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A high-fiber, moderate-glycemic-index, Mexican style diet improves dyslipidemia in individuals with type 2 diabetes

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Abstract

The typical Mexican diet includes beans and tortillas, which are foods with a low glycemic index. The objective of this paper was to compare the effects of a lower and a higher glycemic index Mexican style diet on metabolic control. In a randomized, controlled crossover design, eight subjects with type 2 diabetes were assigned to either a high glycemic index (GI=72), lower dietary fiber (30g/d) diet or a moderate glycemic index (GI=60) higher dietary fiber (53g/d) for three weeks each. Biochemical data was obtained at the start and finish of each dietary period. Multi and univariate one-factor repeated-measures analysis of variance was used to compare biochemical data. The overall differences in the total and LDL cholesterol (5.02±0.6 to 3.36±0.83) population means were significant ($P<0.004$ and $P<0.001$). We conclude that a low GI diet with more than 23g fiber per day, containing Mexican style foods may help to improve dyslipidemia in individuals with type 2 diabetes.

Keywords: Glycemic index; Diabetes; Mexican diet

1. Introduction

In Mexico, current dietary guidelines for people with diabetes and without diabetes focus on lowering dietary fat and increasing carbohydrate intake [1,2]. In the United States, the percentage of dietary energy derived from fat in the national diet has fallen steadily, whereas rates of obesity have risen. Roberts [3] suggests that factors other than the proportion of dietary energy derived from fat are quantitatively more important in determining the trends

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in diabetes, obesity and hyperlipidemia that have occurred to date. One of those factors could be the glycemic index (GI).

The GI is a measure of the effect of carbohydrate-containing foods on blood glucose [4]. High GI values result from an elevated postprandial glucose area under the curve (AUC). Because of the intense insulin response that high-GI foods provoke, consumption of them can also result in lower circulating blood glucose (post-prandial or reactive hypoglycemia) at the end of a 2-hour glucose tolerance test period than at the initial fasting baseline [5]. Additionally, because insulin is a potent stimulus for HMG Co A reductase, this might limit the hepatic cholesterol synthesis, therefore the insulin response to high GI foods may be related to changes in blood lipids.

On the other hand, low-GI values result in lower postprandial glucose AUC and have a lower risk of causing reactive hypoglycemia (because of the reduced insulin response). The rate of starch digestion is a major determinant of glycemia and insulinemia. The factors, which can slow down carbohydrate digestion, are soluble fiber, the type of starch, presence of enzyme inhibitors and antinutrients, the form of the food and the frequency of eating [6]. One of the factors responsible for the differences in GI may be the difference in rates of digestion of starchy food [7]. Wolever et al proposed the calculation of a mean GI for a mixed meal to predict the postprandial blood glucose response to this meal [8]. It has been shown that a reduction of the mean GI by approximately 13% in the diet of hyperlipidemic patients, for a period of four weeks resulted in a significant decrease in plasma total cholesterol of 9%, LDL-cholesterol of 10%, and for serum triglyceride a reduction of 16% [9].

In addition, it has been demonstrated that diabetics who ate a rice-rich diet (low GI) had lower VLDL triglyceride levels than those did eating a potato-rich diet (high GI), despite unchanged blood glucose control [10]. Also, a significant decrease in plasma fructosamine (3.9 ± 0.9 vs 3.4 ± 0.4 mmol/dl) and triglyceride (1.5 ± 0.9 vs 1.2 ± 0.6 mmol/dl)has been shown after 3 weeks on a low GI diet [11]. However, some studies failed to show any differences in the response to a mixed meal [12,13].

Since the publication of the new international tables of the glycemic index and glycemic load values it is now possible to find extensive GI information on many common foods from around the world [14]. The typical Mexican diet includes beans (legumes) and corn tortillas (traditionally made) which are foods with a low GI. In urban areas corn tortillas made from processed flour are most frequently consumed, and these are high GI foods [15,16]. Nevertheless, there are no published studies on the effects of complete Mexican style low GI diets on the metabolic control of people with diabetes.

The aim of the this study was to compare the effect of two Mexican style mixed diets, with different GI's, on fasting blood glucose, LDL, HDL, total cholesterol, and triglyceride over a period of three weeks in individuals with Type 2 diabetes.

2. Methods

2.1. Subjects

Eight free-living individuals with type 2 diabetes, aged 51 ± 3y (mean $\pm$ SD), mean diabetes duration 7 ± 6y participated in the study. One patient was treated by diet alone and the others received oral hypoglycemic drugs (glibenclamide), which were maintained at the same doses throughout the study period. None were taking medications known to influence serum lipids. Their body mass index (BMI) was 30.7 ± 7.9 kg/m^2, mean fasting blood glucose was 10.20 ± 4.22 mmol/L, and mean HbAlc was 8 ± 0.8%. The patients had been seen by a physician on a regular basis for at least 6 months prior to study participation and had been enrolled in a diabetes education program of the Medical School of the University of Baja, California. The Ethical Committee of the Instituto de Nutrición of Baja, California approved the study. Written informed consent was obtained from all participants.

2.2. Study procedure

Two diets, one with a moderate (60) glycemic index and one with a high (72) glycemic index were designed according to the formula proposed by Wolever et al. [17]. The GI of each individual food was based on glucose as the standard. Moderate and high GI diets were designed to meet the food habits of the participants. Each patient entered a run-in period of 15 days before the start of the dietary treatment, during which time they received their standard medications and were given detailed instructions on lower or higher GI foods depending of randomization. Subjects were randomly allocated to the lower and higher GI diets for a 3-week period in a crossover design (each subject received the two diets by random allocation to each diet) with a 4-week washout period. During this time the habitual diet (the same as that eaten before entry into the study) of each individual was eaten. Body weight was measured pre- and post-dietary periods.

2.3. Materials (diets)

Participants were provided with a three day cycle menu plan, with moderate and high GI daily diet plans for each treatment period. Typical 1 day menus for the moderate and high GI are shown in Table 1. Subjects completed unweighed dietary intake diaries for 3 days during the first and the third week of the 2 study periods. Subjects were instructed to estimate portion sizes with standardized household measurements. Computerized dietary analysis was done using Nutritionist V (version 2.3), as this contains a very good database of Mexican foods.

2.4. Blood analysis

Blood samples were taken at 8:00 am from antecubital vein after 12-hour fasting period at the beginning and end of each study period. Blood samples were centrifuged (at 3500 rpm for 3 minutes) and plasma was removed and analyzed immediately after collection for glucose, total serum cholesterol, HDL and triglyceride. For the quantitative determination of glucose in serum, the glucose oxidase procedure based on a modified Trindler method was used. Cholesterol, HDL-cholesterol and triglicerides were measured by enzymatic methods (DMA, Arlington Texas). LDL cholesterol was calculated using the Friedwald Formula: LDL (mmol/L)= total cholesterol-(triglyceride/2.2)-HDL) [12].

Table 1
Representatives Diets Followed in the Moderate and High GI diets

	High-GI Diet	Moderate-GI Diet
Breakfast	Orange. Cereal (Corn Flakes) and milk (1% fat).	Orange. Corn tortillas and boiled pinto beans.
Lunch	Baked potato. Italian squash, corn and tomato puree. Avocado. Salsa (tomato, onion, and hot pepper). Grilled fish or chicken. Corn tortilla.	Mexican rice (rice, tomato, peas, and carrots). Salad (cucumber, lettuce, avocado, tomato, and lemon juice). Grilled fish or chicken. Salsa (tomato, onion, and hot pepper). Corn tortillas.
Dinner	Corn tortilla and Mexican farmer cheese. Cereal (Corn Flakes) and milk (1% fat). Banana.	Boiled pinto beans, Corn tortilla, and Mexican farmer cheese.
Between meals	Papaya. Sandwich (white bread (bolillo), ham, low fat mayonnaise, tomato and lettuce).	Papaya. Fat free yogurt.

2.5. Statistical analysis

Data were analyzed using SPSS 8.0 for Windows (Chicago, Illinois). To test the differences between selected nutrients of the low and high GI diets, the Mann-Whitney nonparametric test for independent samples was performed. Multi and univariate one-factor repeated-measures analysis of variance was used to compare the mean fasting serum glucose, total cholesterol, LDL cholesterol, HDL cholesterol, and triglyceride at baseline, after the run- in period, and after each dietary treatment period. The Bonferroni-adjusted paired samples confidence intervals were calculated to determine which population means were different. A P-value of less than 0.05 was taken as indicating statistical significance.

3. Results

Individual questioning of subjects established that both diets were found acceptable and the diet plans were found easy to follow. Table 2 shows that there was no difference in energy, protein, and fat between the moderate and the high GI periods. Carbohydrate intake was significantly higher during the high GI period ($P < 0.04$), total dietary fiber was significantly lower during the high GI period ($P < 0.04$), and the mean glycemic index was significantly higher during the high GI period ($P < 0.04$).

All blood biochemistry is shown in Table 3. The overall differences in total and LDL cholesterol population means were significant ($P < 0.004$ and $P < 0.001$). Total and LDL cholesterol were both significantly lower during the low GI period ($P < 0.037$ and $P < 0.003$). Although fasting serum glucose was reduced after the low GI diet it was not significant, and glycated hemoglobin was not measured due to the short duration of the study.

Table 2
Dietary intakes (x ± SD)

	High GI Period	Low GI Period	P*
Energy (kcal/d)	1998 ± 61.0	1938 ± 71.3	0.82
(MJ/d)	8.36 ± 0.3	8.11 ± 0.3	
Protein (g/d)	92 ± 8.8	113 ± 27.0	0.27
(% energy)	18 ± 2.0	23 ± 4.0	
Fat (g/d)	63 ± 8.0	56 ± 3.4	0.27
(% energy)	27 ± 2.5	26 ± 2.3	
Saturated fat (g/d)	20 ± 3.0	20 ± 2.0	0.51
Monounsaturated (g/d)	26 ± 4.1	22 ± 3.9	0.18
Polyunsaturated (g/d)	12 ± 2.7	10 ± 2.8	0.27
Carbohydrates (g/d)	279 ± 7.4	255 ± 7.0	0.04
(% energy)	54 ± 0.6	51 ± 2.5	
Cholesterol (mg/d)	175 ± 41	186 ± 22	0.82
Total dietary fiber (g/d)	30 ± 0.7	53 ± 0.6	0.04
Glycemic index	72 ± 0.4	60 ± 0.3	0.04
Glycemic load	199 ± 0.4	153 ± 0.4	0.04

4. Discussion

This study shows that a high carbohydrate and high fiber diet with a moderate low GI, containing Mexican style foods is associated with improvement in total and LDL cholesterol, when compared to a high-GI diet in individuals with type 2 diabetes. Although not statistically significant, it also shows an improvement in average blood glucose, and HDL levels. These results were achieved without altering body weight or energy intake. The dietary instruction that was given was simple, and both low and high-GI diets included foods, which are normally, part of the habitual diet in the northern border region of Mexico. The study subjects considered the dietary changes acceptable.

Table 3
Biochemical Data and Body Mass Index (x ± SD)

	High GI Period		Low GI Period		P*
	Baseline	Post-diet	Baseline	Post-diet	
FSG (mmol/L)	9.7 ± 2.6	10.1 ± 2.2	10.3 ± 4.3	8.6 ± 2.9	n.s.
CI 95%	(6.88–12.01)	(7.89 ± 12.90)	(5.85–14.80)	(5.56–11.67)	
Cholesterol (mmol/L)	5.96 ± 0.72	6.44 ± 0.96	6.41 ± 0.88	4.86 ± 1.35*	0.004
CI 95%	(5.35–6.57)	(5.83–7.05)	(5.33–7.50)	(3.45–6.26)	
LDL (mmol/L)	4.27 ± 0.70	4.28 ± 0.60	5.02 ± 0.06	3.26 ± 0.83**	0.001
CI 95%	(3.84–4.70)	(3.93–4.64)	(4.38–5.67)	(2.39–4.12)	
HDL (mmol/L)	0.98 ± 0.26	1.22 ± 0.49	0.88 ± 0.34	1.11 ± 0.41	n.s.
CI 95%	(0.74–1.20)	(0.63–1.80)	(0.53–1.21)	(0.68–1.54)	
Triglyceride (mmol/L)	1.85 ± 1.04	2.02 ± 0.67	1.71 ± 0.95	1.81 ± 0.77	n.s.
CI 95%	(0.96–3.27)	(2.10–2.72)	(0.71–2.70)	(0.99–2.61)	
Body Mass Index (Kg/m^2)	30.7 ± 7.5	30.7 ± 7.6	30.8 ± 8.4	30.4 ± 8.4	n.s.
CI 95%	(25.2–36.7)	(25.1–36.2)	(25.3–36.3)	(25.1–36.0)	
Body Weight (kg)	70.9 ± 11.7	70.9 ± 12	71.1 ± 11.9	70.6 ± 11.9	n.s.
CI 95%	(58.2–84.1)	(57.9–83.6)	(58.4–83.8)	57.9–83.20	

Contrary to the findings reported by Fontvielle AM et al [11] and Brand J et al [18], which showed that a low-GI diet improved the glycemic control but not improved the blood lipid profiles, our findings show a statistically significant improvement in both total and LDL cholesterol. However, subjects in the Brand study, had a baseline level of LDL and total cholesterol close to normal, while subjects in this study had mean baseline values of 8.0 mmol/L of total cholesterol and 5.03 mmol/L of LDL. Our results were consistent with those reported by Jenkins et al, who showed a reduction in total cholesterol of 9% and LDL serum cholesterol of 10% and serum triglyceride of 16% using a low GI diet [9,19]. However, our results show a statistically significant reduction of total and LDL-cholesterol; while Jenkins et al (1987) also observed a reduction in triglyceride (19.3±3.2%) levels [19]. Fasting triglyceride levels in this study did not show a significant reduction after the low GI diet; results consistent with a study using a low GI diet in healthy French subjects, which demonstrated a reduction of 8% in triglyceride after lunch, without changes in fasting triglyceride levels [20]. Although not statistically significant, HDL-cholesterol in this study also increased with the low-GI diet. This is consistent with the results found from the 1986/87 Survey of British Adults and the study of US adults, which demonstrated a significant negative relationship between serum HDL-cholesterol concentration and the glycemic index of the diet of both men and women [21,22]. The study by Buyken et al showed that lower dietary GI was related to lower glycated hemoglobin concentrations, independent of the fiber intake, that LDL concentrations were not associated with dietary GI, and that a higher GI was associated with higher triglyceride levels [23]. Similar results were also observed during a 6-week treatment period using flexible Mexican style diet in overweight and obese subjects with diabetes; glycated haemoglobin was improved on the low GI diet, while there were not statistical changes in serum lipids [24]. On the other hand, Heilbronn et al [25] showed that lowering the glycemic index of high carbohydrate, low fat diets increases the fall in LDL cholesterol in 18% in subjects with type 2 diabetes, but has little effect on the glycemic control. The study by Liu et al showed that in multivariate analysis, dietary glycemic load, overall dietary glycemic index, and total carbohydrate intake were each inversely related to plasma HDL concentrations and positively related to fasting plasma triglyceride concentrations [26]. Jarvi et al also demonstrated significant changes in total and LDL cholesterol after a low compared with a high GI diet [27]. This study shows that in the short-term dietary manipulation resulted in a significant LDL-C reduction, similar to the effects observed by Jenkins et al [28]. In that study, a diet high in plant sterols, soy protein, viscous fibers and almonds resulted in a 28% reduction of LDL-C, after two and four weeks, which was not statistically significant from that of statin drug treatment [28]. On the other hand, other regional diets, such as the Mediterranean diet, prevented coronary events in men and improved survival rates [29,30]. However, when mild hypercholesterolemic subjects consuming a mixed Mediterranean-Western diet, shifted from a low-fat, low fiber diet to a low-fat, high fiber diet, LDL-C decrease significantly [31]; while fasting HDL and glycemia did not change significantly. Those results are also consistent with the results of this study, with a traditional Mexican diet, high in fiber (53g/d), mainly from beans, and low in fat (26%) and in saturated fat (9%).

The limiting factors in this study were that only three daily diet plans for both the low and the high GI diets were devised, patients were only studied for three weeks, and participants were closely monitored by researchers during the three week period. Therefore, longer-term adherence to the diets has not been evaluated, no prediction of the long-term effects can be made, and the outcome may not be the same if patients were monitored less closely. The low-GI diet was based mainly on beans (legumes), which also have a high soluble fiber and carbohydrate content. However, other studies have shown no serum lipid lowering effect with a 72% of energy from carbohydrate high fiber diet for 4 days [32].

There is reasonably good evidence to show that soluble fiber has a blood lipid modulating effect based on the results of a meta-analysis study which showed a reduction in total blood cholesterol of 0.13mmol/L [33]. In addition, Davidson et al [34] showed a decrease in LDL-C levels of 10, 15.9 and 11.5% in groups who were receiving 84 g of oatmeal, 56 g of oat bran, and 84 g of oat bran respectively.

The acceptability of the low-GI foods was an important factor in this dietary intervention, but since traditional Mexican foods contain low GI legumes (varieties of beans) and corn products, this was not a problem for the subjects. One of the problems that Mexicans from urban area face is the high consumption of " fried beans ", rather than boiled beans; therefore, increasing the total fat content of the diet. Much more information relating to practical aspects as well as the metabolic effects of low GI diets is now emerging, and several publications on the subject are now available [35–37] with the aim of simplifying the GI message for doctors, patients, nurses and dietitians. We conclude from this study that a low GI, high carbohydrate and fiber diet containing traditional Mexican foods may help to improve dyslipidemia in type 2 diabetic subjects. This might be taken into consideration when developing the dietary guidelines for a population with economic restraints that have limited access to drug treatment.

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