Effect of fenugreek seeds on blood glucose and serum lipids in Type I diabetes

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The effect of fenugreek seeds (*Trigonella foenum graecum*) on blood glucose and the serum lipid profile was evaluated in insulin-dependent (Type I) diabetic patients. Isocaloric diets with and without fenugreek were each given randomly for 10 d. Defatted fenugreek seed powder (100 g), divided into two equal doses, was incorporated into the diet and served during lunch and dinner. The fenugreek diet significantly reduced fasting blood sugar and improved the glucose tolerance test. There was a 54 per cent reduction in 24-h urinary glucose excretion. Serum total cholesterol, LDL and VLDL cholesterol and triglycerides were also significantly reduced. The HDL cholesterol fraction, however, remained unchanged. These results indicate the usefulness of fenugreek seeds in the management of diabetes.

Beneficial effects of dietary fibre in the management of diabetes have been well recognized (Peterson, 1985; Madar & Thorne, 1987). Seeds of fenugreek (*Trigonella foenum graecum*) are a rich source of fibre (Sharma, 1986*a*). Therefore, there has been greater awareness of the antidiabetic properties of fenugreek seeds.

Several studies, in recent years, have demonstrated the hypoglycaemic effect of fenugreek seeds and its subfractions in experimentally induced diabetic rats (Shani *et al.*, 1974; Madar, 1984), dogs (Ribes *et al.*, 1984, 1986), and mice (Ajabnoor & Tilmisany, 1988). In addition, results of our studies (Sharma, 1986*a*; Sharma & Raghuram, 1989) and of others (Madar *et al.*, 1988) have also indicated the usefulness of fenugreek seeds in the management of Type II diabetes. Since insulin-dependent diabetes differs from non-insulin dependent diabetes with respect to aetiopathogenesis and management, in the present study an attempt has been made to assess the antidiabetic properties of fenugreek seeds in insulin-dependent diabetic patients. Earlier studies have also shown that fenugreek seeds reduce serum lipids in experimental animals (Sharma, 1984, 1986*b*; Valetta *et al.*, 1984) and in non-insulin dependent diabetic patients (Sharma, 1986*a*; Sharma & Raghuram, 1989). Since diabetics frequently have abnormal lipid profiles (Betteridge, 1989), we have also studied the hypolipidaemic properties of fenugreek seeds in Type I diabetic patients.

In India there are many diabetics whose blood glucose levels are not properly controlled because they cannot buy costly medicines such as insulin. Moreover, malnourished diabetic patients, who cannot afford adequate food after insulin administration, intentionally take suboptimal doses of the drug to prevent hypoglycaemic episodes. As fenugreek seeds are commonly used as a condiment in India, the demonstration of beneficial effects of fenugreek would have considerable practical significance.

Fenugreek seeds were powdered and extracted with ether and alcohol as described earlier (Sharma, 1986*a*). The defatted fenugreek powder thus prepared contained (as percentages) moisture 9.9, ash 3.5, lipids 0.1, protein 28.3, starch 6.5, total fibre 51.7 (gum 19.2 and neutral detergent fibre 32.5).

Ten insulin-dependent diabetic patients (7 m, 3 f) aged between 12 and 37 years with a body mass index of 17 ± 0.97, participated in the study. The study was approved by the Ethical Committee of the Institute. The diagnosis was based on WHO criteria (WHO, 1985). All the patients were on continuous insulin therapy (Table 1). During the preliminary stay in the hospital, the patients were put on a fixed dose of insulin which was maintained throughout the metabolic study. This dosage was not enough to maintain the blood sugar at normal levels, otherwise it would not have been possible to test the effect of fenugreek. The carbohydrate intake was increased by 40–50 g daily to prevent hypoglycaemic episodes. The patients were kept under constant clinical supervision by one of the authors (N.S.R.).

A metabolic study of two 10-d periods was carried out in these patients. Fenugreek administration was randomized such that 5 patients received a diet containing fenugreek in the first period and the rest received it in the second period. A standard diet was fed experimental period, 100 g of debitterized powdered fenugreek seeds, treated to remove bitterness, was divided into equal doses, and was incorporated in the 'chapati' (unleavened bread) and served during lunch and dinner. The treated fenugreek seed powder was odourless and tasteless and when incorporated into chapatis was acceptable to all patients. The 100 g of fenugreek powder added to the experimental diet contained 28.3 g of protein and 51.7 g of carbohydrate in the form of dietary fibre. By the addition of protein isolate from groundnut to the control diet, the protein contents of both the diets were equalized. However, no attempt was made to adjust the carbohydrate content of both diets since fenugreek in the experimental diet had only unavailable carbohydrate in the form of dietary fibre. Both diets were similar in all respects, except for the fibre content.

Glucose tolerance test

An oral glucose tolerance test (GTT) was performed at the end of each study period. After an overnight fast, a basal blood sample was collected and the routine insulin dose, which was fixed before the study, was administered with a hypodermic syringe. Ten minutes after the insulin dose, 75 g glucose was given and blood samples were collected at half-hourly intervals for the next 2 h to monitor blood glucose (Nelson &

Table 1. Clinical description of patients.

Subject no.	*Sex*	*Age*	*Duration of disease*		*Insulin dose (units)*		*Fasting glucose*	*Urinary glucose*
		(years)	*(years)*	*(months)*	*Soluble*	*Lente*	*(mmol/l)*	*(mmol/24 h)*
1	M	12	1	6	10	25	17.9	468
2	M	16	R.D.		10	25	9.9	194
3	M	32	15	0	10	40	28.5	833
4	F	19	10	0	10	30	11.4	422
5	F	15	2	0	10	30	12.4	255
6	M	25	R.D.		10	30	27.4	497
7	M	37	10	0	10	40	13.4	301
8	M	30	6	0	10	0	5.6	181
9	M	15	1	0	10	30	13.2	461
10	F	26	10	0	10	30	10.9	20
Mean		22.7					15.1	363
s.e.m.		2.7					2.4	71

Somogyi, 1963) and insulin (Phillai & Mani, 1978) levels. The glucose load, the insulin dose and the time schedule followed during each study period were all similar.

On the last day of each study period, 24-h urinary glucose excretion was estimated. Serum cholesterol (Zlatkis, Zak & Boyle, 1953), and its fractions (Warnick & Albers, 1981) and triglycerides (Van Handel & Zilversmit, 1957) were determined in the blood sample collected after overnight fasting. Areas under the glucose and insulin concentration curves were determined using the trapezoidal rule.

Statistical significance was determined using Student's *t*-test for paired data.

Results

Both the control and experimental diets were isocaloric and had similar nutrient composition except for the fibre content which was higher in the fenugreek diet. The food intake during the control and experimental period was similar. The mean energy intake was 2016 ± 479 kcal (8439 ± 2005 kJ) of which 63.3 per cent was derived from carbohydrate, 18 per cent from fat and 18.7 per cent from protein. Total dietary fibre intake was 28 ± 3.5 g/d during the control period and 79.7 ± 6.6 g/d during the experimental period.

There was no significant change in body weight during the two study periods. The average change in the whole group was 0.12 ± 1.4 kg during the control period and 0.18 ± 0.8 kg during the experimental period. Four patients, while on the fenugreek diet, complained initially of minor gastrointestinal symptoms such as diarrhoea and excess flatulence which subsided after 3–4 d. No other adverse effects were observed. The diabetic symptoms such as polyuria and polydipsia were also found to be under control in a majority of the patients on the fenugreek diet.

The mean fasting blood glucose levels after fenugreek diet were significantly reduced from 15.1 ± 2.4 to 10.9 ± 2.75 mmol/l ($P < 0.01$). After the glucose load, the rise in blood glucose levels at 30, 60 and 90 min were also lower. As a result, the area under the blood glucose concentration curve was significantly reduced ($P < 0.05$). However, serum insulin levels and the area under the insulin curve were not significantly altered by fenugreek administration (Table 2).

The fenugreek diet reduced the 24-h urinary excretion of sugar to the extent of 54 per cent from 363 ± 71 to 167 ± 61 mmol ($P < 0.01$). Serum total cholesterol, VLDL and LDL cholesterol and triglyceride levels were also significantly reduced after the fenugreek diet as compared to the control diet. However, the HDL cholesterol fraction was not significantly affected (Fig. 1).

Discussion

The incorporation of fenugreek in the diet of Type I diabetic patients reduced fasting blood sugar levels and improved the glucose tolerance. These changes were in agreement with the earlier observations made in Type II diabetic patients with a fenugreek diet

Table 2. Effect of fenugreek seeds on blood glucose and serum insulin levels (mean ± s.e.m.).

Time (h)	*Blood glucose (mmol/l)*		*Serum insulin (pmol/l)*	
	Control	*Experimental*	*Control*	*Experimental*
0.0	15.1 ± 2.4	10.9 ± 2.7**	306.4 ± 116.2	210.7 ± 114.1
0.5	21.1 ± 2.8	15.8 ± 2.5**	418.3 ± 155.7	330.8 ± 155.5
1.0	24.7 ± 3.1	20.4 ± 3.3*	445.6 ± 152.1	367.4 ± 117.7
1.5	24.8 ± 3.1	20.1 ± 3.1***	442.0 ± 145.6	365.2 ± 120.5
2.0	22.3 ± 3.1	19.1 ± 2.1	472.1 ± 164.3	359.5 ± 116.2
	AUC (mmol/l per min)		*AUC (pmol/l per min)*	
	2679 ± 342.5	2178 ± 343.3*	49 170 ± 17 557	41 952 ± 14 027

*Levels of significance: *P < 0.05, **P < 0.01, ***P < 0.005*

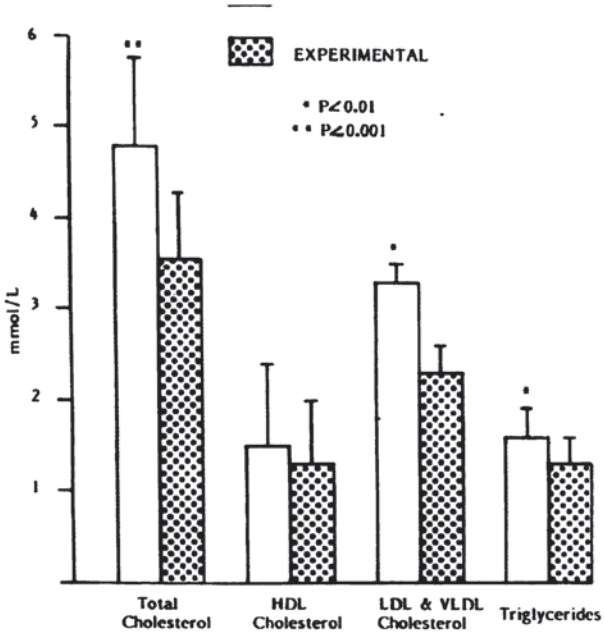

Fig. 1. Effect of fenugreek seeds on serum lipid profile.

(Sharma, 1986*a*; Sharma & Raghuram, 1989). Fenugreek seeds are rich in fibre (51.7 per cent) (Sharma, 1986*a*). Fenugreek resembles guar gum in chemical structure with a high viscosity of 20 cP (Ribes *et al.*, 1984). Jenkins *et al.* (1978) have demonstrated the beneficial effects of guar gum for insulin-dependent diabetic patients.

In the present study, it is unlikely that much of the fenugreek remained in the gastrointestinal tract for a period of 12 h and impeded the absorption of glucose resulting in an improvement in glucose tolerance. It is known that not all effects of dietary fibre on carbohydrate metabolism are related to events in the gastrointestinal tract. Long-term studies have shown that dietary fibre dose not have to be concurrently administered with a meal in order to produce beneficial effect on glucose tolerance (Brodribb & Humphreys, 1976). Several studies provide direct and indirect evidence to suggest that subjects become sensitive to insulin after adaptation to the high fibre diets (Reiser, 1979). In the present study, although the serum insulin levels on control and experimental diets were similar, the blood glucose levels were significantly lower after the experimental diet. This suggests insulin.

Studies in experimental animals also demonstrate the hypoglycaemic properties of fenugreek seeds. Decoction of fenugreek seeds has been shown to reduce fasting blood glucose even after 24 h in alloxan-treated mice (Ajabnoor & Tilminsany, 1988). Similarly, a factor isolated from fenugreek seeds is found to suppress the glucose tolerance test for a period of 1 week in alloxan-treated rabbits (Moorthy, Prabhu & Murthy, 1989). Since these effects have been observed in alloxan-treated animals where there would be significant destruction of beta cells of the pancreas, they suggested that the factor from fenugreek seeds may have an extra pancreatic effect.

Another significant effect of the fenugreek diet was its ability to reduce the urinary loss of sugar. This effect is similar to that observed with guar gum in diabetics (Jenkins *et al.*, 1978). It is likely that in the presence of dietary fibre, the glucose absorption was delayed and as a result there was minimal post-prandial rise in blood glucose level beyond renal threshold level. Reduced urinary excretion of sugar resulted in greater retention of dietary carbohydrate in the body. It is known that increased carbohydrate intake improves glucose tolerance both in healthy and diabetic subjects (Brunzell *et al.*, 1971).

Some patients who were on suboptimal doses of insulin due to socioeconomic factors had high blood glucose levels. They were included in the study as beneficial effects of guar gum had been demonstrated in such subjects (Jenkins *et al.*, 1978). In the present study, there was considerable improvement in clinical condition as a result of reduction in urinary excretion of sugar even in these inadequately controlled diabetics. Since fenugreek is commonly used as a condiment in India by all the socioeconomic groups, this observation has considerable practical importance.

There was a significant reduction in serum lipid levels in spite of the patients' normal values before the study. The fall in the total cholesterol was mainly due to reduction in LDL and VLDL fractions. The HDL choles-

studies in experimental rats demonstrated that fenugreek administration increased excretion of bile acids and neutral sterols in faeces, thus depleting the cholesterol stores in the body (Sharma, 1984, 1986*b*; Bhat, Sambaiah & Chandrasekhara, 1985). Since alterations in serum lipid profiles are known in diabetics (Betteridge, 1989), which are likely to increase the risk of coronary heart disease (Stamler *et al*., 1986), a reduction in serum lipids, particularly in the LDL and VLDL fractions and triglyceride levels, should be considered as beneficial in the long-term prognosis of these patients.

In conclusion, these results indicate that dietary intake of fenugreek seed powder improves glucose tolerance and the serum lipid profile in insulin-dependent diabetic patients. Further, since a high proportion of diabetic patients in the tropics and subtropics suffer from malnutrition (Tripathy & Kar, 1965), fenugreek which is rich in protein (28 per cent) has an added advantage in that it is a good source of protein as well as fibre.

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