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Some Complementary Hypoglycemic Supplements from Grains and Legumes for the Management of Type 2 Diabetes Mellitus

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In this study the aim was to introduce and incorporate some of the traditional plants as test foods supplements: namely wheat, two forms of fenugreek (both powdered and germinated), lupine and chickpea. Also, the combination of two test foods in the same mixture in the form of biscuits in which whole wheat is the main constituent, to serve as adjuncts to the orthodox medical treatment, to aid in the rapid normalization and consequent stabilization of the blood glucose levels. Volunteers of apparently uncomplicated type 2 diabetic patients recruited from the National Research Center, Cairo Egypt. They were divided to 9 groups and instructed to follow a low hypocaloric balanced diet. Eight groups instructed to substituted known amounts of the above mentioned nutrients for part of their daily breakfast bread for one week for each test food item calculated according to their carbohydrate content. The last group followed the diet only. Mean blood sugar levels were decreased at all time points in the glucose tolerance test. Significant values were noted on the glucose curve of lupine, fenugreek powdered, partially decorticated belila and at all the points of the curve in the data of two biscuits 1 and 2 in comparison to basal levels. A significant fall in serum insulin levels after 2 h were observed in lupine with a percentage decrease (-39.93%) and after introducing partially decorticated wheat (belila) with a percentage decrease of -44.94% after 2 h. Data for HBA1c showed a numerical decrease for all groups except for that of lupine and a significant loss was found for whole wheat and biscuit 1. In conclusion various combinations of different grains and legumes led to a beneficial hypoglycemic effect together with the improvement of glucose, insulin and glycosylated haemoglobin in type 2 diabetics.

Key words: Grains, whole grain cereals, legumes, hypoglycemic, management, type 2 diabetes mellitus

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INTRODUCTION

Increasing evidence in both experimental and clinical studies suggests that oxidative stress plays a major role in the pathogenesis of both types of diabetes mellitus. Free radicals are formed disproportionately in diabetes by glucose oxidation, nonenzymatic glycation of protein and the subsequent oxidative degradation of glycated proteins. Abnormally high levels of free radicals and the simultaneous decline of antioxidant defense mechanisms can lead to damage of cellular organelles and enzymes, increased lipid peroxidation and development of insulin resistance. These consequences of oxidative stress can promote the development of complications of diabetes mellitus (Maritim *et al*., 2003). Phytochemicals are components of plants that convey healthful properties beyond their use as macronutrients or micronutrients. Scientists have identified thousands of phytochemicals in vegetables fruits, grains legumes and other plant sources (Block, 2003).

Brazilian type 2 diabetic patients have a six-fold excess infection-related mortality than the general population. This increased mortality is mainly determined by the presence of micro and macrovascular complication (Claudia *et al*., 2007).

Food structure plays an important role in determining the accessibility of starch to digestion, thus inflaming the postprandial blood glucose response, which modulates plasma insulin and lipid levels (Riccardi *et al*., 2003).

Dietary carbohydrates that produce both low post prandial blood glucose and insulin responses are considered beneficial for health (Juntunen *et al*., 2000). Animal research suggested that fenugreek may contain a substance that stimulates insulin production and improves blood sugar control (Puri *et al*., 2002).

Investigation of the effects of dietary fiber (as in wheat germ) supplementation in type 2 diabetes versus acarbose on glycemia and serum lipid fractions demonstrated that high-fiber diabetic diets were effective in lowering the blood glucose and serum lipids (Englyst *et al*., 2001).

Only recently have epidemiologic and other data shown that whole grains have a role in preventing cardiovascular disease, diabetes, some types of cancer and even obesity. What nearly all consumers and most health professional fail to realize is that whole grains deliver as many if not more phytochemicals and antioxidants then do fruits and vegetables (Jones *et al*., 2004). The incidence of type 2 diabetes is increasing dramatically worldwide, resulting from the increasing prevalence of obesity (Yale, 2000). Unfortunately patients who have metabolic syndrome or diabetes are at greatly increased risk of cardiovascular morbidity and mortality (Ford and Giles, 2002).

While the aetiology of obesity and diabetes is complex diet clearly plays an important role both in the development and management of these diseases. This is of interest in functional foods that could help in prevention and/or management of obesity and type 2 diabetes. This could involve food products that help the management of hunger or that increase Satiety. Food may be targeted towards maximizing insulin sensitivity and towards Prevention of diabetes. In addition to food that impact upon body weight, these may include foods that affect the glucose and/or insulin levels that are seen either following the ingestion of the food or eaten in the day (Hill and Peters, 2002).

The 2000 edition of Nutrition and your Health: Dietary Guidelines for Americans was the first to include a specific guideline for grain foods, separate from fruits and vegetables and to recognize the unique health benefits of whole grains (Kantor *et al*., 2001).

Therefore, it was the aim in this project to take advantage of the above mentioned facts to incorporate some of the popular traditional plants as test foods namely wheat, two forms of fenugreek (both powdered and germinated), lupine and chickpea as adjuncts to the orthodox medical treatment, to aid in the rapid normalization and consequent stabilization of the blood glucose levels thus leading to the control of the complications of the disease.

Another very important approach to the problem was to use different combinations of these separate food items to emphasize certain beneficial effects.

MATERIALS AND METHODS

Ninety-four type 2 diabetic patients shared in this study, their age ranged from 43-64 years. They were recruited from the National Research Center, Cairo-Egypt, in January 2006. They were classified into 9 groups with approximately similar age and BMI. Each of the volunteer diabetic patient was medically monitored by her own physician and given medications appropriate to her condition. Essentially all the patients among the first eight groups were instructed to consume a low caloric balanced diet (1000 kcal day^{-1}) for at least one week before the introduction of the test foods, which were intended to function as a beneficial adjunct in the nutritional setting of the patients. Group 9 patients were instructed to follow the low caloric balanced diet for the same week, to be served as a control.

Table 1: Chemical analysis of the dried some grains and legumes

Content	Whole wheat	Partially decorticated	Fenugreek powder	Fenugreek germinated	Lupine	Chickpea
Moisture	9.5	9.2	7.2	7.8	6.7	5.0
Ash (g/100 g)	0.5	0.4	2.8	2.9	1.7	1.0
Total protein (g/100 g)	12.6	13.5	33.0	35.0	53.4	24.7
Fat (g/100 g)	2.0	1.5	7.8	8.5	5.5	5.6
Carbohydrate (g/100 g)	75.4	75.4	49.2	45.8	32.7	63.7
Fiber (g/100 g}	2.3	1.5	7.2	4.0	9.0	3.4

Table 2: The ingredient contents of the two different biscuits

Ingredients (g)	Biscuit 1	Biscuit 2
Whole wheat flour	1000	500
Chickpea flour	--	500
Fenugreek powder	250	--
Skimmed milk powder	125	125
Sun flower oil	100	100
Yeast	25	25
Salt	15	15
Cumin	30	30

Tested food:

- Group 1: Eight patients consumed 100 g unsweetened boiled whole wheat (belila 1).
- Group 2: Ten patients consumed 100 g partially decorticated wheat (belila 2).
- Group 3: Twelve patients consumed 15 g fenugreek powder seeds (Madar *et al*., 1988).
- Group 4: Twelve patients consumed 100 g germinated fenugreek seeds.
- Group 5: Ten patients consumed 100 g soaked and boiled edible lupine (Smith, 1987).
- Group 6: Ten patients consumed 50 g roasted chickpea ready to eat.
- Group 7: Twelve patients consumed 30 g ready to eat salty biscuit 1.
- Group 8: Ten patients consumed 30 g ready to eat salty biscuit 2.
- Group 9: Ten patients consumed only the constructed hypocaloric diet.

The patients were then instructed to substitute part of their daily breakfast bread (carbohydrate content) ration by an appropriate amount of each of the above mentioned foods for one week. The calculated macronutrients contents of the patients breakfast were; 24.7 g protein, 8.4 g fat and 45.8 g carbohydrate, that supply 356 K calories. Every patient would have served as his own control (Table 1). The first (biscuit 1) was made from a mixture of baked whole grain wheat and powdered fenugreek and the second from whole grain wheat and milled chickpea (biscuit 2), Table 2. The ingredients were purchased of the best qualities, from the local markets.

Fasting blood was drawn from all patients at the last day of consuming the low caloric balance diet and before the introduction of the tested foods and was considered as basal and designated 1st visit. Another sample was drawn at the end of one-week period for each of the tested foods and was designated 2nd visit. Blood for the analysis of glucose and insulin was drawn at 0, 30, 60, 90, 120 min intervals before and after eating breakfast, which consisted of each of the above mentioned test foods supplement in the breakfast, which was assigned to each of the volunteers. Other biochemical analyses were performed on fasting blood serum samples stored at -70°C until needed.

Anthropometric measurements: Weights and heights were recorded according to standard methods. Body Mass Index (BMI) was calculated.

$$BMI = weight\ (kg)/(height)^2\ (m)$$

Abdominal-1 and hip circumferences were measured. The waist hip ratio W/H ratio then calculated.

$$WHR = waist\ in\ cm/hip\ in\ cm$$

Chemical food analysis: Chemical food analysis of the legumes and biscuits was undertaken for:

Macronutrients including: Protein, fat, carbohydrate was using AOAC Association of Official Analysis Chemists, Official Methods, (AOAC, 1990).

Biochemical analysis:

- Haemoglobin level was measured using cyanomethaemoglobin method (Van Kampen and Zijlstra, 1961).
- Glycohaemoglobin concentration was measured by using quantitative colorimetric determination of glycohaemoglobin in whole blood (Abraham *et al*., 1978).
- Blood glucose was determined in fresh samples using oxide peroxidase method (Barham and Trinder, 1972).
- Insulin level was determines using ELISA Kit (Frier *et al*., 1981).

Statistical analysis: Statistical significance was set at the p<0.05 and less and values are expressed as mean±SEM. Dependent t-tests were calculated comparing all measured variables using SPSS programme, version 7.5

RESULTS

Table 1 showed the chemical analysis of the dried grains and legumes per 100 dried weight, include, moisture, total protein, fat and carbohydrate. Table 2 showed the amount of the different ingredients that were used in the preparation of the two biscuits. Table 3 showed that the mean weight and BMI of the examined groups decreased significantly in case of fenugreek powder with a percentage decrease of -0.45% and belila partially decorticated wheat (-0.90%) and in case of the two formulae of biscuits 1 and 2 (-0.93 and -1.13%) respectively. Significant data was obtained in case of whole wheat, lupine and the two biscuits for hip measurements. WHR showed significant loss among fenugreek powder consumers.

After one week of administration, data for HBA_{1c} showed a numerical decrease for all groups except that of lupine and a significant loss was found for data of whole wheat and biscuit 1 (Table 4).

Table 3: Some anthropometric parameters of the different groups before and after intervention

	Weight (kg)			BMI (kg m^{-2})		
	Mean±SEM			Mean±SEM		
Diabetic groups	1st visit	2nd visit	Percent change	1st visit	2nd visit	Percent change
Whole wheat (Group 1, n = 8)	87.6±4.7	87.3±4.8	-0.34	36.2±1.9	36.0±2.0	-0.55
Partially decorticated wheat (Group 2, n = 10)	89.1±4.3	88.3±4.2**	-0.90	36.3±1.9	36.0±1.9**	-0.83
Fenugreek powder (Group 3, n = 12)	89.3±3.7	88.9±3.7*	-0.45	35.4±2.0	35.3±2.0*	-0.28
Fenugreek germinated (Group 4, n = 12)	88.8±3.4	88.9±3.6	+0.11	36.2±1.6	36.3±1.6	+0.28
Lupine (Group 5, n = 10)	76.1±2.0	76.0±1.8	-0.13	31.4±1.1	31.4±1.0	--
Chickpea (Group 6, n = 10)	77.2±2.2	76.8±2.3	+0.52	35.0±2.3	34.9±2.3	-0.29
Fenugreek biscuit 1 (Group 7, n = 12)	86.2±4.1	85.4±4.0***	-0.93	35.4±2.0	35.2±2.0**	-0.56
Chickpea biscuit 2 (Group 8, n = 10)	88.7±4.1	87.7±4.1**	-1.13	37.3±1.7	36.9±1.7**	-1.07
Control (Group 9, n = 10)	81.5±3.7	81.2±3.1	-0.37	33.9±2.6	33.7±2.4	-0.59
	Hip (cm)			WHR (cm)		
	Mean±SEM			Mean±SEM		
Diabetic groups	1st visit	2nd visit	Percent change	1st visit	2nd visit	Percent change
Whole wheat (Group 1, n = 8)	120.1±2.9	118.4±3.0*	-1.42	0.81±0.10	0.81±0.07	--
Partially decorticated wheat (Group 2, n = 10)	117.7±3.6	117.3±3.5	-0.34	0.86±0.02	0.86±0.02	--
Fenugreek powder (Group 3, n = 12)	115.3±3.9	115.2±3.9	-0.09	0.91±0.02	0.89±0.02*	-2.20
Fenugreek germinated (Group 4, n = 12)	117.7±2.8	117.4±2.9	-0.25	0.88±0.02	0.89±0.02	+1.14
Lupine (Group 5, n = 10)	108.8±2.1	108.1±2.1*	-0.64	0.86±0.02	1.00±0.01***	+16.28
Chickpea (Group 6, n = 10)	108.8±2.2	108.8±2.2	--	0.86±0.02	0.86±0.02	--
Fenugreek biscuit 1 (Group 7, n = 12)	118.3±3.4	117.0±3.3**	-1.10	0.86±0.02	0.85±0.02	-1.16
Chickpea biscuit 2 (Group 8, n = 10)	119.3±2.7	117.6±2.4**	-1.42	0.83±0.09	0.84±0.01*	+1.20
Control (Group 9, n = 10)	114.9±3.7	114.2±5.9	-0.63	0.81±0.03	0.81±0.02	--

1st visit vs 2nd visit p-value *<0.05 **<0.01 ***<0.001

Table 4: Duration, age, haemoglobin and HBA1c of the different groups before and after intervention

	Duration, years	Age, years	Haemoglobin (mg dL^{-1})			HBA1c		
	Mean±SEM	Mean±SEM	Mean±SEM			Mean±SEM		
Diabetic groups	1st visit	1st visit	1st visit	2nd visit	Percent change	1st visit	2nd visit	Percent change
Whole wheat (Group 1)	5.3±1.9	54.0±3.4	12.1±0.6	11.6±0.7*	-4.13	15.1±0.7	13.3±1.1**	-11.92
Partially decorticated wheat (Group 2)	4.1±1.3	50.7±2.2	12.5±0.6	12.5±0.6	--	15.4±0.7	15.2±0.9	-1.30
Fenugreek powder (Group 3)	4.3±1.1	52.4±2.2	13.3±0.7	13.3±0.7	--	16.1±0.7	13.9±0.8	-13.66
Fenugreek germinated (Group 4)	3.6±1.2	50.8±1.8	13.0±0.5	13.2±0.5	+1.54	13.9±0.3	13.6±0.8	-2.16
Lupine (Group 5)	4.6±1.3	56.1±2.1	12.2±0.3	12.6±0.4*	+3.28	9.1±1.0	9.4±2.3	+3.30
Chickpea (Group 6)	4.6±1.3	56.1±2.1	12.7±0.2	12.2±0.3***	-3.94	9.7±1.1	9.4±0.9	-3.09
Fenugreek biscuit 1 (Group 7)	5.2±1.2	52.8±2.4	12.9±0.6	13.2±0.5	+2.33	15.0±0.9	12.3±0.8***	-18.00
Chickpea biscuit 2 (Group 8)	5.6±1.4	52.8±2.9	12.1±0.6	11.9±0.4	-1.65	13.4±0.8	12.2±0.8	-8.96
Control (Group 9)	4.8±1.1	51.0±2.1	12.9±0.6	12.8±0.5	-0.78	15.5±0.7	15.9±0.9	+2.30

1st visit vs 2nd visit p-value *<0.05 **<0.01 ***<0.001

Table 5: Blood glucose and insulin levels in the different groups before and after intervention

Diabetic groups	Visits	Blood glucose (mg/100 mL) Fasting	½ h	1 h	1½ h	2 h
Whole wheat (Group 1)	1st	125.5±10.1	158.5±8.9	186.0 ±17.1	185.5±19.6	168.0±18.6
	2nd	119.3±9.5***	168.2±10.9	180.3±6.3	168.8±4.6	144.8±3.4
	Percent change	-4.94	-6.12	-3.06	-9.0	-13.81
Partially decorticated wheat (Group 2)	1st	151.0±11.1	196.4±9.5	224.2±12.6	209.2±17.4	196.8±15.5
	2nd	119.6±9.3***	174.8±9.7	190.6±11.5**	160.2±10.1***	143.2±11.8***
	Percent change	-20.79	-11.0	-14.99	-23.42	-27.24
Fenugreek powder (Group 3)	1st	126.5±8.5	178.2±10.1	200.7±13.4	186.0±14.9	164.3±12.5
	2nd	124.0±10.2	157.5±10.4***	167.8±9.2***	155.3±14.6*	139.5±14.8**
	Percent change	-1.98	-11.62	-16.39	-16.51	-15.09
Fenugreek germinated (Group 4)	1st	126.7±13.9	166.5±13.2	167.3±9.8	147.7±9.3	129.8±9.2
	2nd	142.2±12.7**	167.2±12.7	162.5±7.1	141.3±10.8	116.2±11.1
	Percent change	+1.2.23	+0.42	-2.87	-4.33	-10.48
Lupine (Group 5)	1st	127.2±7.0	171.6± 8.2	204.8±4.9	186.8±8.7	180.0±5.3
	2nd	113.4±3.6	165.4± 5.3	160.8±5.9***	137.8±5.2***	116.6±3.4***
	Percent change	-10.85	-3.61	-21.48	-26.23	-35.22
Chickpea. (Group 6)	1st	132.6±12.9	185.8±21.9	220.6±23.4	205.6±21.3	189.6±21.4
	2nd	132.8±14.4	194.6±30.5	215.4±29.9	196.6±25.2	170.2±17.3
	Percent change	+0.15	+4.74	-2.36	-4.38	-10.23
Fenugreek biscuits 1 (Group 7)	1st	157.7±29.9	195.7±24.1	228.5±21.6	206.5±21.5	184.5±20.2
	2nd	137.8±19.6	167.7±17.3**	187.0±21.6***	162.5±21.7***	147.7±21.9**
	Percent change	-12.62	-14.31	-18.16	-21.31	-19.95
Chickpea biscuits 2 (Group 8)	1st	152.2±23.1	190.6±18.4	216.0±18.4	216.8±19.3	193.4±19.7
	2nd	139.4±18.3*	166.6±17.0***	176.4±12.9***	165.2±15.6***	145.8±13.1***
	Percent change	-8.41	-12.59	-18.33	-23.80	-24.61
Control group (Group 9)	1st	138.2±10.6	189.8±15.6	230.4±12.1	215.3±20.5	200.8±14.5
	2nd	137.2±9.4	196.5±20.1	228.2±11.3	208.4±13.4	198.1±15.1
	Percent change	-0.74	+3.53	-0.96	-3.21	-1.35

Diabetic groups	Visits	Insulin (μIU mL^{-1}) Fasting	½ h	1 h	1½ h	2 h
Whole wheat (Group 1)	1st	6.9±0.5	16.7±1.7	20.2±3.2	18.2±1.7	19.9±2.0
	2nd	7.7±0.9	14.3±2.1	14.4±1.3*	12.9±1.3	12.3±1.1***
	Percent change	+11.59	-14.37	-28.71	-29.12	-38.19
Partially decorticated wheat (Group 2)	1st	9.0±1.4	18.7±2.4	17.8±1.4	20.2±1.7	17.8±2.8
	2nd	6.5±1.8	16.8±2.8	17.6±3.5	12.9±2.5	9.81±0.1*
	Percent change	-27.78	-10.16	-1.12	-36.14	-44.94
Fenugreek powder (Group 3)	1st	5.2±0.7	16.9±2.0	31.5±5.1	26.1±4.7	17.1±1.2
	2nd	6.5±1.1	21.4±4.4	34.3±7.0	25.9±4.0	14.0±2.1
	Percent change	+25.00	+26.63	+8.89	-0.77	-18.13
Fenugreek germinated (Group 4)	1st	7.4±0.4	22.2±4.8	57.8±21.2	32.8±10.4	43.4±18.5
	2nd	9.0±1.2	19.3±3.0	24.6±5.1	21.7±3.4	19.4±3.0
	Percent change	+21.62	-13.06	-57.44	-33.84	-55.30
Lupine (Group 5)	1st	10.7±0.9	20.1±3.1	41.1±10.4	47.3±15.5	27.3±7.5
	2nd	8.3±1.7*	28.9±7.6	32.9±9.9***	20.0±5.3*	16.4±1.2
	Percent change	-22.43	+43.78	-19.95	-57.72	-39.93
Chickpea. (Group 6)	1st	12.5±0.9	35.0± 4.4	35.0±8.5	43.0±15.7	21.5±6.7
	2nd	13.5±2.3	28.0±7.3	33.0±7.2	32.5±7.3	21.0±4.7
	Percent change	+8.0	-20.0	-5.71	-24.42	-2.33
Fenugreek biscuits 1(Group 7)	1st	9.1±2.2	18.4±1.0	21.4±0.7	22.9±5.6	13.7±0.66
	2nd	6.6±1.1	10.6±1.2***	14.8±3.3	19.3±3.6	12.6±2.3
	Percent change	-27.47	-42.39	-30.84	-15.72	-8.03
Chickpea biscuits 2 (Group 8)	1st	5.9±1.0	14.7±1.4	29.5±4.5	28.7±7.2	15.5±1.9
	2nd	5.2±0.7	12.9±2.1	13.4±1.4**	13.4±2.7*	8.0±0.4***
	Percent change	-11.86	-12.24	-54.58	-53.31	-48.39
Control group (Group 9)	1st	12.9±1.7	30.4±4.2	39.1± 3.9	33.1±4.7	30.6 ±3.8
	2nd	13.1±1.5	29.1±6.3	37.9±2.8	32.3±4.9	29.9 ±3.9
	Percent change	+1.56	-4.28	-3.07	-2.42	-2.27

Significant values were noted on the glucose curve of lupine, fenugreek powdered, partially decorticated belila and at all the points of the curve in the data of two biscuits 1 and 2 in comparison to basal levels Table 5.

A significant fall in serum insulin levels after 2 h were observed in lupine with a percentage decrease (-39.93 %) and after introducing partially decorticated wheat (belila) with a percentage decrease of -44.94% after 2 h.

From our data all legumes and seeds used have negative effect on glucose, insulin and glycosylated haemoglobin.

DISCUSSION

Thus, dietary supplements that can modulate glucose homeostasis and potentially improve lipid parameter would be desirable. Legumes are recommended for better glucose control in persons with diabetes (Paul *et al*., 2004) and that the inclusion of legumes in the diets of diabetic patients has resulted in better glucose disposal (Wolever *et al*., 1992). At the same time regular consumption of whole grain foods has been associated with reduction in the incidence of cardiovascular disease and diabetes, reduction in cancer at certain sites and over all reduction in premature death (Lang and Jebb, 2003). Recently, prospective studies showed an inverse association between whole grain intake and type 2 diabetes in women (Pereira *et al*., 2002).

The scientific data so far obtained on the two most important biochemical parameters concerning diabetes, namely blood glucose and insulin are more than satisfactory compared to diabetic control, as it is noticed from the glucose tolerance curve in all the first six groups. However, the mixing of more than one item in the form of biscuits as used in the last two groups (group 7, 8) evoked the lowest blood glucose and insulin response.

To comment on the whole wheat introduced in the diet of diabetic patients, there is a growing literature highlighting that the carbohydrates which are high in grains produce both low post prandial blood glucose and insulin responses (Wolever *et al*., 1994). The low glycemic responses were explained by the viscous fiber content of the grain (Lu *et al*., 2000) which may slow the gastric emptying rate or the absorption of nutrients in the small intestine (Champ and Noah, 1997). It was also reported that postprandial insulin responses to grains and their products are determined by the form and botanical structure rather than by the amount of fiber or the type of cereal in the food (Juntunen *et al*., 2000).

In this study, both whole wheat seeds and also the partially decorticated wheat (belila) gave a good response by significantly decreasing the blood sugar.

Fenugreek seeds have been shown to have a high efficacy at relatively low doses and during both short and longer term interventions (Sharma *et al*., 1990; Gupta *et al*., 2001). Long term feeding fenugreek brings about substantial morphological changes in the large bowel and changes in activities of some brush border enzyme (Bond and Levitt, 1967). In other studies an increase in the molar insulin bonding sites of the erythrocytes was demonstrated (Raghuram *et al*., 1994). The beneficial effects of fenugreek is due to its active principal in which, the unique dietary fiber composition galactomannans inhibit the absorption of glucose from small intestine (Evans *et al*., 1992; Hannan *et al*., 2003) and to its high saponin content. The presence of 4-HO isoleiucine found also in fenugreek seed has both insulinotropic and antidiabetic properties, in vitro work indicate that 4-HO isoleucine directly caused pancreatic β-cell stimulation (Madar and Stark, 2002).

In this study, when fenugreek seed powder was included in the daily diet of diabetic patients, it improved glucose tolerance and serum insulin levels. Unfortunately, the use of fenugreek has been limited due to its bitter taste and pungent odour. To overcome this problem we tried to use germinated seeds, which was more acceptable than seed powder. The rapid normalization of blood sugar curve of the dried seed powder was more effective and was more significant in many points on the curve than that of germinated seed, which, might have lost some of its active principal in germination.

Our data after introducing edible lupine in the diet for one week. Showed a considerable significant decrease of blood glucose curve after hour, 1½ and 2 h with a percentage loss -21.48, -26.23 and 35.22%, respectively, also a percentage reduction of insulin concentration 19.95, 57.72 and 39.93%.

Villaroel *et al*. (1996) found that, data on lupine marmalade was lower in individual after 2-test meal of lupine marmalade compared to fructose marmalade. The fact that 13-alpha-OH lupinine and 17-Oxo-lupinine only exert their secretogogue effect at high glucose concentration could be of additional value when considering their potential use in the treatment of type 2 diabetes (Garcia-Lopez *et al*., 2004).

Newairy *et al*. (2002) said that the elevated glucose level of diabetic rats was restored to its normal level after treatment with hypoglycemic (termis seed). By using a dose of 1.5 mL aqueous suspension/100 g body weight four weeks. While a specific lupine protein named Conglutin δ, was found to display a binding capacity to some small regulatory proteins including insulin (Duranti, 2006).

A low glycemic index food such as chickpea results in lower plasma glucose, insulin and the homeostasis model assessment (HOMA) responses after a single meal than after meals of similar available carbohydrate content derived from wheat based or higher glycemic index foods (Paul *et al*., 2004; Habib and Ahsan, 2004) found that Chickpea is capable of lowering blood cholesterol and blood glucose levels and is consequently effective against coronary heart disease and diabetes mellitus.

The data of this study showed that consumption of chickpea for one week led to numerical loss in the glucose and insulin curves which was significant after 2 h for insulin assessed by HOMA. This may reflect the higher amylose content and the botanical structure of chickpea. It is also likely that the starch in the chickpea is digested and absorbed more slowly in the small intestine than from wheat (Paul *et al*., 2004). Botham *et al.* (1996) reported that 15% of the starch in chickpea escaped hydrolysis in the small intestine of ileostomy patients. The total loss of chickpea is lessened through fermentation in the large intestine and is consistent with the absence of weight loss in the long term study (Paul *et al*., 2004).

The effect of the composite biscuits (whole wheat/ fenugreek/(biscuit 1)) and (whole wheat/chickpea (Biscuit 2)) was a beneficial lowering all through the curves of blood sugar and insulin.

Significant reduction of mean glycosylated hemoglobin (Table 4) was observed on ingestion of whole wheat and biscuit 1 for one week in the diet and a numerical decrease in all the other items studied except lupine. The reduction in glycosylated haemoglobin levels may be due to a decrease of glucose concentration in blood leading to lowered rate of glycosylation (Morris *et al*., 1980; Testa *et al*., 1996).

Lower insulin response to the ingestion of these seeds and legumes in the diet of diabetic patients compared to diabetic control was observed in the present study (Table 5), which might be due merely to low glucose response caused by low glycemic index diet.

Kiens and Richer (1996) said that reducing the level of insulin required to maintain normal blood glucose is an indication of improvement in insulin resistance or greater insulin sensitivity.

Accumulating data indicate that a diet characterized by low glycemic index (GI), not only improve metabolic ramifications of insulin resistance, but also reduce insulin resistance *per se* (Bjorck *et al*., 2000). Furthermore, high GI would increase insulin production and at the same time, decrease synthesis of insulin receptor (Augustin *et al*., 2002).

In this study the body weight and body mass index (BMI) of the patients decreased significantly on fenugreek seeds, belila and biscuit (1) and (2). Hip circumference decreased in patient on lupine biscuit (1) and (2). WHR decreased significantly on fenugreek powder (Table 3). These changes were obtained after one week of consumption of these test foods. The greater decrease was recorded with the use of the two biscuits, which contained grains, legumes and seeds in a mixture.

In this context, the rich fiber content of the biscuit could have played a role as a filling agent promoting satiety and better bowel functioning thus leading to diminished food intake. Also, the biscuits may provide the body with key micronutrients such as vitamins, minerals and antioxidants, which would have positively influenced the function of the metabolic machinery.

The fact that dietary chemicals play such key roles in regulating gene expression beyond their well-known roles of producing energy and affecting insulin levels is a consistent evolutionary theory, given that the human genome evolved in response to the plant-and animal derived dietary chemicals we consume (Kaput and Rodriguez, 2004).

In conclusion, consumption of whole grain foods and legumes in many forms daily by diabetic patients, improves glucose tolerance and serum insulin levels.

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