Effect of *Trigonella foenum-graecum* seeds on the glycemic index of food: A clinical evaluation

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BACKGROUND: A diet with a low glycemic index (GI), rich in dietary fiber content, is good for the management of postprandial blood glucose levels (PBG), both in normal people as well as in those with type II diabetes mellitus (type 2 DM). **AIM:** The present study was carried out to evaluate the effect of food products containing *Trigonella foenum-graecum* seed (fenugreek) on PBG by determining the GI value of foods in healthy volunteers and in those with type 2DM. **METHODOLOGY:** Three food products (foods A, B, and C), containing known amounts of fenugreek seeds were prepared and evaluated for their acceptance value. After a stipulated time interval food C (which was found to be the most acceptable of the three) and standard food was given to healthy human volunteers and type 2 DM to determine the area under blood glucose increment (AUC) and the GI value of the food. **RESULT**: In healthy volunteers and diabetic patients, the GI of food C was 60.4 ± 16.4 and 36.83 ± 12.8, respectively; this is significantly (P<0.05) lower than the GI of standard food in the two groups, which was 76.6 ± 16.9 and 46.9 ± 15, respectively. In both healthy volunteers and diabetic patients there is a slower and more sustained glucose release from food C compared to standard food and the AUC is less than that of standard food. **CONCLUSION**: These results confirm that high fiber content is capable of lowering the GI value of the food, and this has a beneficial effect on the PBG levels in persons with type 2 DM as well as in healthy people.

KEY WORDS: Dietary fibre, fenugreek seeds, glycemic index, type II diabetes

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Diabetes is emerging in epidemic proportions throughout the world. Nearly 171 million people worldwide suffer from diabetes and the figure is likely to double by 2030, to reach 366 million.[1] Diet modification plays an important role in the management of type 2 diabetes mellitus (type 2DM) and several scientific studies provide evidence in support of this.[2–10] In the past, diabetic patients were advised to avoid carbohydrates, but it is now accepted and recommended by diabetic associations that 60-70% of the calories in a diabetic diet should be provided by carbohydrate and that the carbohydrate should be in the form of complex polysaccharides (starch) and nonstarch polysaccharide (dietary fiber).[10-12] Both the amount and the type of carbohydrate induce distinct plasma glucose and insulin responses which is quantified by the glycemic index (GI).[2,6,13-15] Clinical and preclinical experiments suggest that foods with a low GI improves glycemic control and reduces hypoglycemic episodes, both in animal models and in diabetic patients.[3,14,16] Intake of food high in dietary fiber (such as whole grain, unrefined cereals, and legumes) instead of more rapidly digested forms of carbohydrates improves glycemic control because of the slow release of carbohydrate due to the high fiber content.[7,14,17–20] Fiber, particularly soluble fiber, has repeatedly been shown to decrease postprandial blood glucose (PBG) and insulin response, both in persons with diabetes and in those without the disease.[19,21,22]

Trigonella foenum-graecum L (Fenugreek) is a legume, rich in soluble dietary fiber and protein.[6,22,23] Fenugreek seeds and its extract have exhibited hypoglycemic and hypocholesterolemic activity in animal and human models.[24–29] Inclusion of fenugreek in the daily diet in amounts of 25–100 gm can serve as an effective therapy in the clinical management of diabetes.[20] Its hypoglycemic activity is ascribed to the presence of soluble dietary fiber,[26] saponin fraction, and 4-hydroxyisoleucine, a free amino acid.[27] The hypoglycemic activity of fenugreek

seed is also due to glucose-dependent insulin secretion from pancreatic beta cells and soluble dietary fiber (50%) that can slow the rate of glucose absorption.[23]

The poor acceptability of fenugreek seeds in the diet, due to its bitter taste, poses a problem. To overcome this, in our present study we designed foods in which fenugreek seed was combined with regular food items (e.g. chapatti) to mask its taste. The prepared food was analyzed for its acceptance value and then subjected to clinical evaluation to determine its effect on PBG and The GI value.

Methodology

The study protocol was approved by the institutional ethics committee.

Preparation of food products containing fenugreek seed powder (FSP)

Fenugreek seeds and wheat grains were purchased from the local market, cleaned and sun dried before being powdered. FSP and wheat flour were mixed in the ratio of 1:3 (food A), 1:6 (food B), and 1:9 (food C). After adding sufficient water, the mixture was kneaded to make dough and then seasoned overnight. The required amount of dough was rolled into chapattis and roasted on a hot *tava* using only a little oil. Chapattis prepared with plain wheat flour were taken as the standard food. The nutritive values of all the prepared foods and the standard food are given in Table 1; these figures are as per the reported values in the book 'Nutritive Value of Indian Food.'[27]

Evaluating acceptance value of the prepared food

Prepared food products and standard food were given to thirty healthy volunteers for evaluating the acceptance value.[30] The volunteers assessed the foods for nine attributes on a scale of 0 to 5 [Table 2] and food C was found to be the most acceptable of the three.

Determination of GI

1. *In healthy volunteers:* Ten well-informed and motivated healthy volunteers in the age-group of 20–25 years participated in the double-blind cross-over study. The volunteers were instructed to come on an empty stomach after overnight fasting. They underwent a physical examination, where height, weight, waist to hip ratio, blood pressure, and pulse rates were recorded; fasting blood glucose (FBG) was also determined. Following this, 50 gm of glucose in 150 ml of water was administered and blood samples were collected at 15, 30, 45, 60, 90, and 120 min to estimate the blood glucose levels. In next two successive weeks instead of glucose they were instructed to consume food C and next week standard food. Each food consumed contains 50 gm of available carbohydrate.

2. *Type 2DM:* Ten known cases of type 2DM, without evidence of hypertension, renal or cardiac disease, or any other chronic disorder, were selected for the study. Among the ten, six patients participated in the study, while four patients dropped out due to poor health. The patients were in the age-group of 30-65 years. They were asked to stop hypoglycemic medication one night before the start of the study. The procedure followed was similar to that for the healthy volunteers.

Blood glucose estimation[31]

Venous blood (2 ml) was drawn and placed in a centrifuge tube containing 2 mg sodium fluoride and sodium oxalate (1:1 ratio) as anticoagulant. Serum was separated by centrifugation. The blood glucose was estimated by o-toluidine method, using a glucose reagent kit (Dr. Reddy's Laboratories; Hyderabad, India).

Calculation of AUC and GI[13]

Blood glucose response at different time intervals were used to calculate AUC, and GI value was calculated using the following equation.

Area under the blood glucose increment for 50 gm

$$GI = \frac{\text{Carbohydrate from test food}}{\text{Area under blood glucose increment for 50 gm glucose}} \times 100$$

Statistical analysis

Statistical analysis was done with the help of GraphPad InStat package and all data were expressed as mean ± standard deviation. Data of sensory evaluation and AUC were analyzed by one-way ANOVA with Student-Newman-Keul's multiple comparison procedure. Paired t test was used for comparison of the GI of standard food and test food. Only differences with $P<0.05$ were considered significant.

Results

Acceptance values of all the prepared foods are shown in Table 2. The acceptance value of food C (3.42 ± 0.33) was

Table 1: Nutritional values of prepared food

	Composition per 100 gm of edible portion					
Reported values of	**Protein**	**Fat**	**Fiber**	**Carbohydrate**	**Minerals**	**Energy (K cal)**
Wheat flour (whole)	12.1	1.7	1.9	69.4	2.7	341
Fenugreek seed (whole)	26.2	5.8	7.2	44.1	3.0	333
Food C	13.42	2.11	2.43	66.81	2.73	339.3
Food B	14.10	2.28	2.65	65.6	2.78	339.8
Food A	15.61	2.71	3.23	63.06	2.78	338.6

Table 2: Acceptance evaluation of prepared food products

Attributes	Food A	Food B	Food C	Standard food
Liking for the colour	2.0 ± 0.26	2.9 ± 0.30	3.4 ± 1.7	4 ± 0.3
Breakability	2.7 ± 0.20	2.9 ± 0.30	3.2 ± 0.11	4.2 ± 0.37
Chewability	2.5 ± 0.23	3.0 ± 0.28	3.5 ± 0.15	3.9 ± 0.26
Taste	1.9 ± 0.28	2.6 ± 0.10	3.7 ± 0.20	4.5 ± 0.12
Flavor	1.9 ± 0.28	2.7 ± 0.09	3.3 ± 0.1	4.7 ± 0.34
Oiliness	2.2 ± 0.25	2.6 ± 0.66	2.8 ± 0.20	4.3 ± 0.10
Aftertaste	1.7 ± 0.34	2.7 ± 0.45	3.4 ± 0.25	4 ± 0.40
Cooked well	2.4 ± 0.86	3.1 ± 0.20	3.5 ± 0.37	4.4 ± 0.19
Over all liking	1.9 ± 0.15	3.0 ± 0.10	3.7 ± 0.10	4.7 ± 0.13
Mean ± SD	2.1 ± 0.335 [a]	2.8 ± 0.187 [b]	3.4 ± 0.276 [c]	4.3 ± 0.3

n=30, Data of food A, food B, and food C were subjected to one way analysis of variance by Student-Newman-Keul's multiple comparison test. [a]*P*<0.01 compared to food B, [b]*P*<0.01 compared to food C, [c]*P*<0.01 compared to food A

significantly greater (*P*<0.01) than that of food B (2.8 ± 0.18) and food A (2.1 ± 0.33). The calculated nutritional values of all the foods are reported in Table 1. Mean incremental blood glucose profile of healthy volunteers and diabetic patients are shown in Figures 1 and 2. The AUC and GI values of the subjects (both healthy volunteers and diabetic patients) after consumtion of glucose, standard food, and food C is given in Table 3. In healthy volunteers, the AUC for glucose (5217 ± 1012 mg.min/dl) was more than that for standard food (3923 ± 529 mg.min/dl), which was more than that for food C (3050 ± 787 mg.min/dl, *P*<0.05 when compared to standard food). Comparison of the GI values from the Table 3, shows that food C had significantly less value (60.4 ± 16.4) than standard food (76.4±16.9); *P*<0.05.

In diabetic patients, the AUC of glucose, standard food and food C followed the same order as that of healthy volunteers. Similarly, the GI of food C (36.83 ± 12.8) was significantly lower (*P*<0.05) than that of standard food (46.9 ± 15).

Discussion

The data suggests that the GI value of food C is significantly reduced by 21% when compared to standard food. Similarly, Figures 1 and 2 clearly indicate that after a meal challenge test with food C, both healthy

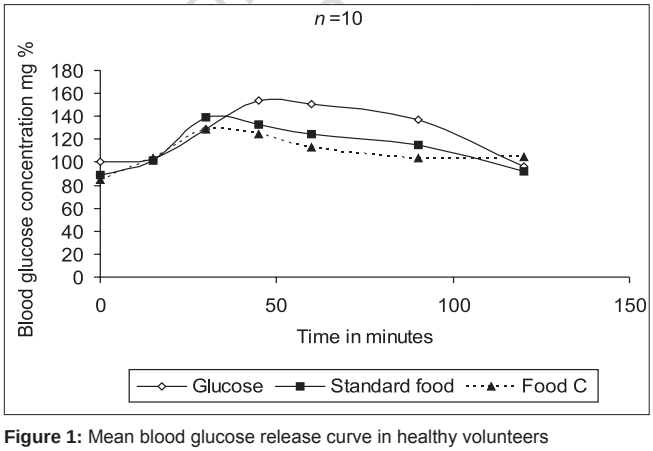

Figure 1: Mean blood glucose release curve in healthy volunteers

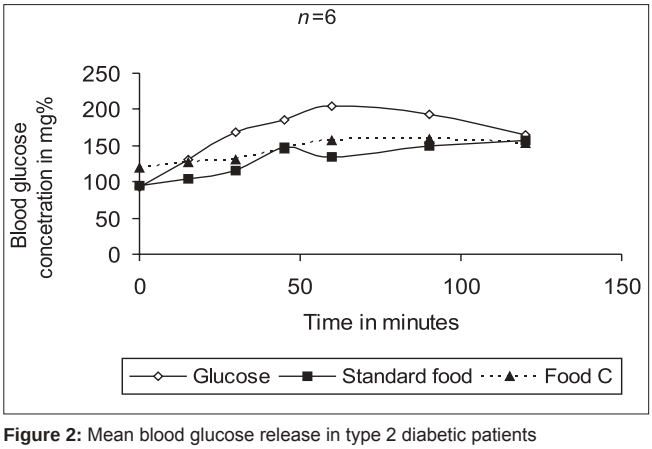

Figure 2: Mean blood glucose release in type 2 diabetic patients

Table 3: Mean area under blood glucose increment and glycemic index

Volunteers	Area under blood glucose Increment (mg.min/dl)			Glycemic index	
	Glucose	Standard food	Food C	Standard food	Food C
Healthy (*n*=10)	5217 ± 1012	3923 ± 529	3050 ± 787[a]	76.6 ± 16.9	60.4 ± 16.4*
Type 2DM (*n*=6)	9791 ± 3867	4180 ± 888	3239 ± 175[b]	46.9 ± 15	36.83 ± 12.85**

[a, b]AUC of food C is significantly less $P<0.05$ than standard food. *,**GI value of food C is significant at $P=0.0159$, $P=0.0333$ compared to standard food.

volunteers and diabetic patients showed a sustained blood glucose release from food C in comparison with standard food. The slow release from food C helps in maintaining PBG by reducing glucose response and serum insulin.[6,19]

These effects of food C are due to the addition of 10% fenugreek seed powder containing 2.43% of fiber, which retards glucose absorption and thus reduces the serum insulin levels;[21,32] the effect may also be partly due to the presence of the constituent 4-hydroxyisoleucine.[27]

Therefore, food C could be used as a replacement food for plain chapattis; it provides a healthy and easily digested carbohydrate diet that can help maintain PBG within a normal range in healthy and diabetic patients.[20]

Conclusion

In keeping with our aim, we were able to successfully improve the acceptability of fenugreek seed as a food supplement by incorporating the required quantity in the regular diet. This helped in lowering the GI value of food by retarding the release of glucose. Hence, including food C as a supplement in the daily diet can help in the management of type 2DM.

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