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Phytotherapy of Type 2 diabetes by using *Trigonella foenum-graecum*

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Diabetes mellitus is a metabolic disorder rising mortality and morbidity worldwide. It needs precise identification and appropriate management. The aim of study was to analyze the effect of fenugreek seeds powder on type-2-diabetes mellitus because its cost effective and provides a lot of health benefits and are feasible to low- and middle-income population. This study was conducted in the community of a village. Twenty human subjects were taken and divided into 4 groups. Maximum 5 subjects were kept in one group. First group was kept as controlled. Second group was fed with normal diet and dose of fenugreek seed powder (0.5g/capsule). Third group was fed with normal diet and dose of fenugreek seed powder (0.75g/capsule). Fourth group was fed with normal diet and dose of fenugreek seed powder (1g/capsule). Two capsules were given thrice a day after meal (breakfast, lunch and dinner) respectively. Total 6 capsules per day were recommended. This study was completed in 8 weeks, so 336 capsules in one bottle was given to each subject of 2nd, 3rd and 4th group. Then their dose dependency and comparison with control group was done. All three parameters (FBS, PPBG, UA) showed that hypoglycemic effect was more pronounced with high doses. From this study it is concluded that Fenugreek seed powder has significant positive effect on Type 2 Diabetic patients in dose dependent manner.

Keywords: Fenugreek seed, Diabetes mellitus, seed powder

INTRODUCTION

As a food additive, spices and herbs are used and known as natural antioxidant. Aromatic spices and herbs are used in daily diet and many medical therapies because it prevents from biological deterioration as well as delays aging. Owing to the existence of phytochemicals such as cumarins,

flavonoids, lignin, saponin, vitamins, and terpenoids, plant material exhibit the greater antioxidant potential (Bukhari et al. 2008). For an extended period of time, spices are used to increase the sensory attributes of foods. These spices get better colour, essence, aroma and tastiness of food (Srinivasan et al. 2006).

Fenugreek is known as *Trigonella foenum-graecum* which is a perennial herb and belongs to the family *Leguminose*. It is also known as 'methhe' in Urdu and are using as a spice in European, African, Pakistan and Asian countries. Fenugreek leaves are utilized as vegetable and its seeds are using as a seasoning to process the different items (Kaviarasan et al. 2004).

Fenugreek seeds are unpleasant in taste which is due to alkaloids and saponins that can leads to stimulate the stomach and increases in appetite and acidity. Its key saprogenic component which is known as diosgenin that is helpful in treating menopause and act as an estrogen precursor. Alkaloids and saponins are present approximately 1 % and 4 % to 8 % respectively. Women of Arabs and Persian used these seeds to increase the lean muscle mass. Steroid saponins of fenugreek seeds used to prepare progesterone pharmaceutically (Srinivasan et al. 2006). Fenugreek also contain saponins which is a bioactive component include gitogenin, yamogenin, diosgenin, tigogenin and notigogens. Fenugreek seeds contain alkaloids which increases the triglycerides, cholesterol, blood sugar and prevents from cataracts which caused by diabetes. Fenugreek seeds contain ample amount of polyphenolic compounds that enhances the antioxidant activity (Rayyan et al. 2010). Owing to the presence of polyphenolic component, fenugreek is considered to have a great antioxidant potential among all other natural sources (Phadnis et al. 2011). *Foenum-graecum* also consist of phenolic acids such as gallic acid, ferulic acid, vanilic acid and coumaric acid. Using HPLC analysis, its antioxidant potential can be evaluated.

By injecting seed extract, plasma glucose and insulin responses can be improved. Extract of fenugreek seed is beneficial in the reduction of urinary concentrations. Serum cholesterol and plasma glucose concentration can be controlled by the ingestion of 25 grams of fenugreek seed powder (Sharma, 1986). Fenugreek has antiulcer, antifertility and immune modulatory effects. Fenugreek seed is very useful in digestion problems and diabetes management (both insulin dependent and non-insulin dependent diabetes) (Meghwal and Goswami, 2012).

Fenugreek seeds are included in daily diet and used as a supplement for bread making from whole meal flour. It's considered a rich source of top quality protein and also lysine which is round about 5-6 percent and 20 to 25 percent respectively. Owing to the manifestation of

insoluble and soluble dietary fiber in fenugreek seeds, its potential increased and also perform hypoglycemic and hypocholesterolemic activities (Hooda and Jood, 2005). To all kinds of food formulation, fenugreek seed powder can be useful. Scientific research showed that its use in nutraceutical and functional foods (Kumar and Maliakel, 2008). Fenugreek supplemented flour has physiological, organoleptic and rheological characteristics which enhance the fat and protein contents (Hooda and Jood, 2003). Fenugreek seeds powder with 8 to 10 percent fortified flour, utilized for making bakery products like muffins, cakes, pizza, breads with appropriate sensory evaluation (Srinivasan, 2005). The Objective of this study were to asses and compares the FBS (fasting blood sugar), PPBS (post prandial blood sugar) and urine analysis among type 2 diabetic patients before and after the administration of fenugreek seed powder in capsulated form and investigate the anti- diabetic effect of fenugreek seed powder. It is assessed and compared in experimental groups and control group.

MATERIALS AND METHODS

2.1 Procurement and preparation of raw material

The present study was conducted in the National Institute of Food Science and Technology, university of agriculture Faisalabad. Fenugreek seeds were bought from the local market of Faisalabad. In order to take out the dust, straw and stones, fenugreek seeds were cleaned. After sieving and tempering, to get a smooth powder, it was grounded manually. Prior to further analysis it was placed in air tight container (Brummer et al. 2003).

2.2 Moisture content

All samples were estimated according to their moisture content by the method revealed in AACC (2000). In pre-weighed china dish, ten grams of sample was taken and put up in a hot air oven (Model: DO-1-30/02, PCSIR, Pakistan) for twenty four hours, it was dried at 105 °C temperature. After 24-hour, sample was far away from the oven and cooled in a desiccator. Using the following formula that described below, the moisture content was evaluated.

Moisture (%) = $\frac{\text{Wt. of original fenugreek seed flour} - \text{Wt. of dried fenugreek seed flour sample}}{\text{Wt. of original flour sample}} \times 100$

2.3 Crude protein

According to AACC (2000) method No. 46-10, Kjeldhal apparatus (Model: D-40599, Behr Labor Technik, GmbH-Germany) was utilized to evaluate nitrogen percentage. The protein percentage (%) determined according with respect to this formula mentioned below:

$$N (\%) = \frac{\text{Volume of } 0.1N \text{ H}_2\text{SO}_4 \times 0.0014 \times \text{Volume of dilution}}{\text{Volume of sample taken weight of sample}} \times 100$$

$$\text{Crude protein } (\%) = \text{Nitrogen } (\%) \times 5.71$$

2.4 Total Ash

The ash content in all samples was calculated by the method No. 08-01 cited in AACC (2000).

So, ash content calculated with respect to given formula:

$$\text{Ash } (\%) = \frac{\text{Wt. of Ash}}{\text{Wt. of seed powder sample}} \times 100$$

2.5 Crude fat

All samples were examined for crude fat by using the subsequent method No. 25-30 cited in AACC (2000). The temperature was maintained at one hundred and ten degree centigrade for one hour and then evaluated the fat content according to given formula:

$$\text{Crude fat } (\%) = \frac{\text{Wt. of fat}}{\text{Wt. of seed powder sample}} \times 100$$

2.6 Extraction of phenolic acids

The extraction of free phenolic acids was done according to Bukhari et al. (2008). Phenolic acids in extracted form were utilized for the determination of TPC in this procedure.

2.7 Determination of total phenolic contents

By using the 2 different extract of fenugreek seed powder named as methanol and ethanol extract described by Folin-Ciocalteu method, total phenolic compounds of fenugreek seed powder were estimated (Bukhari et al. 2008). For all other samples, same procedure was followed and anticipated 3 replications.

TPC was computed by using the formula $C = e \times V/m$

Where:

C = total contents of phenolic compounds in mg/g bran extract, in GAE

E = concentration of gallic acid mg/ml

V = the volume of extract m = weight of extract in g

2.8 Free radical scavenging ability (DPPH assay)

Using the method of Inzucchi et al. (2012) for DPPH (1,1 -diphenyl-2-picrylhydrazyl) free radical scavenging activity, the extract was analyzed.

By following the formula, the free radical scavenging activity calculated as: Reduction of absorbance (%) = $[(AB-AA)/AB] \times 100$

AB = Absorbance of blank sample at t = 0 minute

AA = Absorbance of tested extract solution at t = 15 minutes

2.9 Antioxidant activity (AA)

Antioxidant activity of the extract was estimated based on coupled oxidation of linoleic acid and B-carotene. Abd El Baky and El Baroty (2008) described the method which was followed.

By using the following equation, the extract degradation rate was evaluated according to 1st order of kinetics;

$$\ln(a/b) \times 1/t = \text{Sample degradation rate} \ln = \text{Natural log}$$

a = Initial absorbance on 470 nm at time zero

b = Absorbance at 470 nm after 30 min

t = Time in minutes

Antioxidant activity calculated by using the following formula given below.

$$\text{AA } (\%) = \frac{\text{Degradation rate of control} - \text{Degradation rate of sample}}{\text{Degradation rate of control}} \times 100$$

2.10 Efficacy study

Efficacy study was conducted on human subject. In this study, 20 subjects were taken from the community of a village with age group from 45 to 55 years. Subjects were divided into 4 groups and maximum 5 subjects were kept in one group. First group was controlled. Second group was fed with normal diet and dose of fenugreek seed powder (0.5g/capsule).

Third group was fed with normal diet and dose of fenugreek seed powder (0.75g/capsule). Fourth group was fed with normal diet and dose of fenugreek seed powder (1g/capsule). 2 capsules was given thrice a day after meal (breakfast, lunch and dinner) respectively. Total 6 capsules per day were recommended. This study was completed in 56 days, so 336 capsules in one bottle were given to each subject. Then their dose dependency and comparison with control group was done.

Table No 3.1: Treatment plan

TREATMENTS	NO.OF SUBJECTS	Dose	Form of dose
T0	5	-	-
T1	5	1 g x 3 doses/day	Fenugreek seed powder
T2	5	1.5 g x 3 doses/day	Fenugreek seed powder
T3	5	2g x 3 doses/day	Fenugreek seed powder

2.11 Body weight estimation

BMI of subjects involved in a study was measured before and at the end of study.

2.12 Biochemical parameters**2.13 Blood sugar test**

Fasting blood glucose level was measured before starting the study. But it was measured on daily basis after starting the treatment. Then comparison of levels of FBG was done at the end of study between 4 groups.

2.14 Postprandial blood glucose test

Two-hour postprandial blood glucose test was measured on daily basis and then comparison of levels of PPBG was done at the end of study between 4 groups.

2.15 Urine analysis

Urine analysis for diabetes was done before and at the end of the study. Their comparison was done within 4 groups and with the controlled group.

2.16 Clinical symptomatic quantitative score

CSQS Performa was filled before and after study and then their comparison was done.

2.17 Statistical Analysis

The resultant data from different analyses was analyzed statistically (Montgomery, 2008).

RESULTS AND DISCUSSION**3.1 Proximate analysis of fenugreek seed powder****3.2 Moisture content**

The calculated mean value of fenugreek seeds powder has mean value of 10.10 which is closely associated to the previous study of Naidu

et al. (2011). Physical properties and quality of fenugreek seed is directly affected by moisture content. If moisture content increases then seed surface area, seed mass and seed volume will increase. If moisture contents increases from 8.8% to 20.2% then surface area, seed volume, sphericity and seed mass increases from 18.08 to 22.18mm², 12.58 to 13.83mm², 60.79 to 64.06mm² and 15.48 to 16.39 mm², respectively (Neveen et al. 2007).

3.3 Total Ash

The mean value of total ash content of fenugreek seed powder mentioned in table no. 2. The mean value accounted for 2.62. This result in accordance with Naidu et al. (2011) who revealed that fenugreek seed powder contains 3.7% ash contents. According to Naidu, fenugreek seed as compared to husk contain higher content of ash. Analysis of ash content usually showed the concentration of mineral contents that are present in that given commodity. Higher ash content is directly proportional to the mineral content concentration. Greater the concentration of ash content, greater will be its mineral content (Klava, 2004).

3.4 Crude fat

The mean value for fat content has been reported as 7.31. The result matches with the consequences of Naidu et al. (2011). He proved that fenugreek contain 6.65 fat percentages. He illustrated that endosperm of fenugreek seed contain higher concentration of fat (6.4g/100 g) as compared to husk of seed which contain low fat content such as (1.2g/100g). These results are also matching with Srinivasan (2006). It increases shelf life and quality of products. It has been evaluated that fenugreek influence the baking tendency of all types of flour possibly due to counteraction with protein and surfactant effects.

3.5 Crude protein

Protein content has mean value 27.50 and this value has been mentioned in table no. 2. Naidu et al. (2011) estimated the protein content of fenugreek seeds and the value was 27.57. This result is also in accordance with Meghwal and Goswami (2012). As a functional and nutritional value of any product or commodity, protein content is intended to be a vital quality criterion. Legumes and cereals have different chemical composition and this difference in chemical composition is also not noticeable in legumes and cereals protein content. Genetic background and

environmental conditions results in wide variation in their protein content.

3.6 Total phenolic contents

As compare to methanol extract, the C₂H₅OH extract gave the elevated TPC contents. Methanol extract has total phenolic content of 7.82 mg GAE/g while ethanol extracts shows the mean value for TPC content 9.11 mg GAE/g. These outcomes are just about equivalent with the consequences of Bukhari et al. (2008) who showed that methanol extract showed value 5.75 mg GAE/g while ethanol (C₂H₅OH) extract of fenugreek seed showed a value of 6.85 mg GAE/g.

On dry weight bases, the total phenolics of hexane extract of fenugreek seed were determined and found a value of 54.3±0.25% mg GAE/g (Taha et al. 2004). The total phenolics of ethanolic extract were determined in India and gave a value of 7.81±0.25% mg GAE/g while total phenolics of methanolic extract gave a value of 78.6% mg GAE/g. This difference may be due to diverse environmental circumstances or different variety (Kaviarasan et al. 2007). In united State of America, the total phenolic content of ethanol extract of fenugreek seeds was determined and showed a value of 0.68 mg GAE/g dw (Bushey et al. 2009). Results of Bushey et al. (2009) are very low in quantity and propose that there is a wide range for % of total phenolics. The distinction between the results may be due to region, solvents, and variety. Plants are considered the major source of antioxidants. It provides the useful effects to human health. TPC would vary according to growth and location in spices (Yu et al. 2003). Phenolic compounds of plant include anthocyanins, flavanoids and phenolic acids have been documented as conferring stability against auto oxidation of vegetable oils (Peterson et al. 2001). By means of the Folin,s reagent, entire phenolic content was measured. For estimating the total phenols, it is the only widely used method.

3.7 Antioxidant activity of fenugreek seeds

Antioxidants are defined as the reduction of oxidative damage by any substance which is a favourable thing for food supplies. There are two classes of antioxidants, one is synthetic and the other is natural. Vitamin C and vitamin E are the examples natural antioxidants (Poole et al. 2010). The consideration of antioxidant activities before and after the digestion and colonic fermentation results in evaluation of firmness of antioxidant

phenolic contents of food in their meticulous surroundings after release in physiological situations. Oxidative stress linked with the pathogenesis of several maladies in which free radical participate. When the equilibrium impel to free radicals, the oxidative stress is thus created and hence consequently, reduction or elevation of antioxidant moieties takes place (Prabhu and Krishnamoorthy, 2010). Oxidative stress is well-known to treat the Alzheimer's disease and many others like that. It also promotes and stimulates the improvement of various severe forms of diseases which include cataract, cancer, cardiovascular and inflammation diseases (Temple, 2000). Oxidative stress has become fretful as one of the initial factor conscientious for tissue injury consequent contact of plants to wide array of stress condition. Numerous indications have demonstrated that drought caused the oxidative stress in plants through the inhibition of antioxidant system or production of oxygen radicals (Zhou et al. 2012).

3.8 Demographic characteristics of subjects

Twenty human subjects were taken, and their BMI was calculated before and at the cease of the study. There was no subject before and at the end of the study (after fenugreek seed powder consumption) that is underweight. Six (6) subjects showed normal weight before study while 14 subjects showed normal weight at the end of the study. Eight (8) subjects were overweight before study while 3 subjects were overweight at the end of the study. One subject was obese before study and one was obese at the end of the study. One subject suffered in grade 1 type obesity while there was no subject in this grade at the end of the study.

Table No. 4.4: BMI of diabetic subjects before and after study

	No. of type 2 diabetic patient	No. of type 2 diabetic patient
BMI(kg/m ²)	Before study	After study (fenugreek seed powder consumption)
< 18.5	0	0
18.5-24.9	6	14
25-29.9	8	3
30-34.9	2	2
35.0-39.9	1	1
>40	1	0

One female and four males were kept in 1st

group (T0) that was controlled group. Two females and 3 males were kept in 2nd group (T1). In third group (T2), 4 females and one male were kept while in fourth group (T3), 2 female and 3 males were kept.

Two subjects were educated up to high school in controlled group while 6 were in treatment groups. Two subjects were educated up to primary school in treatment group while there was no subject educated at primary level in controlled group. One subject was illiterate in control group while two were illiterate in treatment groups. Majority of the subjects were unemployed in this study and overall educational status was normal

Weekly intake of fish was high in experimental groups as compare to control group while monthly intake was frequent in both groups. Daily intake of low carbohydrate fruits was high in treatment groups while control group was not using low carbohydrate Food daily. Weekly intake was considered frequent in both groups while monthly intake was higher in treatment groups. Daily and monthly consumption of red meat was frequent in both groups while weekly intake was slightly higher than control group. Daily consumption of egg was high in control group while higher in experimental groups. There was no subject that consumed the egg on monthly bases as compare to experimental group. Distribution of no. of subjects based on diet related variables in experimental and control group (20) mentioned in Table 4.5.

Table 4.5: Distribution of no. of subjects based on diet related variables in experimental and control group (20)

Variables	Characteristics	Control group	Treatment groups
Fish	Daily	0	0
	Weekly	2	9
	Monthly	3	6
Low carbohydrate fruits	Daily	0	4
	Weekly	3	6
	Monthly	2	5
Red meat	Daily	1	3
	Weekly	2	5
	Monthly	2	7
Egg	Daily	3	5
	Weekly	2	8
	Monthly	0	2

Clinical symptomatic quantitative score

Clinical symptomatic quantitative score performa was designed for diabetic patients. In this

performa, patients exposed which symptoms were scored according to their severity or acute condition. Zero was scored for none, 1 for 1-2 times per night, 2 for 3-4 times per night, 3 for 4-5 times per night and 4 for 5-6 times per night. Symptoms include polydipsia, polyphagia, polyuria, fatigue and weight losses were assessed before and after the fenugreek seed powder administration in capsulated form. All results showed positive means that after the fenugreek seed powder consumption, symptoms reduced day and day as mentioned in Table 4.6.

Table 4.6: Clinical symptomatic score table for diabetic subjects

Clinical symptoms	Score before study	Score after study
Polydipsia	3	1
Polyphagia	2	0
Fatigue	4	2
Polyuria	3	1
Weight loss	2	1

At the baseline of the study, the mean FBG level (Fasting Blood Glucose) of 1st group (T0) was 202.333 mg/dl, mean FBG level of 2nd group (T1) was 192 mg/dl, mean FBG level of 3rd group (T2) was 191 mg/dl and mean FBG level of 4th group (T3) was also 191 mg/dl. At 1st week, the mean FBG level of 1st group (T0) was reduced to 195.666 mg/dl, 2nd group (T1) was reduced to 183.333 mg/dl, third group (T2) was reduced to 184.667 mg/dl while 4th group (T3) was reduced to 185 mg/dl. At 2nd week, the mean FBG level of 1st group (T0) was not significantly reduced while the 2nd group (T1) was reduced to 187 mg/dl, 3rd group (T2) was reduced to 179.667 mg/dl and 4th group (T3) was reduced to 185 mg/dl. At 3rd week, the mean FBG level of 1st group (T0) was high i.e. 201.667 mg/dl while the 2nd group (T1) was reduced to 184.333 mg/dl, 3rd group (T2) was reduced to 176.667 mg/dl and 4th group (T3) was reduced to 182.333 mg/dl. At 4th week, the mean FBG level of 1st group (T0) was slightly lower (199 mg/dl) as compare to third week while the 2nd group (T1) was reduced to 183.333 mg/dl, 3rd group (T2) was reduced to 174.667 mg/dl and 4th group (T3) was reduced to 173 mg/dl. At 5th week, the mean FBG level of 1st group (T0) was reduced to 198.333 mg/dl while the 2nd group (T1) was reduced to 180.667 mg/dl, 3rd group (T2) was reduced to 171.333 mg/dl and 4th group (T3) was reduced to 170.333 mg/dl. At 6th week, the mean FBG level of 1st group (T0) was slightly increase to 199.333 mg/dl as compare to 5th week of the

study while the 2nd group (T1) was reduced to 177.667 mg/dl, 3rd group (T2) was reduced to 169 mg/dl and 4th group (T3) was reduced to 165.667 mg/dl. At 7th week, the mean FBG level of 1st group (T0) was increased to 203.333 mg/dl as compare to 6th week of the study while the 2nd group (T1) was reduced to 174 mg/dl, 3rd group (T2) was reduced to 165.666 mg/dl and 4th group (T3) was reduced to 158.333 mg/dl. At 8th week, the mean FBG level of 1st group (T0) was increased to 204.333 mg/dl while the 2nd group (T1) was reduced to 170 mg/dl, 3rd group (T2) was reduced to 162.333 mg/dl and 4th group (T3) was reduced to 153 mg/dl. These results are closely resemble to the results of Parkin et al. (2002) who proved that if the human subjects consume 700 mg fenugreek seed powder thrice a day, their fasting blood sugar level improved significantly.

Table 4.7: Analysis of variance table for FBG

Source	DF	SS	MS	F	P
Days	4	675.0	168.74		
Treatments	3	21439.0	7146.32	94.09	0.0002
Error	532	40404.4	75.95		
Total	539	62518.3			

Grand Mean: 181.36 CV: 4.81

At the baseline of the study, the mean PPBG level (Post Prandial Blood Glucose) of 1st group (T0) was 202.3333 mg/dl, mean PPBG level of 2nd group (T1) was 208 mg/dl, mean PPBG level of 3rd group (T2) was 209.667 mg/dl and mean PPBG level of 4th group (T3) was 199 mg/dl. At 1st week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was reduced to 195.666 mg/dl, 2nd group (T1) was reduced to 197 mg/dl, third group (T2) was reduced to 196.667 mg/dl while 4th group (T3) was reduced to 191.667 mg/dl. At 2nd week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was slightly reduced to 195 mg/dl, 2nd group (T1) was reduced to 197 mg/dl, third group (T2) was reduced to 196.667 mg/dl while 4th group (T3) was reduced to 191.667 mg/dl. At 3rd week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was increased to 201.667 mg/dl as compare to 2nd week, 2nd group (T1) was reduced to 189 mg/dl, third group (T2) was reduced to 187.777 mg/dl while 4th group (T3) was reduced to 180 mg/dl. At 4th week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was decreased to 199 mg/dl as compare to 3rd week, 2nd group (T1) was reduced to 185.667

mg/dl, third group (T2) was reduced to 184 mg/dl while 4th group (T3) was reduced to 177 mg/dl. At 5th week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was slightly decreased to 198.333 mg/dl, 2nd group (T1) was reduced to 179.333 mg/dl, third group (T2) was reduced to 181.667 mg/dl while 4th group (T3) was reduced to 178 mg/dl. At 6th week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was slightly increased to 199.333 mg/dl as compare to 6th week of the study while 2nd group (T1) was reduced to 178.333 mg/dl, third group (T2) was reduced to 181.667 mg/dl while 4th group (T3) was reduced to 174 mg/dl. At 7th week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was high (203.333 mg/dl) as compare to 6th week of the study while 2nd group (T1) was reduced to 177 mg/dl, third group (T2) was reduced to 172.667 mg/dl while 4th group (T3) was reduced to 169 mg/dl. At 8th week, the mean PPBG (Post Prandial Blood Glucose) level of 1st group (T0) was slightly increased to 204.333 mg/dl as compare to 7th week of the study while 2nd group (T1) was reduced to 177.333 mg/dl, third group (T2) was reduced to 171 mg/dl while 4th group (T3) was reduced to 166 mg/dl. These results matches with the results of Banerji et al. (2016) who proved that PPBG level reduce significantly with the high concentration of fenugreek seed powder.

At the baseline of the study, the mean urine sugar level of 1st group (T0) was 13.5 mg/dl, mean urine sugar level of 2nd group (T1) was 14.83 mg/dl, mean urine sugar level of 3rd group (T2) was 14.16 mg/dl and mean PPBS level of 4th group (T3) was 15 mg/dl. At 1st week, there is no reduction came in the mean urine sugar level of 1st group (T0) while 2nd group (T1) was reduced to 14.16 mg/dl, third group (T2) was reduced to 13.83 mg/dl and 4th group (T3) was reduced to 14.5 mg/dl. At 2nd week, the mean urine sugar level of 1st group (T0) was slightly increased to 13.83 mg/dl while 2nd group (T1) was reduced to 13.16 mg/dl, third group (T2) was reduced to 13.5mg/dl and 4th group (T3) was reduced to 12.83 mg/dl. At 3rd week, the mean urine sugar level of 1st group (T0) was slightly increased to 14 mg/dl while 2nd group (T1) was reduced to 12.5 mg/dl, third group (T2) was reduced to 12.83 mg/dl and 4th group (T3) was also reduced to 12.83 mg/dl.

Table 4.8: Fasting blood glucose (mg/dl) level of type 2 diabetic patients against fenugreek seed powder at different concentration of doses after 56 days intervals

Days	Treatments			
	CK	1 g	1.5 g	2g
0	202.333±1.52	192±1.73	191±1	191±1
7	195.666±2.64	188.333±0.57	184.667±0.57	185±1
14	195±3.21	187±1	179.667±0.57	182.333±3.21
21	201.667±1	184.333±0.57	176.667±0.57	174.667±0.57
28	199±1.52	183.333±1.52	174.667±0.57	173±1
35	198.333±3.51	180.667±0.57	171.333±1.52	170.333±0.57
42	199.333±2.08	177.667±2.51	169±1	165.667±2.08
49	203.333±0.57	174±1.73	165.666±1.15	158.333±2.08
56	204.333±1	170±1	162.333±1.54	153±1.73

Table 4.9: Analysis of variance table for PPBG

Source	DF	SS	MS	F	P
Days	4	2771.1	692.77		
Treatments	3	14609.8	4869.94	50.19	0.0002
Error	532	51621.3	97.03		
Total	539	69002.2			

Grand Mean: 193.96 CV: 5.08

Tab 4.10: Post prandial blood glucose (mg/dl) level of type 2 diabetic patients against fenugreek seed powder at different concentration of doses after 56 days intervals

Days	Treatments			
	CK	1 g	1.5 g	2g
0	202.333±2.08	208±6.24	209.667±0.57	199±1
7	195.666±6.65	197±2	196.667±1.52	191.667±6.42
14	195±5.19	193±1	189.333±0.57	198±1
21	201.667±1.52	189±1	187.333±0.57	180±5.13
28	199±1.73	185.667±1.53	184±1.73	177±2.88
35	198.333±0.57	179.333±0.57	181.667±1.52	178±1
42	199.333±2.08	178.333±1.52	177.333±1.52	174±5.85
49	203.333±0.57	177±1	172.667±2.51	169±0.57
56	204.333±5.03	177.333±0.57	171±1	166±1.52

Table 4.11: Analysis of variance table for UA

Source	DF	SS	MS	F	P
Days	4	43.58	10.895		
Treatments	3	938.42	312.807	31.74	0.0002
Error	532	5242.33	9.854		
Total	539	6224.33			

Grand Mean: 15.535 CV: 20.21

Table 4.12: Urine analysis (mg/dl) of type 2 diabetic patients against fenugreek seed powder at different concentration of doses after 56 days intervals

Days	Treatments			
	CK	1 g	1.5 g	2g
0	13.5±0.353	14.83±0.353	14.16±0.353	15±0.707
7	13.5±0.707	14.16±1.060	13.83±0.353	14.5±0.707
14	13.83±1.414	13.16±0.353	13.5±0.353	12.83±0.707
21	14±0.707	12.5±0.707	12.83±1.060	12.83±0.353
28	13.33±0.353	13±1.060	12.33±0.707	11.83±0.353
35	13.16±0.353	11.5±0.353	11.33±0.353	11.16±0.353
42	13.16±0.353	11.66±0.353	11.33±0.353	11.83±1.060
49	13.33±0.353	11±0.707	11±0.353	10.83±0.353
56	13.5±0.707	10.16±0.353	9.83±0.353	9.66±0.353

At 4th week, the mean urine sugar level of 1st group (T0) was slightly reduced to 13.33 mg/dl as compared to 3rd week while 2nd group (T1) was reduced to 13 mg/dl, third group (T2) was reduced to 12.33 mg/dl and 4th group (T3) was also reduced to 11.83 mg/dl. At 5th week, the mean urine sugar level of 1st group (T0) was slightly reduced to 13.16 mg/dl as compared to 4th week while 2nd group (T1) was reduced to 11.5 mg/dl, third group (T2) was reduced to 11.33 mg/dl and 4th group (T3) was reduced to 11.16 mg/dl. At 6th week, there is no significant reduction in the mean urine sugar level of 1st group (T0) while 2nd group (T1) was reduced to 11.66 mg/dl, third group (T2) was reduced to 11.33 mg/dl and 4th group (T3) was reduced to 11.83 mg/dl. At 7th week, the mean urine sugar level of 1st group (T0) was slightly increased to 13.33 mg/dl as compared to 6th week while 2nd group (T1) was reduced to 11 mg/dl, third group (T2) was also reduced to 11 mg/dl and 4th group (T3) was reduced to 10.83 mg/dl. At 8th week, the mean urine sugar level of 1st group (T0) was slightly increased to 13.5 mg/dl as compared to 7th week while 2nd group (T1) was reduced to 10.16 mg/dl, third group (T2) was also reduced to 9.83 mg/dl and 4th group (T3) was reduced to 9.66 mg/dl. These results are closely associated to the results of Sharma et al. (2005) who proved that 24-hour urinary excretion level reduces significantly by the consumption of fenugreek seed powder.

CONCLUSION

In conclusion, fenugreek seed powder in capsulated form significantly reduced fasting blood glucose, post prandial blood glucose and twenty-four-hour urinary excretion level. It also reduces the symptoms include polyuria, polydipsia, polyphagia, and weight loss.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed to the idea, experimental planning, experiments, data analysis, writing and correction of the manuscript. All authors read and approved the final version of the manuscript.

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