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Effect of Various Doses of Cinnamon on Lipid Profile in Diabetic Individuals

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Abstract: The effect of cinnamon doses on blood serum triglyceride (TGL), total cholesterol, high-density lipoproteins (HDL) and low-density lipoproteins (LDL) was studied in type 2 diabetic individuals for 60 days. Sixty type 2 diabetic individuals of both sexes and of age 48± 6.5 years were divided into 6 groups; each group was having 10 individuals. Groups 1, 2 and 3 were assigned for 1g, 3g and 6g cinnamon doses/day respectively. Groups 4, 5 and 6 were assigned for 1g, 3g and 6g placebo doses/day respectively. The doses were equally distributed over the day. Cinnamon and placebo were given in the form of capsules with breakfast, lunch and dinner. The doses were taken for 40 days and after 40 days; there was a 20 days blank period. Fasting blood samples were taken on days 0 (starting day of the experiment) 20, 40 and 60 and blood serums were separated. The TGL, cholesterol, HDL and LDL of blood serum of both the cinnamon and placebo groups were determined. Cinnamon doses significantly ($P<0.05$) reduced the mean fasting serum TGL and cholesterol levels while the placebo doses did not change the serum TGL and cholesterol levels. Cinnamon doses reduced the mean fasting serum HDL levels but the reduction was non significant at $P<0.05$, while placebo doses did not affect the serum HDL levels. Cinnamon doses significantly ($P<0.05$) reduced the mean fasting serum LDL levels while the placebo doses did not affect the serum LDL levels. The data demonstrated that cinnamon intake reduced blood serum TGL, cholesterol and LDL significantly ($P<0.05$) in type 2 diabetic individuals. In the light of this research, it is recommended that individuals who have high TGL, cholesterol and LDL levels, they should use cinnamon in their food preparations on regular basis. This will keep their TGL, cholesterol and LDL levels low.

Key words: Cinnamon, lipid profile, diabetic

Introduction

Diabetes mellitus is basically a disease of glucose metabolism resulting from dysfunction of pancreatic-beta cells and insulin resistance, but at later stages of the disease, lipid metabolism is also affected. Spices like cinnamon, cloves, bay leaves, and turmeric have insulin-potentiating effect *in vitro* (Khan *et al*., 1990). So these spices might have a role in lipid metabolism.

Rashwan (1998) studied the effects of dietary additions of spices namely anise, fenugreek and caraway on reproductive and productive performance of New Zealand White rabbit does. He reported that dietary anise supplementation increased total serum lipids and cholesterol while fenugreek addition decreased total serum lipids.

Khan *et al.* (1996) studied the biochemical response in rats to the addition of curry leaf (Murraya koenigii) and mustard seeds (Brassica juncea) to the diet. Three groups of 12 weanling male albino rats were group fed for 90 days on 1 of 3 diets: a standard laboratory rat diet supplemented with 20% coconut oil (high fat control diet) or the high fat diet supplemented with 10% curry leaf (M. koenigii) or 10% mustard seeds (B. juncea). Feed was offered at a level of 10% body weight. At the end of the trial total serum cholesterol, HDL, LDL and VLDL fractions, release of lipoproteins into the circulation, lecithin cholesterol acyl transferase (LCAT) activity and lipoprotein lipase activity were examined. Curry leaf and mustard seeds decreased total serum cholesterol and LDL and VLDL, increased HDL, decreased the release of lipoproteins into the circulation and increased LCAT activity.

Khan *et al.* (1998) studied the influence of spices - Murraya koenigii and Brassica juncea on rats fed atherogenic diet. A high fat cholesterol diet containing 10% Murraya koenigii leaf (curry leaf) or 10% Brassica juncea (mustard) seeds or a high fat cholesterol diet alone was fed to Sprague-Dawley rats for 3 months (n=12 per diet). The plasma lipoprotein profile at 3 months showed that these spices reduced the concentrations of cholesterol, TGL and phospholipids in serum, aorta, liver and heart ($P<0.01$). The low-density lipoproteins and very low-density lipoprotein fractions were also decreased and the HDL fraction was increased. It is suggested that these 2 common spices could play a significant role in controlling the development of hypercholesterolaemia and atherosclerosis.

Chithra and Leelamma (1997) reported the hypolipidemic effect of coriander seeds (Coriandrum sativum) and its mechanism of action. Female albino Sprague-Dawley rats (65-70 g) were randomly assigned to receive a high fat diet [rodent chow + coconut oil (15%) + cholesterol (2%)] or a high fat diet including coriander seeds (Coriandrum sativum, 10%) for 75 days. The level of cholesterol decreased in the tissues of rats fed

coriander seeds (89.10±2.60, 1050±30.50 and 90.43±2.62 vs. 160.30±4.65 mg/100 ml, 1751.20±50.80 and 281.60±8.17 mg/100 g in serum, liver and heart, respectively). Corresponding values for triacylglycerols were 7.390±0.214, 329.75±9.56 and 26.93±0.78 vs. 14.80±0.43 mg/100 ml, 797.90±23.14 and 71.80±2.10-mg/100 g, respectively. Beta-hydroxy, beta-methyl glutaryl CoA reductase [hydroxymethylglutaryl-CoA reductase (NADPH)]-phosphatase] and plasma lecithin-cholesterol acyltransferase [phosphatidylcholine-sterol O-acyltransferase] activity increased in the experimental group. They noted that LDL and VLDL cholesterol decreased and HDL cholesterol increased in the experimental group vs. the control group. They concluded that the hypocholesterolaemic effect of coriander seeds was as a result of increased activity of plasma LCAT enhanced hepatic bile acid synthesis and the increased degradation of cholesterol to faecal bile acids and neutral sterols. Zhang *et al.* (1999) suggested that turmeric might have a role in reducing the risk of atherosclerosis.

Spices like cinnamon has insulin potentiating activity and due to this property, cinnamon might have a role in lipid metabolism. This study was designed to see the effect of various doses of cinnamon on blood serum lipid profile in type 2 diabetic individuals.

Materials and Methods

Location, sample size and criteria for registration of the study: The study was conducted in the department of Human Nutrition, NWFP Agricultural University Peshawar, Pakistan. Sixty type 2 diabetic individuals of both sexes and of age 40 years or older, who were residing in Peshawar city and its vicinity, were registered for the study. These diabetic individuals were registered at different times and at different locations, because diabetics were not available at one time. Only those diabetic subjects, who were not on insulin therapy, were not taking medicine for other health conditions and whose fasting blood glucose were in the range of 140-400mg/dl, were included in the study.

Preparation of cinnamon and placebo capsules: Cinnamon and wheat flour were used for the preparation of cinnamon and placebo capsules. The required amount of cinnamon and wheat flour were purchased from the local market and ground finely. The ground cinnamon and wheat flour were given to Mehran Traders, Pharmaceutical Suppliers, Khalid Market, Charsadda Road, Peshawar for preparation of the capsules. Capsules were prepared and each capsule was having 500mg of cinnamon or wheat flour. Packages of 40 (1g or 2 capsules/day for 20 days), 120 (3g or 6 capsules/day for 20 days) and 240 (6g or 12 capsules/day for 20 days) of both the cinnamon and placebo capsules were prepared in plastic bags.

Protocol of the study: The study was conducted for 60 days. The 60 type 2 diabetic individuals were divided into 6 groups. Each group was having 10 individuals. Groups 1, 2 and 3 were assigned to cinnamon and groups 4, 5 and 6 were assigned to placebo. The individuals were allowed to take their routine diet and usual diabetic medicine. Groups 1, 2 and 3 were given 1g, 3g and 6g cinnamon/day respectively for 40 days. From day 41 to 60, no dose of cinnamon was given. On similar pattern, 1g, 3g and 6g placebo/day were given to groups 4, 5 and 6 respectively for 40 days. The 1g doses of cinnamon and placebo were spread over the day as 0.5g (1 capsule) at the time of lunch and 0.5g (1 capsule) at the time of dinner. The 3g and 6g doses of cinnamon and placebo were spread over the day as 1g (2 capsules) and 2g (4 capsules) at the time of breakfast, lunch and dinner respectively. The individuals were told to take the capsules immediate after breakfast and meals.

Collection of blood samples and biochemical analysis: Approximately 5ml fasting blood samples were taken from each individual on day 0, 20, 40 and 60. Blood samples were transferred to sterilized centrifuge tubes and allowed for clotting at room temperature. The blood samples were centrifuged for 10 minutes in a centrifuge at 4000 rpm for serum separation. Serum samples were stored in freezer at 0 ^{o}C for later analysis of TGL, total cholesterol, high and low-density lipoproteins(HDL and LDL) cholesterol.

Determination of TGL: TGL were determined by the enzymatic calorimetric method of Werner *et al.*, 1981. Auto analyzer (Express plus, Ciba corning USA) and Elitech kit were used.

Determination of cholesterol: Cholesterol was determined by enzymatic calorimetric method of Allain *et al.*, 1974. Auto analyzer (Express plus, Ciba corning USA) and Elitech kit were used.

Determination of HDL cholesterol: Chylomicrons, VLDL (very low-density lipoproteins), and LDL (low-density lipoproteins) were precipitated by adding phosphotungstic acid and magnesium ions to the sample. Centrifugation left only the HDL (high-density lipoproteins) in the supernatant; their cholesterol content was determined (Virella *et al.*, 1977).

Determination of LDL cholesterol: LDL cholesterol was calculated by the following formulae:

$$\text{LDL cholesterol (mg/dL)} = \frac{\text{TGL}}{5} - \text{HDL cholesterol}$$

The calculations were done automatically.

Statistical analysis: Two-way Analysis of Variance and

Randomized Complete Block Design was used for statistical analysis (Freed, 1989)

Results and Discussion

Effect of cinnamon on TGL: The effect of various doses of cinnamon on TGL levels of diabetic individual is shown in Fig. 1. The TGL values on day 0 indicate the fasting serum TGL of diabetic individuals before the start of cinnamon capsules. So these TGL levels were the control values for the study.

On the starting day of the experiment (day 0), the mean fasting serum TGL levels of the diabetic individuals of the 3 groups, assigned for 1g, 3g and 6g cinnamon doses per day, were 199.2 mg/dl, 243.8 mg/dl and 220.1 mg/dl respectively. When the diabetic individuals of these groups used the doses of cinnamon for 20 days, their mean fasting serum TGL dropped to 170.3 mg/dl and 159.8 mg/dl respectively in the first and third groups' individuals, who used 1 g and 6 g cinnamon doses/day but did not change in the second group's individuals (242.9 mg/dl), who used 3 g cinnamon dose per day for the first 20 days. The reduction in the mean fasting blood TGL was not significant ($P<0.05$) from the mean fasting blood TGL in the first group, but was significant ($P<0.05$) in the third group.

When the same individuals of the same groups used 1g, 3g and 6g cinnamon doses/day for 40 days, their mean fasting serum TGL dropped to 138.9 mg/dl, 178.2 mg/dl and 169.3 mg/dl respectively. Consumption of the various doses of cinnamon for 40 days significantly ($P <0.05$) lowered the mean fasting serum TGL of diabetic individuals of all the three groups as compared to the mean fasting serum TGL values of the diabetic individuals of the same groups at the start of the experiment (day 0). The mean fasting serum TGL levels of the diabetic individuals of the groups, who used 1 g and 6 g cinnamon per day for 40 days were significantly ($P<0.05$) lower than the serum TGL levels of the diabetic individuals of the same groups who consumed cinnamon for 20 days. The mean fasting serum TGL level of the diabetic individuals, who used 3 g dose of cinnamon/day for 40 days, were significantly ($P<0.05$) lower than the serum TGL when they consumed the same dose of cinnamon for 20 days. The data indicated that longer use of cinnamon was more beneficial than shorter use for TGL reduction in diabetic individuals.

The mean fasting serum TGL levels of the diabetic individuals of all the 3 groups on day 60, when they were not using cinnamon for the last 20 days, were 148.2 mg/dl, 191.4 mg/dl and 182.6 mg/dl respectively. The mean fasting serum TGL levels of the groups of diabetic individuals, who used 1 g and 3 g cinnamon per day, on day 60 were significantly ($P<0.05$) lower than the mean fasting serum TGL of the same groups on day 0. On day 60, the mean fasting serum TGL level of the group, which used 6 g cinnamon dose per day, was non-significantly lower than the mean fasting serum TGL level of the same group on day 0.

Cinnamon doses significantly ($P<0.05$) reduced the TGL levels in diabetic individuals. This effect of cinnamon is particularly important for hyperlipidemic individuals. Cinnamon is a spice; so hyperlipidemic individuals can make a regular schedule of cinnamon eating. The lipid lowering effect of cinnamon might be due to insulin potentiating action of cinnamon (Khan *et al.*, 1990). Usually when glucose metabolism is improved lipid metabolism is also improved. The maintenance of lower value of TGL, even when the individuals were not using cinnamon, was of particular significance, as cinnamon might have brought some biochemical changes in the body that kept the TGL level low. This property of cinnamon is of immense therapeutic use particularly for hyperlipidemic individuals.

Spices and natural products may lower TGL in humans. Cinnamon bark has also shown strong lipolytic (ability to hydrolyze fats) action (Leung and Foster, 1996). Chithra and Leelamma (1997) reported the hypolipidemic effect of coriander seeds (Coriandrum sativum) and its mechanism of action. Botanical products can improve glucose metabolism and over all condition of persons with diabetes not only by hypoglycemic effect but also by improving lipid metabolism, antioxidant status, and capillary function (Broadhurst, 1997). Rashwan (1998) reported that addition of fenugreek to diet decreased total blood lipids in rats.

To verify that the drop in serum TGL level was not due to psychological effect of the capsules, placebo in the dose of 1 g, 3 g and 6 g were given in the same pattern, as the cinnamon. The doses of placebo did not affect the TGL level during the intake of placebo (Fig. 2).

The effect of different cinnamon doses on the mean fasting blood TGL is given in Table 1. There was no significant effect of cinnamon doses on the concentration of TGL in type 2 diabetic individuals. The study indicated that small dose of cinnamon like 1-3g/day would reduce the TGL concentration in diabetic individuals. The usual addition of cinnamon as a spice to food preparations will be sufficient.

Effect of cinnamon on cholesterol: The effect of various doses of cinnamon on the blood cholesterol levels of diabetic individual is shown in Fig. 3. The values on day 0 indicate the fasting blood cholesterol of diabetic individuals before the start of cinnamon capsules. So these cholesterol levels were control values for the study.

On the starting day of the experiment (day 0), the mean fasting serum cholesterol levels of the diabetic individuals of the 3 groups, assigned for 1g, 3g and 6g cinnamon dose/day, were 189.6 mg/dl, 212.9 mg/dl and 205.3 mg/dl respectively. When the diabetic individuals

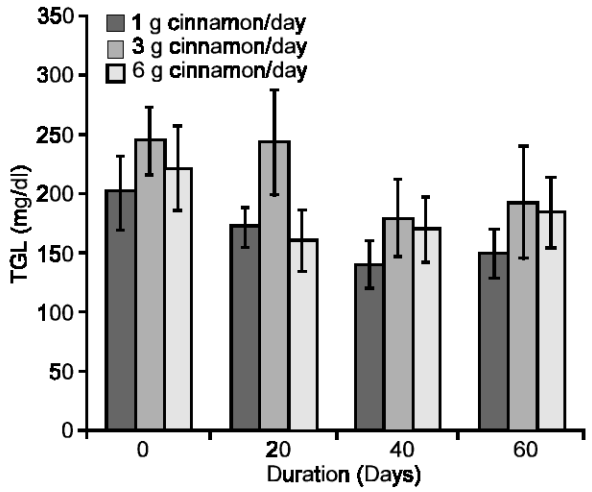

Fig. 1: Effect of Cinnamon on TGL in diabetic individuals

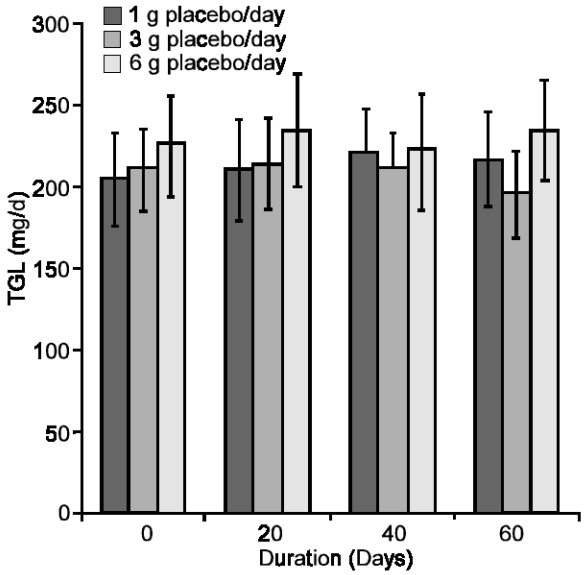

Fig. 2: Effect of placebo on TGL in diabetic individuals

of these groups used cinnamon doses for 20 days, their mean fasting blood cholesterol level dropped to 166.7 mg/dl, 183.6 mg/dl and 179.3 mg/dl respectively. This reduction in cholesterol levels was statistically significant ($P<0.05$) from the mean fasting blood cholesterol values on day 0. When the same individuals of the same groups used cinnamon doses for 40 days, their mean fasting blood cholesterol were 165.8 mg/dl, 157.9 mg/dl and 180.1 mg/dl respectively. Consumption of cinnamon doses for 40 days further lowered the mean fasting serum cholesterol levels of diabetic individual of all the 3 groups of cinnamon as compared to the mean fasting serum cholesterol values of the diabetic individuals of the same groups at the start of the experiment.

The mean fasting serum cholesterol levels of the diabetic individuals of the cinnamon groups on day 60 (when they were not using cinnamon for the last 20 days) were 157.7 mg/dl, 155.8 mg/dl and 188.2 mg/dl respectively. These values were significantly lower ($P<0.05$) than the mean fasting blood cholesterol levels of the diabetic individuals of these groups on day 0. The mean fasting blood cholesterol levels did not raise even the individuals of the groups were not taking cinnamon doses for the last 20 days. This indicates that cinnamon has lasting hypocholesterolemic effect in diabetic individuals. Spices and natural products have an effect on cholesterol in humans. Cinnamon bark has also shown strong lipolytic (ability to hydrolyze fats) action (Leung and Foster, 1996). Curry leaf and mustard seeds decrease total serum cholesterol (Khan *et al.*, 1996). Spices-Murraya koenigii and Brassica juncea reduce the concentrations of cholesterol, TGL and phospholipids in serum (Khan *et al.*, 1998).

The cholesterol lowering effect of cinnamon will have an immense effect in the treatment strategy of patients who are suffering from cardio-vascular problems. We, at present, do not have any explanation for this reduction but seems that some constituents of cinnamon are blocking the synthesis of cholesterol or facilitating the clearance of cholesterol from the body. The insulin potentiating property of cinnamon may be helping reducing cholesterol level. Those individuals who have high cholesterol levels may adopt regular eating of 1-3g cinnamon daily to lower their cholesterol levels.

To verify that the reduction in cholesterol levels was not due to psychological effect of the capsules, placebo in the dose of 1 g, 3 g and 6 g was given in the same pattern, as the cinnamon. The doses of placebo did not affect the total cholesterol levels during the intake of placebo (Fig. 4).

The effect of different cinnamon doses on the mean fasting blood cholesterol is given in Table 2. There was no significant effect of cinnamon doses on the concentration of serum cholesterol in type 2 diabetic individuals. The results indicated that small dose of cinnamon like 1-3g/day was as effective as large dose (6g/day) in reduction of cholesterol concentration in diabetic individuals.

Effect of cinnamon on HDL: The effect of various doses of cinnamon on the serum HDL levels of diabetic individual is shown in Fig. 5. The values on day 0 indicate the fasting blood HDL of diabetic individuals before the start of cinnamon capsules. So these HDL levels were control values for the study.

On the starting day of the experiment (day 0), the mean fasting serum HDL levels of the diabetic individuals of the 3 groups, assigned for 1g, 3g and 6g cinnamon dose/day, were 46.6 mg/dl, 57.0 mg/dl and 50.4 mg/dl respectively. When the diabetic individuals of these

Table 1: Effects of Different Doses of Cinnamon on TGL

Group* of Diabetics	Doses of Cinnamon (g/day)	Mean Fasting TGL (mg/dl) **	
		Before Cinnamon Intake	After Cinnamon Intake
1	1	199.2[a]	154.6[a]
2	3	243.8[a]	210.6[a]
3	6	220.1[a]	164.6[a*]

* = 10 individuals in each group

**= The figures in column No. 4 are the average of values on days 20 and 40. Means followed by different letters in rows are significantly different at P < 0.05 as determined by analysis of variance and LSD test.

Table 2: Effects of Different Doses of Cinnamon on Cholesterol

Group* of Diabetics	Doses of Cinnamon (g/day)	Mean Fasting Cholesterol (mg/dl)**	
		Before Cinnamon Intake	After Cinnamon Intake
1	1	189.6[a]	166.3[a]
2	3	212.9[a]	170.8[a]
3	6	205.3[a]	179.7

[a]* = 10 individuals in each group

**= The figures in column No. 4 are the average of values on days 20 and 40. Means followed by different letters in rows are significantly different at P < 0.05 as determined by analysis of variance and LSD test.

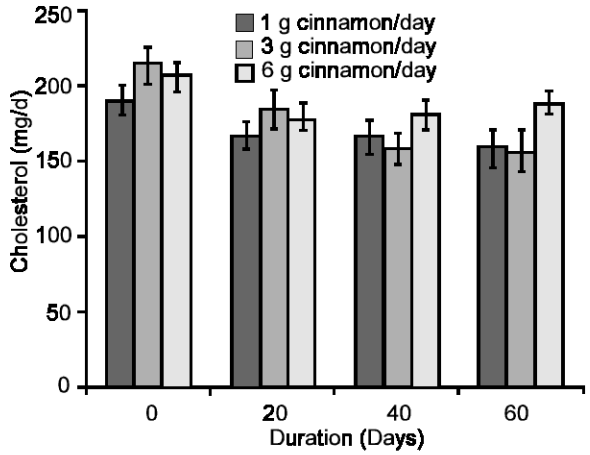

Fig. 3: Effect of cinnamon on cholesterol in diabetic individuals

groups used cinnamon doses for 20 days, the mean fasting serum HDL level dropped to 44.3 mg/dl, 47.2 mg/dl and 46.3 mg/dl respectively. This reduction in HDL levels was not statistically significant (P<0.05) from the mean fasting serum HDL values on day 0 except for group 2 individuals, who used 3g cinnamon/day. When the same individuals of the same groups used cinnamon doses for 40 days, their mean fasting serum HDL further dropped to 43.3 mg/dl, 43.3 mg/dl and 46.1 mg/dl respectively. But this reduction was also non-significant (P >0.05) except for group 2 who used 3g cinnamon/day.

The mean fasting serum HDL levels of the diabetic individuals of all the 3 groups on day 60 (when they were not using cinnamon for the last 20 days) were 40.9 mg/dl, 43.6 mg/dl and 46.8 mg/dl respectively. The mean fasting serum HDL levels of the diabetic individuals of all the 3 groups on day 60 were also showing non-significant results. It was expected that cinnamon intake will increase the HDL level of type 2 diabetic individuals but it did not.

To see the psychological effect of the capsules, placebo in the dose of 1 g, 3 g and 6 g was given in the same pattern as the cinnamon. The doses of placebo did not affect the HDL levels (Fig. 6).

The effect of different cinnamon doses on the mean fasting serum HDL is given in Table 3. There was no significant effect of cinnamon doses on the concentration of HDL in Type 2 diabetic individuals. The data demonstrated that small dose of cinnamon like 1-3g/day was as effective as large dose (6g/day) in reduction of serum HDL concentration in diabetic individuals.

Effect of cinnamon on LDL: The effect of various doses of cinnamon on the serum LDL levels of diabetic individual is shown in Fig. 7. The values on day 0 indicate the fasting serum LDL of diabetic individuals before the start of cinnamon capsules. So these LDL levels were the control values for the study.

On the starting day of the experiment (day 0), the mean fasting serum LDL levels of the diabetic individuals of the 3 groups, assigned for 1g, 3g and 6g cinnamon dose/day, were 102.8 mg/dl, 107.0 mg/dl and 111.0 mg/dl respectively. When the diabetic individuals of these groups used cinnamon doses for 20 days, the mean fasting blood LDL levels dropped to 87.8 mg/dl,

Table 3: Effects of Different Doses of Cinnamon on HDL

Group* of Diabetics	Doses of Cinnamon (g/day)	Mean Fasting HDL (mg/dl)**	
		Before Cinnamon Intake	After Cinnamon Intake
1	1	46.6[a]	43.8[a]
2	3	57.0[a]	45.3[a]
3	6	50.4[a]	46.2

a* = 10 individuals in each group

** = The figures in column No. 4 are the average of values on days 20 and 40. Means followed by different letters in rows are significantly different at P < 0.05 as determined by analysis of variance and LSD test.

Table 4: Effects of Different Doses of Cinnamon on LDL

Group* of Diabetics	Doses of Cinnamon (g/day)	Mean Fasting LDL (mg/dl)**	
		Before Cinnamon Intake	After Cinnamon Intake
1	1	102.8[a]	92.0[a]
2	3	107.0[a]	86.3[a]
3	6	111.0[a]	99.4

[a]* = 10 individuals in each group

**= The figures in column No. 4 are the average of values on days 20 and 40. Means followed by different letters in rows are significantly different at P < 0.05 as determined by analysis of variance and LSD test.

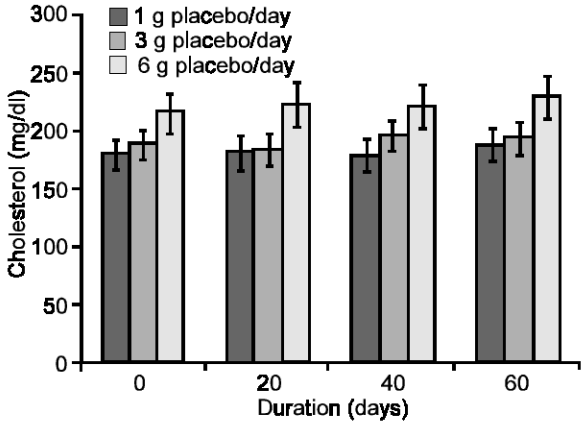

Fig. 4: Effect of placebo on cholesterol in diabetic individuals

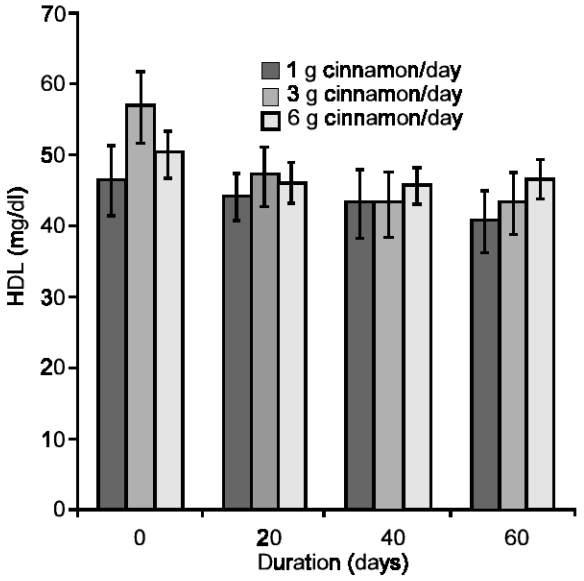

Fig. 5: Effect of cinnamon on HDL in diabetic

93.6 mg/dl and 98.9 mg/dl respectively. The data demonstrated that cinnamon doses reduced the mean fasting serum LDL levels significantly (P<0.05) in groups 1 and 3 and non-significantly in group 2 as compared with the mean fasting serum LDL values on day 0. When the same individuals of the same groups used cinnamon doses for 40 days, their mean fasting blood LDL was noted 96.2 mg/dl, 78.9 mg/dl and 99.8 mg/dl respectively. Consumption of the various doses of cinnamon for 40 days significantly (P <0.05) lowered the mean fasting blood LDL levels of diabetic individual of all the 3 groups of cinnamon as compared to the mean fasting blood values of the diabetic individuals of the same groups at the start of the experiment (day 0). In group 1, the reduction in LDL cholesterol was significant when the individuals used cinnamon for 20 days, but changed to non-significance when they used cinnamon for 40 days. This observation was perhaps an error somewhere in the process of sample preparation/determination.

The mean fasting serum LDL levels of the diabetic individuals of all the 3 groups on day 60 (when they were not using cinnamon for the last 20 days) were 90.9 mg/dl, 75.5 mg/dl and 104.9 mg/dl respectively and were significantly lower (P<0.05) than the mean fasting blood LDL levels of the diabetic individuals in groups 1 and 2

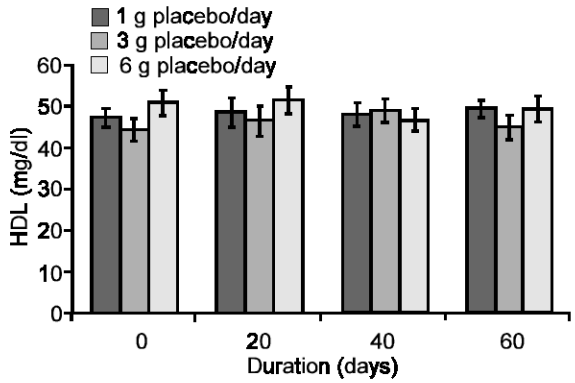

Fig. 6: Effect of placebo on HDL in diabetic individuals

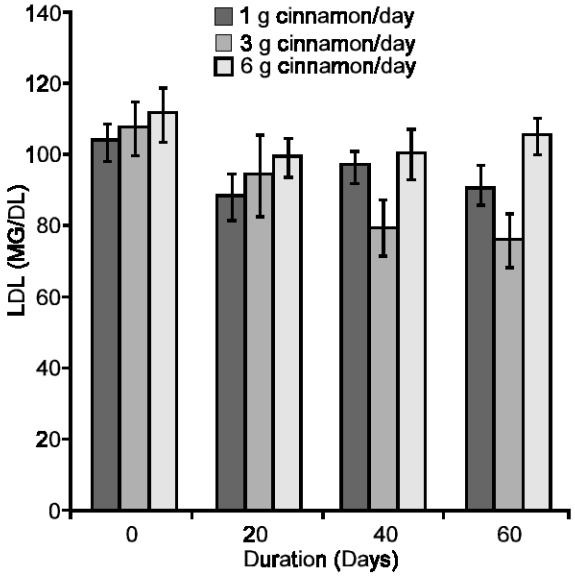

Fig. 7: Effect of cinnamon on LDL in diabetic individuals

and non-significant in group 3 on day 0. The data showed that cinnamon doses reduced the LDL level in diabetic individuals, so people who have higher LDL level are recommended to use cinnamon in their diet. This will keep their LDL level low. Curry leaf and mustard seeds have been reported to decrease total serum LDL in rats (Khan *et al*., 1996).

Keeping the mean fasting serum LDL levels lower even the individuals were not taking cinnamon doses indicated that cinnamon had lasting effect in diabetic individuals as their mean fasting serum LDL levels did not rise up to the mean LDL levels which was at the start of the experiment (day 0), though they were not using cinnamon for the last 20 days. It is possible that cinnamon might have brought some change in the synthesis/metabolism of LDL.

To verify that the reduction in LDL was not due to psychological effect of the capsules, placebo in the dose

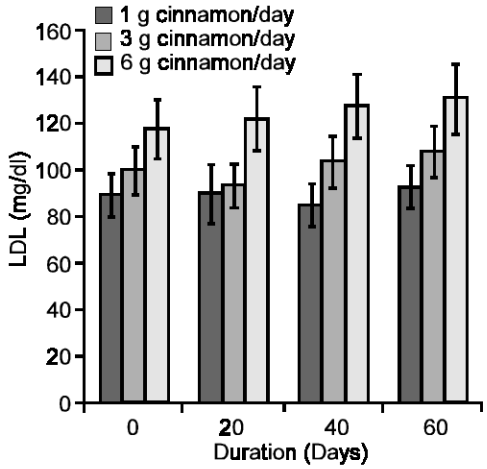

Fig. 8: Effect of placebo on LDL in diabetic individuals

of 1 g, 3 g and 6 g was given in the same pattern, as the cinnamon. The doses of placebo did not affect the LDL levels (Fig. 8).

The effect of different cinnamon doses on the mean fasting serum LDL is given in Table 4. There was no significant effect of cinnamon doses on the concentration of LDL in type 2 diabetic individuals. The data revealed that small doses of cinnamon are as good as large doses for reduction of LDL concentration in diabetic individuals.

In conclusion, cinnamon reduced blood serum TGL, total and LDL cholesterol significantly ($p < 0.05$) in type 2 diabetic individuals. Cinnamon is a spice and many people are using it in food preparations for taste and flavor development. Those who have type 2 diabetes mellitus, or they are hyperlipidemic or hypercholesterolemic, they should use cinnamon on regular basis. They can use 1-3 g cinnamon per day. It can be added to foods by sprinkling over it or food can be prepared with cinnamon added as spice. It can be chewed or cinnamon tea without sugar can be prepared. It can be taken with breakfast and meals.

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