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EFFECT OF DAILY CONSUMPTION OF A VARIETY OF GRAINS ON SOME OF TYPE 2 DIABETIC COMPLICATIONS

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Diabetes mellitus is associated with oxidative stress, evidence of inflammatory markers and other mechanisms, which may contribute to accelerated atherosclerosis. This study was designed to find the effect of the consumption of whole grains, cereals and dried legumes used in different forms on the levels of blood glucose, serum lipid profiles, antioxidant enzymes activity, C-reactive protein (CRP) and microalbuminuria. Eighty-four type 2 diabetic patients participated in this study. They were divided into eight groups; for one week each of the groups consumed different forms of the tested food, which is intended to function as a beneficial adjunct in the nutritional setting of the patients. Certain food items, which replaced equivalent amount of breakfast carbohydrate, were used as food supplements, namely: unsweetened boiled whole wheat (Belila 1), unsweetened boiled partial decorticated wheat (Belila 2), germinated fenugreek seeds, grinded fenugreek seeds, soaked boiled edible lupine, roasted chickpea. Group 7 and group 8 consumed also a defined amount of biscuits made from whole wheat flour and either grinded fenugreek or chickpea. Weight, height and waist circumference of the subjects were recorded, and body mass index (BMI) was calculated. Blood glucose, total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and very low-density lipoprotein cholesterol (VLDL-C), triglyceride levels were determined. Lipid peroxide (oxidative LDL-C), superoxide dismutase (SOD), glutathione peroxidase enzyme (GPx) activity, CRP and urinary microalbumin levels were measured as well. After intervention diabetic patients showed different percent decreases in the mean levels of the fasting and postprandial glucose, within a range of -1.97 to 20.8 and -10.23 to 35.22, respectively. A significant difference at $p<0.05$ and $p<0.01$ was detected between group 2 and 8. Mean levels of TC and LDL-C decreased significantly among patients of group 2 only at $p<0.01$. VLDL-C and triglyceride levels decreased in all groups with different percent, a significant difference at $p<0.05$ $p<0.01$ was found also among group 2 and 8. HDL-C increased within a range of 0.76–24.58%, and a significant difference at 0.05 was detected in group 6 and 7. Lipid peroxide level decreased among the first seven groups and significantly among group 8. GPx activity showed higher improvement compared to SOD activity, five groups showed a significant difference in the SOD activity after the end of the intervention period at $p<0.05$–0.01. CRP and microalbuminuria improved in all groups, the greater decrease was –56.06% and -52.54% in group 1 and group 7, respectively. In conclusion, the results of this study showed that daily consumption of whole grains, cereals and legumes by the diabetic patients had a beneficial effect on improving the glycemic control that is showed by decreasing their fasting and postprandial blood glucose, also in decreasing serum lipids markers. Positive findings were also detected as regards their antioxidant and anti-inflammatory properties, which could alleviate some complications such as microalbuminuria.

INTRODUCTION

Diabetes mellitus is associated with oxidative stress, evidence of inflammatory markers and other mechanisms, which may contribute to accelerated atheroschelorosis [Kalousova *et al*., 2004]. Oxidative stress may be increased in diabetes owing to the high production of reactive oxygen species (ROS) and/or deficiency in the antioxidant defence system [Baynes, 1991; Gillery *et al*., 1989]. The increased production of ROS has been attributed to protein glycation and/or glucose autooxidation owing to a hyperglycemic environment [Hunt *et al*., 1990]. The impaired radical scavenger function has been linked to a decreased activity of enzymatic and non-enzymatic scavengers of the free radicals [Kesavulu *et al*., 2001]. In addition many observations have related atherosclerosis to chronic low-degree inflammation characterised by an increase in circulating acute-phase proteins produced by the liver such as acid glycoprotein (AGP), C-reactive protein (CRP) and fibrinogen [Kuller *et al*., 1996; Stec *et al*., 2000; Lowe *et al*., 2001; Ridcker *et al*., 2000]. Recent evidence indicates the role of both oxidation and inflammation in cardiovascular disease and endothelial dysfunction, exacerbated by factors such as dyslipidemia. Because endothelial dysfunction can also be manifested as microalbuminuria this provides a potential explanation of the observed association of the metabolic syndrome, chronic inflammation and microalbuminuria [Rowley *et al*., 2003].

Grain products along with fruits and vegetables form the base of a healthy diet. Grain provides complex carbohydrate, fiber and key vitamins and minerals, which may protect against coronary heart disease, diabetes, and some types of cancer [Kantor *et al*., 2001]. Whole grains also contain many phytochemicals and antioxidants [Jones *et al*., 2004]. Because of the low glycaemic index (GI) and the high content of indigestible fibers, dry legumes are claimed to help glycaemic control in diabetic individuals. Moreover, dry legumes may contribute to prevent insulin-resistance, which represents the prodrome to type 2 diabetes [Duranti, 2006].

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So it had been emphasized the importance of including legumes in the diets of patients with type 2 diabetes to achieve the desired overall glycaemic index [Venn & Mann, 2004].

The objective of this study was to determine the effect of the consumption of whole grains, cereals and dried legumes used in different forms on the levels of both blood glucose and lipids, in type 2 diabetes patients. In addition their effects on lipid oxidation antioxidant enzymes (SOD and GPx), C-reactive protein and microalbuminuria were also investigated. A comparison between the effect of the different grains and legumes used on different parameters was taken in consideration as well.

MATERIALS AND METHODS

Subjects

Eighty-four volunteers, type 2 diabetic patients, participated in this study, their age ranged from 43-64 years. They were classified into 8 groups. Each of the volunteer diabetic patient was medically monitored by their own physician and given medications appropriate to their condition. Essentially all the patients were instructed to consume balanced diet suitable for diabetic plus the test foods which were intended to function as a beneficial adjuncts in the nutritional setting of the patients. The amount of each supplement was chosen to replace a calculated portion of the carbohydrate present in the breakfast bread. To reach our aim the volunteers should be compliant enough with this regimen, in order to get the beneficial effect without causing any major change in their daily breakfast. The groups examined were as follows:

– Group 1: eight patients consumed 100 gm unsweetened boiled whole wheat (belila 1).

– Group 2: ten patients consumed 100 gm partially decorticated wheat (belila 2).

– Group 3: twelve patients consumed 100 gm germinated fenugreek seeds.

– Group 4: twelve patients consumed 15 gm grinded fenugreek seed [Raju *et al*., 2001].

– Group 5: ten patients consumed 100 gm soaked and boiled edible lupine [Smith, 1987].

– Group 6: ten patients consumed 50 gm roasted chickpea ready to eat.

– Group 7: twelve patients consumed 30 gm ready to eat salty biscuits, made from whole wheat flour and grinded fenugreek seeds (Biscuit I).

– Group 8: ten patients consumed 30 gm ready to eat salty biscuit, made from whole wheat flour and grinded chickpea (Biscuit П).

The patients were instructed to substitute part of their daily breakfast bread ration by one of the above mentioned foods for one week, tailored to the needs of each patient, so as to comply with their prescribed diet by their medical doctors. All the above kinds of food supplements were designed to supply approximately equal amount of carbohydrate. Fasting blood was drawn from all patients 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, in that case every patient would have served as his own control. Blood glucose determination was done immediately, while analyses of the other biochemical parameters were performed on fasting blood serum, heparinized blood and washed erythrocyte, samples that were stored at -70°C until needed. Three successive morning urine samples were collected from each patient, and stored at –70°C until used for microalbumin determination.

Anthropometric measurements

Weights and heights were recorded according to standard methods [Jellife, 1966]. Body mass index (BMI) was calculated according to the formula: $BMI = weight\ (kg)/\ (height)^2\ (m)$. Waist circumference was measured as well.

Blood pressure

It was obtained with the participants sitting quietly for 5 minutes using a mercury sphygmomanometer. Three readings were recorded, the means of the second and third of the first (systolic) and fifth (diastolic) Korotkoff sounds were used.

Biochemical analyses

Blood glucose was determined in fresh samples using the oxide peroxidase method [Barham & Trinder, 1972]. Lipid profiles were assayed as follows: cholesterol was determined by using procedure NO.1010, Stanbio [Trinder, 1969]; HDL-C was determined by using procedure NO.0599, Stanbio [Finley, 1978]; triglyceride was determined by using procedure No.2100, Stanbio [Wahlefeld, 1974]; and LDL-C concentration was calculated by Friedewalds formula: LDL-cholesterol = (total cholesterol)-((HDL-cholesterol) +(triglyceride/5)) [Friedewald *et al*., 1972], where TG was below 400 mg/dL.

Lipid peroxide was determined with the method of Draper & Hadley [1990].

Superoxide dismutase enzyme (SOD) was determined in washed erythrocytes using WAK-Chemie GMBH, Germany, Kit [Suttle &McMurray, 1983].

Glutathione peroxidase enzyme was assayed as follows: whole blood was used for estimation of glutathione peroxidase enzyme by using WAK-Chemie Medical GMBH, Germany, Kit [Anderson *et al*., 1978].

Micro-albumin was determined by using enzyme immunoassay for the quantitative determination in urine [Walker *et al*., 1992]. Kits were provided by ORGENTEC Diagnostika GmbH

C-reactive protein was determined using the CRP-turbilatex method (SPAIN REACT KIT) [Chetana, 1996].

Statistical analysis

Data were expressed as means ± standard error of the means. Two-tailed Students' t-test was used to compare the variables. The p values of <0.05 – 0.01 were considered to be significant. All calculations were made with SPSS software ver. 7.5.

RESULTS

Table 1 showed the characters of the studied diabetic patients, the mean ±SEM of the age, anthropometric parameters and blood pressure that were recorded before and after

TABLE 1. Age, some anthropometric parameters and blood pressure in the different groups before and after intervention

Groups	Age (Y)	Height (cm)	Weight (kg)			BMI (kg/m^2)			Waist circumference (cm)			Systolic blood pressure (mmHg)			Diastolic blood pressure (mmHg)		
	x̄±SE	x̄±SE	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change
	1st	2nd	1st	2nd		1st	2nd		1st	2nd		1st	2nd		1st	2nd	
Group 1	54.0 ±3.4	155.8 ±1.5	87.6 ±4.7	87.3 ±4.8	-0.34	36.2 ±1.9	36.0 ±1.9	-0.55	97.3 ±2.9	96.0 ±2.9	-1.34	130.0 ±2.3	128.8 ±2.8	-0.92	82.5 ±1.6	82.5 ±1.6	--
Group 2	50.7 ±2.2	157.0 ±1.6	89.1 ±4.3	88.3 ±4.2**	-0.90	36.3 ±1.9	35.9 ±1.9**	-1.10	100.5 ±2.7	100.2 ±2.5	-0.30	130.0 ±4.4	125.0 ±4.2	-3.85	81.0 ±2.2	79.0 ±2.2	-2.47
Group 3	52.4 ±2.2	159.8 ±2.4	89.3 ±3.7	88.9 ±3.7*	-0.45	35.4 ±2.0	35.3±2.0*	-0.28	103.7 ±1.5	102.8 ±1.7	-0.87	140.8 ±3.3	137.5 ±2.4	-2.34	83.3 ±1.7	82.5 ±1.2	+0.96
Group 4	50.8 ±1.8	156.8 ±1.3	88.8 ±3.4	88.9±3.6	+0.11	36.2 ±1.6	36.3±1.6	+0.28	103.3 ±2.3	104.3 ±2.3	+0.97	128.0 ±2.6	121.7 ±1.9	-4.92	80.0 ±0.9	78.8 ±1.0	-1.50
Group 5	56.1 2.1	155.8 ±1.33	76.1 ±2.0	76.0±1.8	-0.13	31.4 ±1.1	31.4±1.0	--	93.4±1.1	93.4 ±1.2	--	133.4 ±3.4	129.0 ±3.4	-3.30	82.4 ±1.7	81.0 ±1.9	-1.70
Group 6	56.1 ±2.1	155.8 ±1.3	77.2 ±2.2	76.8±2.3	+0.52	35.0 ±2.3	34.9±2.3	-0.29	93.9±1.6	93.7 ±1.9	-0.21	138.4 ±3.6	137.4 ±1.5	-0.72	81.4 ±1.5	81.0 ±0.7	-0.49
Group 7	52.8 ±2.4	156.8 ±1.9	86.2 ±4.1	85.4 ±4.0***	-0.93	35.4 ±2.01	35.2 ±1.9**	-0.56	101.1±3.2	99.5 ±3.1	-1.58	134.2 ±3.5	134.2 ±3.1	--	82.5 ±1.4	82.5 ±1.2	--
Group 8	52.8 ±2.9	154.4 ±1.8	88.7 ±4.1	87.7 ±4.1**	-1.13	37.3 ±1.7	36.9±1.7**	-1.07	99.1 ±2.8	98.5 ±2.8	-0.61	128.0 ±2.5	129.0 ±1.9	+0.78	79.2 ±0.3	80.0 ±1.1	+1.01

x̄ – mean, SE – Standard Error, *p<0.05, **p<0.01, ***p<0.001

intervention. The mean age of the patients from different groups ranged from 50.70 to 56.10 years. The mean weight and BMI of the patients slightly decreased after intervention in most groups. Significant differences at p<0.01 were observed among the two groups consuming the formulae that was made from whole wheat and either fenugreek (group 7) or chickpea (group 8). Patients consuming partial decorticated wheat (group 2) and fenugreek powder (group 3) showed only a significant decrease in their BMI, at p<0.01 and 0.05, respectively. Six groups examined showed a slight decrease in their waist circumference. Values of systolic and diastolic blood pressure showed slight variation within normal range.

Table 2 showed the mean±SE of the duration of the disease and both the fasting and postprandial blood sugar level of the different diabetic groups, before and after intervention. The decrease detected in the levels of the fasting blood sugar ranged from -1.98 to -20.79 percent, while that of the postprandial showed a greater decrease ranging from -10.48 to -35.22 percent. Group 2 that consumed partial decorticated wheat (Belila) and group 8 that consumed biscuits made from whole wheat and chickpea showed a significant decrease in both fasting and postprandial blood sugar at p<0.05 and 0.001.

Table 3 showed the mean±SE of serum lipids among the different diabetic groups before and after intervention. The effect on the level of the serum lipids varied among the groups, TC level was observed to decrease in the first 5 groups, ranging from -0.72 to 7.02 percent. A significant decrease was detected (p<0.01 and 0.05) among group 2 and 6 that consumed belila made of partial decorticated wheat and roasted chickpea. LDL-C decreased significantly among group 2 only. HDL-C increased significantly at p<0.05 among group 7. VLDL-C and triglyceride levels decreased in all groups at different percent, whereas a significant difference was detected at p<0.05among group 2, who consumed partial decorticated wheat belila, and group 8, that consumed chickpea biscuit.

Table 4 showed the mean±SE of the serum lipid peroxide, antioxidant enzymes, urinary microalbumin and CRP in different groups, before and after intervention. Lipid peroxide decreased in all groups, the percent decrease ranged between -0.96 to -31.07. Significant differences were found in consumers of grinded fenugreek (group 3) and chickpea biscuit (group 8) at p<0.05-0.001, respectively. SOD enzyme activity increased in most groups. The higher percent increase (32.87) was recorded among lupine consumers (group 5). Its decreased activity was detected in two groups: partial decorticated wheat belila (group 2) and roasted chickpea consumers (group 6). GPx enzyme showed a significant increase in its activity (p<0.05 – 0.001) in groups consuming partial decorticated wheat belila (group 2), germinated fenugreek (group 4), roasted chickpea (group 6) as well as in groups 7 and 8 who consumed the biscuit formulae. Urinary microalbumin decreased among all groups. A high level of microalbumin was detected in patients of group 7 before intervention, they also showed the highest percent decrease that reached -52.48 percent after intervention. CRP level decreased in all groups within a range of -5.3 to -55.4 percent, reaching a significant difference (p<0.001) with the use of whole wheat belila (group 1).

TABLE 2. Duration of disease and blood glucose in the different groups before and after intervention.

Groups	Visits	Duration (years)	Blood glucose (mg/dL)	
			Fasting	Postprandial
Group 1	1st	5.3±1.9	125.5±10.1	168.0±18.6
	2nd		119.3±9.5**	144.8±3.4
	Percent change		-4.94	-13.8
Group 2	1st	4.1±1.3	151.0±11.1	196.8±15.5
	2nd		119.6±9.26***	143.2±11.8***
	Percent change		-20.79	-27.24
Group 3	1st	4.3±1.1	126.5± 8.54	164.3±12.51
	2nd		124.0±10.2	139.5±14.8**
	Percent change		-1.98	-15.11
Group 4	1st	3.6±1.2	126.7±13.9	129.8±9.2
	2nd		124.2±12.7	116.2±11.1
	Percent change		-1.97	-10.48
Group 5	1st	4.6±1.3	127.2±7.0	180.0±5.3
	2nd		113.4±3.6	116.6±3.4***
	Percent change		-10.85	-35.22
Group 6	1st	4.6±1.3	132.6±12.9	189.6±21.4
	2nd		132.8±14.4	170.2±17.3
	Percent change		+0.15	-10.23
Group 7	1st	5.2±1.2	157.7 ±29.9	184.5±20.2
	2nd		137.8±19.6	147.7±21.9**
	Percent change		-12.62	-19.95
Group 8	1st	5.6±1.4	152.2±23.1	193.4 ±19.7
	2nd		139.4±18.3*	145.8±13.1***
	Percent change		-8.41	-24.61

*p<0.05, **p<0.01, ***p<0.001

DISCUSSION

Long-term complications are the main cause of morbidity and mortality in diabetic patients. A number of studies have suggested that enhanced oxidation is the underlying abnormality responsible for some of the complications of diabetes [Hasanain & Mooradian, 2002]. Antioxidants are important in diabetes, with low levels of plasma antioxidants implicated as a risk factor for the development of the disease [Pisanti *et al*., 1988; Salonen *et al*., 1995; Facchini *et al*., 2000].

The diabetic patients in this study are characterised by high glucose levels especially the postprandial, in addition to dyslipidemia denoted by high levels of TC, LDL-C. Data obtained showed different responses of the postprandial glucose among the different groups, after intervention. It has been reported that some carbohydrate–rich foods induce less post-ingestive hyperglycaemia – hyperinsulinaemic than others, depending on their glycaemic index [Slavin *et al*., 1999].

TABLE 3. Serum lipids in different groups before and after intervention.

Groups	Total cholesterol (mg/dL)			LDL-C (mg/dL)			HDL-C (mg/dL)			VLDL-C (mg/dL)			Triglyceride (mg/dL)		
	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change
	1st	2nd		1st	2nd		1st	2nd		1st	2nd		1st	2nd	
Group 1	247.2 ±17.7	243.7±10.3	-1.42	214.6 ±17.8	182.3 16.1	-15.05	35.8 ±6.4	38.2 ±7.6	+6.70	24.3 ±3.7	23.2 ±1.6	-4.53	121.3 ±18.3	115.8 ±8.1	-4.53
Group 2	256.8 ±24.1	212.6 ±12.2**	-17.21	191.9 ±23.2	149.9 ±15.0**	-21.89	43.8 ±3.1	48.3±3.8	+10.27	20.9 ±2.7	14.4 ±0.4*	-31.10	104.8 ±13.5	71.8 ±1.8*	-31.49
Group 3	208.6 ±18.4	207.1 ±17.9	-0.72	140.6 ±15.0	142.5 ±17.3	+1.35	52.3 ±2.1	48.4 ±3.4	-7.46	15.8 ±1.9	15.7 ±1.9	-0.63	78.9±9.8	78.7 ±9.3	-0.25
Group 4	249.2 ±18.2	231.7±16.6	-7.02	185.2 ±18.6	168.9 ±17.2	-8.80	46.2 ±3.0	46.2 ±1.9	--	17.8 ±1.7	16.5 ±1.9	-7.30	89.1 ±8.3	82.6 ±9.7	-7.30
Group 5	240.9 ±17.7	238.0±24.7	-1.20	165.4 ±17.6	167.0 ±22.9	+0.97	49.3 ±3.1	50.2±2.2	+1.83	25.3 ±3.1	21.7 ±4.3	-14.23	126.3 ±15.4	108.7 ±21.2	-13.94
Group 6	250.6±19.2	242.4±17.6*	-3.27	179.3 ±17.7	173.7 ±15.5	-3.12	47.3 ±1.2	42.5 ±1.1*	-10.15	23.9 ±4.7	23.6 ±4.4	-1.26	119.6 ±23.7	117.9 ±22.2	-1.42
Group 7	282.0 ±35.9	269.5 ±33.3	-4.43	193.2 ±30.3	176.6 ±27.9	-8.59	53.7 ±4.9	66.9 ±4.2*	+24.58	32.4 ±5.5	27.4 ±4.6	-15.43	161.9 ±27.4	137.2 ±22.9	-15.26
Group 8	287.9 ±13.5	304.2 ±10.3	+5.66	175.2 ±11.2	211.8±11.2**	+20.89	66.1 ±3.9	66.6 ±0.6	+0.76	28.8 ±3.1	24.4 ±3.6*	-15.28	144.2 ±15.6	121.8 ±17.9*	-15.53

x̄ – mean, SE – Standard Error, *p<0.05, **p<0.01, ***p<0.001

TABLE 4. Lipid peroxide, antioxidant enzymes, microalbumin and CRP in different groups before and after intervention.

Groups	Lipid peroxide (μu/mL)			SOD (U/mL)			GPx (U/mL)			Microalbumin (μg/mL albumin)			CRP (mg/L)		
	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change	x̄±SE		Percent change
	1st	2nd		1st	2nd		1st	2nd		1st	2nd		1st	2nd	
Group 1	6.9±0.17	6.3±0.3	-7.7	132.2 ±4.5	135.5 ±12.5	+2.5	32.3 ±2.2	27.6 ±3.7	-14.55	6.2 ±2.2	5.6 ±0.9	-9.68	6.6±0.7	2.9 ±0.6***	-56.06
Group 2	15.8±1.4	15.8±0.7	-0.13	292.4 ±35.1	239.1±14.2	-18.3	48.7 ±11.9	68.8 ±20.4*	+41.27	6.8 ±1.4	3.9 ±0.3	-42.65	5.1±1.3	4.9±2.4	-3.92
Group 3	15.3±1.2	18.5±0.5*	+21.34	215.4±32.3	244.7 ±25.2	+13.60	47.6 ±6.7	33.5 ±2.2	-29.62	7.3 ±2.3	5.2 ±1.4	-28.77	3.3±0.8	2.8±0.9	-15.15
Group 4	13.5±1.1	11.9±2.0	-11.19	237.6 ±35.6	273.4 ±14.9	+15.07	40.8 ±5.7	55.2 ±10.7*	+35.16	9.6 ±1.6	5.3±0.7	-44.79	4.5 ±0.79	3.5±1.4	-22.22
Group 5	12.8±1.3	12.7±1.3	-0.71	143.0 ±14.1	190.0 ±15.8	+32.87	60.8 ±15.1	69.2 ±22.9	+13.82	24.9 ±10.1	21.2 ±10.2	-14.86	2.6±0.4	1.9±0.8	-26.92
Group 6	13.2±0.9	11.7±1.2	-11.02	216.7±38.4	166.7±25.9	-23.07	35.6 ±4.1	72.1 ±15.2*	+102.53	7.3 ±1.2	5.1 ±0.3	-30.14	4.4±0.3	3.1±0.7	-29.55
Group 7	10.4±1.5	10.3±1.1	-0.96	216.7 ±27.7	283.1 ±23.1	+30.64	33.2 ±4.8	39.5 ±5.9**	+18.98	80.7 ±13.4	38.3 ±8.2	-52.54	3.3±1.0	2.9±0.7	-12.12
Group 8	10.3±0.9	7.1 ±0.5***	-31.19	201.2 ±9.9	238.1 ±41.4	+18.34	25.7±1.38	32.9 ±3.0**	+28.07	13.3 ±3.5	7.5±1.2	-43.61	5.9±2.3	5.2±1.2	-11.86

x̄ – mean, SE – Standard Error, *p<0.05, **p<0.01, ***p<0.001

No constant changes could be found in the serum lipid profiles after the consumption of the different forms of the grains either cereals or legumes. However the partial decorticated wheat, which was consumed in a boiled form (Belila), gave a significant decrease in the TC, LDL-C, VLDL-C and the triglyceride levels. The same results were obtained as regards the decrease in the serum glucose, where a significant difference was found in both of the fasting and postprandial glucose concentrations at the end of the intervention period. Partially decorticated wheat, which has a lesser fiber content, might have preserved the serum level of some minerals and vitamins like vitamin E, and magnesium which may affect postprandial glucose and insulin response [Lang *et al*., 1999]. In this context fasting blood glucose was a significant predictor of hypercholesterolemia [Stehbens, 1990], which may explain the high percent decrease in the cholesterol level among the patients of this group, in addition to the reported significant decrease in both their body mass and BMI. Chickpea biscuit consumers showed a significant decrease in both VLDL-C and triglyceride, which may be attributed to its peculiar starch composition [Nestel *et al*., 2004].

It has been reported that the concentration of plasma TC, LDL-C and HDL-C and TG may not provide a full or accurate picture of atherogenic risk [Parthiban *et al*., 1995]. It has been suggested that there are abnormalities in the lipid metabolism and erythrocyte antioxidant enzymes in diabetics [Wolever *et al*., 2003]. The lipid peroxides are thought to be formed by oxidation of LDL-C by free radicals and may play an important role in the development of atheromatous vascular disease [Kesavulu *et al*., 2001]. The results of this study showed that the consumption of these different cereals and legumes that possess antioxidant properties had beneficial effects among the diabetic patients. Lowering the serum lipid peroxides in association with an increase in the activity of the antioxidant enzymes especially GPx and to a lesser extent SOD, were detected. The antioxidant defence system may act synergistically with enzyme activities and cellular antioxidants are likely to display transient changes [Vincent *et al*., 2004], this may explain the variations in the levels of lipid peroxide and both the antioxidants enzymes activity that were observed among the different groups in the present study. Patients of group 3 showed the worst results as regards the oxidative parameters, germinated fenugreek seeds might lost some of their active principles that have antioxidant functions [Allam, 1987]. In this context, whole grains are rich in nutrients and phytochemicals. Whole grains are concentrated sources of phytoestrogens such as lignans [Slavin, 2005]. In addition the decreased oxidative stress in these patients after consumption of these specific cereals and legumes may result from their low glycaemic index due to their starch peculiar composition [Jenkins *et al*., 1988], or in other specific components, such as Conglutin gamma, the specific protein in lupine [Hanada & Hirano, 2004]. Other biologically active substances include galactomannan-rich soluble dietary fiber or to modified amino acid 4-hydroxyl isoleucine in fenugreek [Gupta *et al*., 2001]. In addition, a general claim on the antidiabetic role of legume seed α amylase inhibitors has been published [McCarty, 2005].

Two prospective studies in patients with type 2 diabetes as well in nondiabetic individual demonstrated that microalbuminuria was predicted among other factors by a high level of CRP, fibrinogen and other markers of endothelial dysfunction [Stehouwer *et al*., 2002; Jager *et al*., 2002]. It has been reported that hyperglycemia would serve to exaggerate the proatherogenic effect of CRP [Qi & Hu, 2007]. The data obtained in this study showed that both serum CRP and urinary microalbumin were decreased in most groups of the diabetic patients after intervention. Yet no association could be detected between the percent decreases of the two parameters among the different groups. In this context the absence of this association might be due to the effect of the other inflammatory markers than CRP that have their effect on the kidney functions. However, the protective effects of low GI load by high whole grains consumption on systemic inflammation may be explained, in past by reduction in hyperglycemia–induced over production of oxidative stress and by amelioration in insulin resistance adiposity, dyslipidemia and hypertension [Verma *et al*., 2003]. Recently, the observed effects of whole grains, bran and cereal fiber were suggested to have additional mechanisms. It has been found that cereal fiber intake, dietary glycemic index and glycemic load were associated with the levels of blood adiponectin in diabetic patients [Qi *et al.*, 2005]. It has been documented that adiponectin has profound anti-inflammatory effects [Berg & Scherr, 2005].

CONCLUSIONS

In conclusion, the results of this study showed that daily consumption of whole grains, cereals and legumes was associated with improvement of the hyperglycemia and some serum lipid parameters in Egyptian diabetic patients. The positive findings detected might be related to their antioxidant and anti-inflammatory effects. The lipid peroxide level was decreased while the activity of the antioxidant enzymes GPx and SOD was increased. The decrease in the level of the inflammatory marker CRP was associated with a reduction in the level of the microalbuminurea. So our results support the recommendation that patients with type 2 diabetes should increase their intake of whole grains (cereals and legumes) and whole grain products that may be associated with decreasing the probability of diabetic complications.

REFERENCES

1. Allam M.H., Chemical composition & nutritional value of fenugreek seeds during germination. Ann. Agri. Sci., 1987, 32, 1538––1551.
2. Anderson P.H., Berret S., Patterson D.S., Glutathione peroxidase activity in erythrocytes and muscle in cattle and sheep and its relationship to selenium. J. Comp. Pathol., 1978, 88, 181–189.
3. Barham D., Trinder P., An improved for the determination of blood glucose by oxidase system. Analyst, 1972, 97, 142–145.
4. Baynes J.W., Role of oxidative stress in development of complications in diabetes. Diabetes, 1991, 40, 405–412.
5. Berg A.H., Scherr P.E., Adipose tissue, inflammation and cardiovascular disease. Cir. Res., 2005, 96, 939–949.
6. Chetana V., Turbidimetry assay for measurement of CRP in human serum or plasma. Immunol. Infect. Dis., 1996, 6, 139–144.
7. Draper H.H., Hadley M., Malondialdehyde determination as index of lipid peroxide. Methods Enzymol., 1990, 186, 421–431.
8. Duranti M., Grain legume proteins and nutraceutical properties. Fitoterapia, 2006, 77, 67–82.
9. Facchini F.S., Humphreys M.H., DoNascimento C.A., Abbasi F., Reaven G.M., Relation between insulin resistance and plasma concentrations of lipid hydroperoxides, carotenoids and tocopherols. Am. J. Clin. Nutr., 2000, 72, 776–779.
10. Finley P.R., Schifman R.B., Williams R.J., Lichti D.A., Cholesterol in high-density lipoprotein. Use of Mg/dextrane sulfate in its enzymatic measurement. Clin Chem., 1978, 24, 931.
11. Friedewald W.T., Levy R., Fredrickson D.S., Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. Clin. Chem., 1972, 18, 499–502.
12. Gillery P., Monboissa J.C., Mauquart F.X., Borel J.P., Does oxygen free radical increase formation explain long term complications of diabetes mellitus. Med. Hypothesid., 1989, 29, 47–50.
13. Gupta A., Gupta R., Lai B.J., Effect of *Trigonella foenum-graecum* (fenugreek) seeds on glycaemic control and insulin resistance in type 2 diabetes mellitus: a double blind placebo controlled study. Ass. Phys. India., 2001, 49, 1057–1061.
14. Hanada K., Hirano H., Interaction of a 43-KDa receptor-like protein with a 4-KDa hormone-like peptide soybean. Biochemistry, 2004, 28, 12105–1212.
15. Hasanain B., Mooradian A.D., Antioxidant vitamins and their influence in diabetes mellitus. Curr. Diab. Rep., 2002, 2, 448––456.
16. Hunt J.V., Smith C.C., Wolff S.P., Autooxidative glycosylation and possible involvement of peroxides and free radicals in LDL modification by glucose. Diabetes, 1990, 39, 1420–1424.
17. Jager A., Van Hinsberg V.W.M., Kostene P.J., C-reactive protein and soluble vascular cell adhesion molecule 1 are associated with elevated urinary albumin excretion but do not explain its link with cardiovascular risk. Arterioscler Thromb. Vasc. Biol., 2002, 22, 593–598.
18. Jellife D.B., The assessment of the nutritional status of the community. World Health Organization. Geneva Monograph., 1966, 35, 63–69.
19. Jenkins D.J.A., Wolever T.M., Jenkins A.L., Starchy foods and glycemic index. Diabetes Care, 1988, 11, 149–159.
20. Jones J.M., Reick M., Adams J., Fulcher G., Marquat L., Becoming proactive with the whole–grains message. Nutr. Today, 2004, 39, 10–17.
21. Kalousova M., Fialova L., Skrha J., Zima T., Soukupova J., Malbohan I.M., Stipek S., Oxidative stress, inflammation and autoimmune reaction in type 1 and type 2 diabetes mellitus. Prague Med. Rep., 2004, 105, 21–28.
22. Kantor L.S., Variyam J.N., Allshouse J.E., Putnam J.J., Lin B.H., Choose a variety of grains daily, especially whole grains: A challenge for consumers. J. Nutr., 2001, 131, 4735–4865.
23. Kesavulu M.M., Rao B.K., Giri R., Vijaya J., Subramanyam G., Apparao C., Lipid peroxidation and antioxidant enzyme status in type 2 diabetics with coronary heart disease. Diab. Res. Clin. Pract., 2001, 53, 33–39.
24. Kuller L.H., Tracy R.P., Shaten J., Meilahn E.N., Relation of C-reactive protein and coronary heart disease in MRFIT nest-

ed case-control study. Multiple Risk Factor Intervention Trial. Am. J. Epidemiol., 1996, 144, 537–547.
25. Lang V., Vaugelade P., Bernard F., Darcy-Vrillon B., Almowitch C., Slama G., Duèe P.H., Bornet F.R., Euglycemic hyperinsulinemic clamp to assess posthepatic glucose appearance after carbohydrate loading. 1. Validation in pigs. Am. J. Clin. Nutr., 1999, 69, 1174–1182.
26. Lowe G.D.O, Yarnel J.W.G., Rumley A., Bainton D., Sweetnam P.M., C-reactive protein, fibrin D-dimer, and incident ischaemic heart disease in the speed well study. Art. Thromb. Vasc. Biol., 2001, 21, 603–610.
27. McCarty M.F., Nutraceutical resources for diabetes prevention-an update. Med. Hypotheses, 2005, 64, 151–158.
28. Nestel P., Cehun M., Chronopoulos A., Effects of long-term consumption and single meals of chickpeas on plasma glucose, insulin and triacylglycerol concentrations. Am. J. Clin. Nutr., 2004, 79, 390–395.
29. Parthiban A., Vijayalingan S., Shanmugasundaram K.R., Mohan R., Oxidative stress and the development of diabetic complications antioxidants and lipid peroxidation in erythrocytes and cell membrane. Cell Biol. Inter., 1995, 19, 987–993.
30. Pisanti F.A., Frascatore S., Papaccio G., Superoxide dismutase activity in the BB rat: a dynamic time-course study. Life Sci., 1988, 43, 1625–1632.
31. Qi L., Hu F.B., Dietary glycemic load, whole grains and systemic inflammation in diabetes: the epidemiological evidence. Curr. Opin. Lipidol., 2007, 18, 4–8.
32. Qi L., Rimm E., Liu S., Rifai N., Hu F.B., Dietary glycemic index, glycemic load, cereal fiber and plasma adiponectin concentration in diabetic men. Diabetes, 2005, 28, 1022–1028.
33. Raju J., Gupta D., Rao A.R., Yadava P.K., Baquer N.Z., *Trigonellafoenum graecum* (fenugreek) seed powder improves glucose homeostasis in alloxan diabetic rat tissues by reversing the altered glycolytic, gluconeogenic and lipogenic enzymes. Mol. Cell. Biochem., 2001, 224, 45–51.
34. Ridcker P.M., Hennekens C.H., Buring J.E., Rifai N., C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women. N. Engl. J. Med., 2000, 342, 836–843.
35. Rowley K., O Deo K., Best J.D., Association of albuminuria and metabolic syndrome. Curr. Diab. Rep., 2003, 3, 80–86.
36. Salonen J.T., Nyyssonen K., Tuomanen T.P., Maenpaa P.H., Korpela H., Kaplan G.A., Lynch J., Helmrich S.P., Salonen R., Increased risk of non-insulin dependent diabetes mellitus at low plasma vitamin E concentrations: a 4 year follow up study in men. Br. Med. J., 1995, 311, 1124–1127.
37. Slavin J., Whole grains: Protection against cardiovascular disease, diabetes and cancer. SAJCN., 2005, 49,(Suppl.), 51.
38. Slavin J.L., Martini M.C., Jacobs D.R.J., Marquart L., Plausible mechanisms for the protectiveness of whole grain. Am. J. Clin. Nutr., 1999, 70(Suppl.), 4595–4635.
39. Smith R.A., Potential edible lupine poisoning in humans. Vet. Hum. Toxicol., 1987, 29, 444–445.
40. Stec J.J., Silbershatz H., Tofler G.H., Matheny T.H., Sutherland P., Lipinska I., Massaro J.M., Wilson P.F., Muller J.M., D'Agostino R.B. Sr., Association of fibrinogen with cardiovascular risk factors and cardiovascular disease in the Framingham offspring population. Circulation, 2000, 102, 1634–1638.
41. Stehbens W.E., The epidemiological relationship of hypercholesterolemia, hypertension, diabetes mellitus and obesity to coronary heart disease and atherogenesis. J. Clin. Epidemiol., 1990,43, 733–741.
42. Stehouwer C.D.A., Gall M.A., Twisk J.W.R., Knudsen E., Emeis J.J., Parving H.H., Increase urinary albumin excretion, endothelial dysfunction and chronic low-grade inflammation in type 2 diabetes. Diabetes, 2002, 51, 1157–1165.
43. Suttle N.F., McMurray C.H., Use of erythrocyte copper: zinc superoxide dismutase activity and hair fleece copper concentrations in the diagnosis of hypocuprosis in ruminants. Res. Vet. Sci., 1983, 35, 47–52.
44. Trinder P., Determination of glucose oxidase with blood using glucose oxidase with an alternative oxygen receptor. Ann. Clin. Biochem., 1969, 6, 24.
45. Venn B.J., Mann J.I., Cereal grains, legumes and diabetes. Eur. J. Clin. Nutr., 2004, 58, 1443–1461.
46. Verma S., Hungwang C., Weisel R.D., Badiwala M.V., Li S.H., Fedak P.W.M., Li R.K., Mickel D.A.G., Hyperglycemia potentiates the proatherogenic effects of C-reactive protein: Reversal with rosiglitazone. J. Mol. Cell Cardiol., 2003, 35, 417–419.
47. Vincent A.M., Russell J.W., Low P., Feldman E.L., Oxidative stress in the pathogenesis of diabetic neuropathy. Endocr. Rev., 2004, 25, 612–628.
48. Wahlefeld A.W., Triglycerides determination after enzymatic hydrolysis. 1974, *in*: Methods of Enzymatic Analysis, vol. 4 (ed. H.U. Bergmeyer). Academic Press, New York, NY., pp. 1881––1885.
49. Walker J.D., Close C.F., Jones C.F., Jones S.L., Rafftery M., Keen H., Viberti G., Osterby R., Glomerular structure in type-1 (insulin-dependent) diabetic patients with normo- and microalbuminuria. Kidney Int., 1992, 41, 741–748.
50. Wolever T.M.S., Tsihlias E.B., McBurney M.I., Le N.A., Long –term effect of reduced carbohydrate or increased fiber intake on LDL particle size and HDL composition in subject with type 2 diabetes. Nutr. Res., 2003, 23, 15–26.

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