Cinnamon Improves Glucose and Lipids of People With Type 2 Diabetes

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OBJECTIVE — The objective of this study was to determine whether cinnamon improves blood glucose, triglyceride, total cholesterol, HDL cholesterol, and LDL cholesterol levels in people with type 2 diabetes.

RESEARCH DESIGN AND METHODS — A total of 60 people with type 2 diabetes, 30 men and 30 women aged 52.2 ± 6.32 years, were divided randomly into six groups. Groups 1, 2, and 3 consumed 1, 3, or 6 g of cinnamon daily, respectively, and groups 4, 5, and 6 were given placebo capsules corresponding to the number of capsules consumed for the three levels of cinnamon. The cinnamon was consumed for 40 days followed by a 20-day washout period.

RESULTS — After 40 days, all three levels of cinnamon reduced the mean fasting serum glucose (18–29%), triglyceride (23–30%), LDL cholesterol (7–27%), and total cholesterol (12–26%) levels; no significant changes were noted in the placebo groups. Changes in HDL cholesterol were not significant.

CONCLUSIONS — The results of this study demonstrate that intake of 1, 3, or 6 g of cinnamon per day reduces serum glucose, triglyceride, LDL cholesterol, and total cholesterol in people with type 2 diabetes and suggest that the inclusion of cinnamon in the diet of people with type 2 diabetes will reduce risk factors associated with diabetes and cardiovascular diseases.

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The incidence of cardiovascular diseases is increased two- to fourfold in people with type 2 diabetes (1). Although the causes of type 2 diabetes and cardiovascular diseases are multifactorial, diet definitely plays a role in the incidence and severity of these diseases. The dietary components beneficial in the prevention and treatment of these diseases have not been clearly defined, but it is postulated that spices may play a role. Spices such as cinnamon, cloves, bay leaves, and turmeric display insulin-enhancing activity in vitro (2,3). Botanical products can improve glucose metabolism and the overall condition of individuals with diabetes not only by hypoglycemic effects but also by improving lipid metabolism, antioxidant status, and capillary function (4). A number of medicinal/culinary herbs have been reported to yield hypoglycemic effects in patients with diabetes. Examples of these include bitter melon, Gymnema, Korean ginseng, onions, garlic, flaxseed meal, and specific nutrients including α-lipoic acid, biotin, carnitine, vanadium, chromium, magnesium, zinc, and vitamins B_3, E, and K (5).

Rashwan (6) reported that supplementation of the diet of rabbits with fenugreek decreased total serum lipid level. In rats, curry leaf and mustard seeds decreased total serum cholesterol, LDL cholesterol, and VLDL cholesterol and increased HDL cholesterol levels (7) and reduced cholesterol, triglycerides, and phospholipids in aorta, liver, and heart (8). The LDL and VLDL fractions were also decreased and the HDL fraction was increased. Coriander seeds fed to rats consuming a high-fat diet led to decreased LDL, VLDL, and total cholesterol and increased HDL cholesterol (9). Zhang et al. (10) reported that turmeric may also have a role in reducing the risk of atherosclerosis.

Aqueous extracts from cinnamon have been shown to increase in vitro glucose uptake and glycogen synthesis and to increase phosphorylation of the insulin receptor; in addition, these cinnamon extracts are likely to aid in triggering the insulin cascade system (11,12). Because insulin also plays a key role in lipid metabolism, we postulated that consumption of cinnamon would lead to improved glucose and blood lipids in vivo. Therefore, this study was designed to determine whether there is a dose response of cinnamon on clinical variables associated with diabetes and cardiovascular diseases in people with type 2 diabetes.

RESEARCH DESIGN AND METHODS

— This study was conducted in the Department of Human Nutrition, NWFP Agricultural University, Peshawar, Pakistan and was approved by the Ethics Committee and Human Studies Review Board of the University of Peshawar. Selection criteria for the study included the following for people with type 2 diabetes: age >40 years, not on insulin therapy, not taking medicine for other health conditions, and fasting blood glucose levels between 7.8 and 22.2 mmol/l (140–400 mg/dl). A total of 60 individuals with type 2 diabetes, 30 men and 30 women, were selected for the study. The mean age of the subjects was 52.0 ± 6.87 years in the placebo groups and 52.0 ± 5.85 years in the groups consuming cinnamon. The duration of diabetes was also similar: 6.73 ± 2.32 years for the placebo group and 7.10 ± 3.29 years for the cinnamon groups. There was also an equal number of men and women in the pla-

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Effects of cinnamon on glucose levels in people with type 2 diabetes*

Group*	Doses of cinnamon (g/day)	Fasting serum glucose level (mmol/l)† Before cinnamon intake Day 0	During cinnamon intake Day 20	During cinnamon intake Day 40	After cinnamon intake Day 60
1	1	11.6 ± 1.7^{a}	10.5 ± 1.8^{ab}	8.7 ± 1.6^{c}	9.7 ± 1.4^{bc}
2	3	11.4 ± 1.2^{a}	9.9 ± 1.1^{ab}	9.4 ± 1.1^{b}	9.9 ± 1.6^{ab}
3	6	13.0 ± 1.4^{a}	10.2 ± 1.3^{bc}	9.2 ± 1.5^{c}	11.4 ± 1.8^{ab}
4	Placebo 1	12.2 ± 1.0^{a}	12.7 ± 0.8^{a}	12.4 ± 1.1^{a}	12.6 ± 1.0^{a}
5	Placebo 2	12.4 ± 1.0^{a}	11.8 ± 0.9^{a}	12.7 ± 1.0^{a}	12.6 ± 1.3^{a}
6	Placebo 3	16.7 ± 1.4^{a}	16.7 ± 1.6^{a}	16.8 ± 1.7^{a}	17.0 ± 1.3^{a}

Data are means ± SD. *Ten individuals in each group; †means followed by different superscript letters in the same row are significantly different at $P < 0.05$.

cebo and cinnamon groups. All subjects were taking sulfonylurea drugs, i.e., glibenclamide; medications did not change during the study.

Cinnamon (*Cinnamomum cassia*) certified by the Office of the Director, Research and Development/Non-Timber Forest Products, NWFP Forest Department, Peshawar, Pakistan, was used in this study. Cinnamon and wheat flour were ground finely and put into capsules (Mehran Traders Pharmaceutical Suppliers, Peshawar, Pakistan). Each capsule contained either 500 mg of cinnamon or wheat flour. Both the cinnamon and placebo capsules were packaged in plastic bags containing 40 capsules (1 g or two capsules per day for 20 days), 120 capsules (3 g or six capsules per day for 20 days), or 240 capsules (6 g or 12 capsules per day for 20 days) and prepared for distribution to the subjects. When subjects finished testing after the first 20 days, they were given the second package of capsules. Compliance was monitored by capsule count and contact with the subjects. Compliance was considered excellent and all capsules were consumed.

The study was conducted for 60 days with 60 individuals with type 2 diabetes divided randomly into six equal groups. Group 1 consumed two 500-mg capsules of cinnamon per day, group 2 consumed six capsules of cinnamon per day, and group 3 consumed 12 capsules of cinnamon per day. Groups 4, 5, and 6 were assigned to respective placebo groups, which consumed a corresponding number of capsules containing wheat flour. Subjects consumed their normal diets and continued their medications throughout the study. From days 41 to 60, no cinnamon or placebo was given. The 1-g dose of cinnamon and placebo was spread over the day as 0.5 g (one capsule) after lunch and 0.5 g after dinner. The 3-g and 6-g doses of cinnamon and placebo were spread over the day as 1 g (two capsules) and 2 g (four capsules) after breakfast, lunch, and dinner, respectively. The subjects were instructed to take the capsules immediately after meals.

On days 0, 20, 40, and 60, ~5 ml of fasting blood was collected from each subject. Blood samples were transferred to sterilized centrifuge tubes and allowed to clot at room temperature. The blood samples were centrifuged for 10 min in a tabletop clinical centrifuge at 4,000 rpm for serum separation. Serum samples were stored in a freezer at 0°C for later analyses.

Glucose level was determined using an autoanalyzer (Express Plus; Ciba Corning Diagnostics, Palo Alto, CA). Triglyceride levels were determined by the enzymatic colorimetric method of Werner et al. (13) using an autoanalyzer (Express Plus; Ciba Corning) and an Elitech kit (Meditek Instrument, Peshawar, Pakistan). Cholesterol levels were determined by enzymatic colorimetric method of Allain et al. (14) using the same autoanalyzer. Chylomicrons, VLDL, and LDL were precipitated by adding phosphotungstic acid and magnesium ions to the sample. Centrifugation left only the HDL in the supernatant (15). LDL cholesterol was calculated by dividing the triglycerides by 5 and subtracting the HDL cholesterol (16).

Two-way ANOVA and randomized complete block design were used for statistical analysis (17). Values are means ± SD.

RESULTS — The addition of 1, 3, or 6 g of cinnamon to the diet led to significant decreases in serum glucose levels after 40 days. Values after 20 days were significantly lower only in the group receiving 6 g of cinnamon (Table 1). At the levels tested, there was no evidence of a dose response because the response to all three levels of cinnamon was similar. Decreases ranged from 18 to 29%. After the subjects no longer consumed the cinnamon for 20 days, glucose levels were significantly lower only in the group consuming the lowest level of cinnamon. Glucose values in the three placebo groups were not significantly different at any of the time points.

The consumption of cinnamon also led to a time-dependent decrease in serum triglyceride levels at all amounts of cinnamon tested after 40 days (Table 2). Values after 20 days were significantly

Table 2—*Effects of cinnamon on triglyceride levels in people with type 2 diabetes*

Group*	Doses of cinnamon (g/day)	Fasting serum triglyceride level (mmol/l)† Before cinnamon intake Day 0	During cinnamon intake Day 20	During cinnamon intake Day 40	After cinnamon intake Day 60
1	1	2.25 ± 0.35^{a}	1.92 ± 0.18^{ab}	1.57 ± 0.21^{b}	1.67 ± 0.21^{b}
2	3	2.75 ± 0.30^{a}	2.74 ± 0.49^{a}	2.01 ± 0.36^{b}	2.16 ± 0.52^{b}
3	6	2.48 ± 0.39^{a}	1.81 ± 0.28^{b}	1.91 ± 0.30^{b}	2.07 ± 0.32^{ab}
4	Placebo 1	2.31 ± 0.32^{a}	2.38 ± 0.34^{a}	2.50 ± 0.30^{a}	2.45 ± 0.32^{a}
5	Placebo 2	2.38 ± 0.29^{a}	2.42 ± 0.31^{a}	2.39 ± 0.28^{a}	2.21 ± 0.29^{a}
6	Placebo 3	2.55 ± 0.34^{a}	2.66 ± 0.38^{a}	2.52 ± 0.40^{a}	2.65 ± 0.35^{a}

Data are means ± SD. *Ten individuals in each group; †means followed by different superscript letters in the same row are significantly different at $P < 0.05$.

Table 3—*Effects of cinnamon on cholesterol levels in people with type 2 diabetes*

		Fasting serum cholesterol level (mmol/l)†			
		Before cinnamon intake	During cinnamon intake		After cinnamon intake
Group*	Doses of cinnamon (g/day)	Day 0	Day 20	Day 40	Day 60
1	1	4.91 ± 0.23^a	4.32 ± 0.21^b	4.32 ± 0.27^b	4.09 ± 0.30^b
2	3	5.51 ± 0.29^a	4.76 ± 0.32^b	4.09 ± 0.26^c	4.03 ± 0.34^c
3	6	5.30 ± 0.22^a	4.63 ± 0.21^b	4.65 ± 0.24^b	4.86 ± 0.19^b
4	Placebo 1	4.58 ± 0.28^b	4.67 ± 0.35^b	4.58 ± 0.31^b	4.78 ± 0.31^a
5	Placebo 2	4.81 ± 0.30^a	4.71 ± 0.30^a	5.04 ± 0.31^a	4.94 ± 0.35^a
6	Placebo 3	5.51 ± 0.41^c	5.69 ± 0.44^{ab}	5.66 ± 0.43^{bc}	5.84 ± 0.42^a

Data are means ± SD. *Ten individuals in each group; †means followed by different superscript letters in the same row are significantly different at $P < 0.05$.

lower only in the group consuming 6 g of cinnamon per day. Decreases after 40 days of cinnamon consumption ranged from 23 to 30%. These data indicate that consumption of cinnamon for >20 days was more beneficial than shorter use for reduction of triglyceride levels in people with type 2 diabetes. The mean fasting serum triglyceride levels of the subjects who consumed 1 g or 3 g of cinnamon per day for 40 days followed by 20 days of not consuming cinnamon were still significantly lower than the mean fasting serum triglyceride levels of the same groups at the beginning of the study. Decreases in the 6-g group were no longer significant. There were no changes in triglyceride levels in any of the three placebo groups (Table 2).

There were also significant decreases in serum cholesterol levels in all three groups consuming cinnamon, and no changes were noted in the respective placebo groups (Table 3). Decreases were significant after 20 days, and values were similar after 40 days, except in the group consuming 3 g per day, which continued to decrease. These decreases in serum cholesterol level ranging from 13 to 26% were maintained even after not consuming additional cinnamon for 20 days (Table 3, last column).

Decreases in LDL were significant in the 3- and 6-g groups after 40 days with decreases of 10 and 24% (Table 4). Decreases in the 1-g group were not significant after 40 days but continued to decline during the washout period and were significant after 60 days (Table 4, last column).

There were nonsignificant changes in HDL in the subjects consuming 1 or 6 g of cinnamon for 40 days. Decreases in the 3-g group were significant after 20 days. These values remained relatively unchanged after the 20-day washout period.

CONCLUSIONS — This study demonstrates effects of low levels (1–6 g per day) of cinnamon on the reduction of glucose, triglyceride, LDL cholesterol, and total cholesterol levels in subjects with type 2 diabetes. The study design serves to replicate the results because there were similar effects at the three doses tested. It is not clear whether even less than 1 g of cinnamon per day would also be beneficial. The data are also reinforced by the observation that there were no significant changes in any of the placebo groups. There were also no problems with compliance or problems associated with the consumption of ≤6 g of cinnamon per day.

The mechanism of the effects of cinnamon on glucose and blood lipids must be determined. Symptoms of insulin resistance include decreased stimulation of muscle glycogen synthesis as well as defects in glycogen synthase activity and glucose uptake (18). In addition, altered enzymatic activities, such as an increased phosphatase activity and/or seryl phosphorylation of the insulin receptor substrate by glycogen synthase kinase-3 (GSK-3), have also been shown to be involved in some cases of type 2 diabetes (19,20). Dephosphorylation of the receptor β-subunit is associated with the deactivation of its kinase activity and, therefore, is associated with insulin signal downregulation (21). Maximal phosphorylation of the insulin receptor is associated with increased insulin sensitivity, which is associated with improved glucose and lipid levels. Extracts of cinnamon activated glycogen synthase, increased glucose uptake, and inhibited glycogen synthase kinase-3β (11,12). Extracts of cinnamon also activated insulin receptor kinase and inhibited dephosphorylation of the insulin receptor, leading to maximal phosphorylation of the insulin receptor (12). All of these effects would lead to increased insulin sensitivity. We have shown that extracts of cinnamon also function as potent antioxidants, which would lead to additional health benefits of this substance (unpublished data). Dhuley (22) showed that cinnamon displays antioxidant activity in rats fed a high-fat diet.

The maintenance of lower serum glucose and lipid levels, even when the individuals were not consuming cinnamon for 20 days, denotes sustained effects of cinnamon, indicating that cinnamon would not need to be consumed every

Table 4—*Effects of cinnamon on LDL levels in people with type 2 diabetes*

		Fasting serum LDL level (mmol/l)†			
		Before cinnamon intake	During cinnamon intake		After cinnamon intake
Group*	Doses of cinnamon (g/day)	Day 0	Day 20	Day 40	Day 60
1	1	2.66 ± 0.12^a	2.28 ± 0.15^b	2.48 ± 0.10^{ab}	2.35 ± 0.13^b
2	3	2.77 ± 0.18^a	2.43 ± 0.28^{ab}	2.04 ± 0.19^{bc}	1.97 ± 0.18^c
3	6	2.87 ± 0.18^a	2.56 ± 0.13^b	2.59 ± 0.16^b	2.72 ± 0.11^{ab}
4	Placebo 1	2.30 ± 0.22^a	2.30 ± 0.31^a	2.20 ± 0.22^a	2.40 ± 0.22^a
5	Placebo 2	2.56 ± 0.25^a	2.40 ± 0.22^a	2.66 ± 0.27^a	2.79 ± 0.27^a
6	Placebo 3	3.03 ± 0.31^b	3.15 ± 0.33^{ab}	3.28 ± 0.34^a	3.36 ± 0.37^a

Data are means ± SD. *Ten individuals in each group; †means followed by different superscript letters in the same row are significantly different at $P < 0.05$.

day. The levels of cinnamon tested in this study, 1–6 g per day, suggest that there is a wide range of cinnamon intake that may be beneficial and that intake of <1 g daily is likely to be beneficial in controlling blood glucose and lipid levels.

In conclusion, cinnamon reduced serum glucose, triglyceride, total cholesterol, and LDL cholesterol levels in people with type 2 diabetes. Because cinnamon would not contribute to caloric intake, those who have type 2 diabetes or those who have elevated glucose, triglyceride, LDL cholesterol, or total cholesterol levels may benefit from the regular inclusion of cinnamon in their daily diet. In addition, cinnamon may be beneficial for the remainder of the population to prevent and control elevated glucose and blood lipid levels.

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