, Joshi SR, Joshi PP, Yajnik CS, Dhandhania VK. Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in urban and rural India: Phase I results of the Indian Council of Medical Research–INdia DIABetes (ICMR–INDIAB) study. Diabetologia, Dec. 1, 2011; 54(12): 3022-7.
3. Pradeepa, R., Anjana, R. M., Joshi, S. R., Bhansali, A., Deepa, M., Joshi, P. P., the ICMR-INDIAB Collaborative Study Group. Prevalence of generalized & abdominal obesity in urban & rural India- the ICMR - INDIAB Study (Phase-I) [ICMR - INDIAB-3]. The Indian Journal of Medical Research, 2015; 142(2): 139–150. http://doi.org/10.4103/0971-5916.164234.
4. Kalra S, Unnikrishnan AG. Obesity in India: The weight of the nation. Journal of Medical Nutrition and Nutraceuticals, Jan., 1, 2012; 1(1): 37.
5. Cassano PA, Rosner B, Vokonas PS, Weiss ST. Obesity and Body Fat Distribution in Relation to the Incidence of Non-lnsulin-dependent Diabetes Mellitus: A Prospective Cohort Study of Men in the Normative Aging Study. American journal of epidemiology, Dec., 15, 1992; 136(12): 1474-86.
6. David S. Ludwig; Dietary Glycemic Index and Obesity, The Journal of Nutrition, 1 January, 2000; 130(2): 280S–283S, https://doi.org/10.1093/jn/130.2.280S.
7. Gopalpura PB, Jayanthi C, Dubey S. Effect of Trigonella foenum-graecum seeds on the glycemic index of food: A clinical evaluation. International Journal of Diabetes in Developing Countries, Jun 1, 2007; 27(2).
8. Prasanna M. Hypolipidemic effect of fenugreek: a clinical study. Indian journal of Pharmacology, Jan 1, 2000; 32(1): 34-6.
9. Smith M. Therapeutic applications of fenugreek. Alternative Medicine Review, 2003; 8(1): 20-7.
10. Srinivasan K. Fenugreek (Trigonella foenum-graecum): A review of health beneficial physiological effects. Food reviews international, Jul 1, 2006; 22(2): 203-24.
11. Kumar P, Bhandari U. Common medicinal plants with antiobesity potential: a special emphasis on fenugreek. Ancient science of life, Jul., 2015; 35(1): 58.
12. Haeri MR, Limaki HK, White CJ, White KN. Non-insulin dependent anti-diabetic activity of (2S, 3R, 4S) 4-hydroxyisoleucine of fenugreek (Trigonella foenum graecum) in streptozotocin-induced type I diabetic rats. Phytomedicine, May 15, 2012; 19(7): 571-4.
13. Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. New England journal of medicine, Sep., 30, 1993; 329(14): 977-86.
14. Satyanarayana TB, Mahendrappa SK. A cross sectional study of knowledge, attitude and practice among patients with type 2 diabetes mellitus at a tertiary care hospital. J of Evolution of Med and Dent Sci., May 12, 2014; 3(19): 5317-21.
15. Kisokanth G, Prathapan S, Indrakumar J, Joseph J. Factors influencing self-management of Diabetes Mellitus; a review article. Journal of Diabetology, Sep 1, 2013; 4(3): 6.
16. Padma K, Bele SD, Bodhare TN, Valsangkar S. Evaluation of knowledge and self-care practices in diabetic patients and their role in disease management. National Journal of Community Medicine, 2012 Jan; 3(1): 3-6.
17. Neelakantan N, Narayanan M, de Souza RJ, van Dam RM. Effect of fenugreek (Trigonella foenum-graecum L.) intake on glycemia: a meta-analysis of clinical trials. Nutrition journal, Dec., 13, 2014; (1)7.
18. Raghuram TC, Sharma RD, Sivakumar B, Sahay BK. Effect of fenugreek seeds on intravenous glucose disposition in non-insulin dependent diabetic patients. Phytotherapy Research, Mar 1; 1994; 8(2): 83-6.
19. Mowl A, Alauddin M, Rahman M, Ahmed K. Antihyperglycemic effect of Trigonella foenum-

graecum (Fenugreek) seed extract in alloxan-induced diabetic rats and its use in diabetes mellitus: a brief qualitative phytochemical and acute toxicity test on the extract. African Journal of Traditional, Complementary and Alternative Medicines, 2009; 6(3).
20. Marks GC, Hughes MC, van der Pols JC. Relative validity of food intake estimates using a food frequency questionnaire is associated with sex, age, and other personal characteristics. The Journal of nutrition, Feb., 1, 2006; 136(2): 459-65.
21. Kumar G, Sng BL, Kumar S. Correlation of capillary and venous blood glucometry with laboratory determination. Prehospital Emergency Care, Oct 1, 2004; 8(4): 378-83.
22. Caswell M, Frank J, Viggiani MT, Pardo S, Dunne N, Warchal-Windham ME, Morin R. Accuracy and user performance evaluation of a blood glucose monitoring system. Diabetes technology & therapeutics, Mar 1, 2015; 17(3): 152-8.
23. Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes care, May 1, 2003; 26(5): 1380-4.
24. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, December 2008; 8-11.
25. Deepashree BN, Prakash J. A study on the nutritional status of diabetics and associated risk factors. Journal of Human Ecology, Apr 1, 2007; 21(4): 269-74.
26. Sharma S, Jain S. Prevalence of obesity among type-2 diabetics. Journal of Human Ecology, Jan., 1, 2009; 25(1): 31-5.
27. Rama Lakshmi G, Bandyopadhyay SS, Bhaskar LV, Sharma M, Rao RV. Appraisal of risk factors for diabetes mellitus type 2 in central Indian population: a case control study. Antrocom Online J Anthropol, 2011; 7: 103.
28. icmr.nic.in/guidelines_diabetes/guide_diabetes.htm
29. Ng SH, Waseem AN, Kadirvelu A. Reality vs illusion: knowledge, attitude and practice among diabetic patients. International Journal of Collaborative Research on Internal Medicine & Public Health, 2012; 4(5).
30. Chevassus H, Gaillard JB, Farret A, Costa F, Gabillaud I, Mas E, Dupuy AM, Michel F, Cantié C, Renard E, Galtier F. A fenugreek seed extract selectively reduces spontaneous fat intake in overweight subjects. European journal of clinical pharmacology, May 1, 2010; 66(5): 449-55.
31. Mathern JR, Raatz SK, Thomas W, Slavin JL. Effect of fenugreek fiber on satiety, blood glucose and insulin response and energy intake in obese subjects. Phytotherapy research, Nov 1, 2009; 23(11): 1543-8.
32. Sharma RD, Raghuram TC, Rao NS. Effect of fenugreek seeds on blood glucose and serum lipids in type I diabetes. Eur J clin nutr, Apr 1, 1990; 44(4): 301-6.
33. Kassaian N, Azadbakht L, Forghani B, Amini M. Effect of fenugreek seeds on blood glucose and lipid profiles in type 2 diabetic patients. International journal for vitamin and nutrition research, Jan 1, 2009; 79(1): 34-9.
34. Kinsky et al. (1967).
35. Sauvaire Y, Petit P, Broca C, Manteghetti M, Baissac Y, Fernandez-Alvarez J, Gross R, Roye M, Leconte A, Gomis R, Ribes G. 4-Hydroxyisoleucine: a novel amino acid potentiator of insulin secretion. Diabetes, Feb., 1, 1998; 47(2): 206-10.
36. Broca C, Manteghetti M, Gross R, Baissac Y, Jacob M, Petit P, Sauvaire Y, Ribes G. 4-Hydroxyisoleucine: effects of synthetic and natural analogues on insulin secretion. European journal of pharmacology, Mar 3, 2000; 390(3): 339-45.
37. Hannan JM, Ali L, Rokeya B, Khaleque J, Akhter M, Flatt PR, Abdel-Wahab YH. Soluble dietary fibre fraction of Trigonella foenum-graecum (fenugreek) seed improves glucose homeostasis in animal models of type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption, and enhancing insulin action. British Journal of Nutrition, Mar., 2007; 97(3): 514-21.
38. (Esposito K, Nappo F, Marfella R, Giugliano G, Giugliano F, Ciotola M, Quagliaro L, Ceriello A, Giugliano D. Inflammatory cytokine concentrations are acutely increased by hyperglycemia in humans: role of oxidative stress. Circulation, Oct 15, 2002; 106(16): 2067-72.
39. Baynes JW, Thorpe SR. Role of oxidative stress in diabetic complications: a new perspective on an old paradigm. Diabetes, Jan 1, 1999; 48(1): 1-9.
40. Kaviarasan S, Naik GH, Gangabhagirathi R, Anuradha CV, Priyadarsini KI. In vitro studies on antiradical and antioxidant activities of fenugreek (Trigonella foenum graecum) seeds. Food chemistry, Jan 1, 2007; 103(1): 31-7.