A Comparative study between Male and Female with Type 2 Diabetic based on the effect of cinnamon supplementation on fasting serum glucose, triglyceride, total cholesterol levels, and blood pressure

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Abstract

Objective: *The objective of this study was to compare the effects of cinnamon on Fasting Serum glucose, triglyceride, total cholesterol levels and, Systolic and diastolic blood pressure (SBP and DBP) between men and women with type 2 diabetes.*

Methods: *The 44 type 2 diabetic individuals were divided in 2 groups. Each group had 22 individuals and were randomly assigned to take either a cinnamon or a placebo capsule two times a day (2g/day) for 60 days in a double-blind study.*

Results: *After 60 days, consumption 2 g/day of cinnamon reduced the mean fasting serum glucose to (– 11.7 % and – 35.5%), triglyceride (– 21.9 % and – 23.4%), total cholesterol (–31.52% and –24.29%), SBP (–10.86% and –17.7%) and DBP was reduced to (-4.1% and -0.22%) for female and male respectively.; no significant changes were noted in the placebo groups. There were changes at 60 days in fasting serum glucose and were significant ($p<0.05$) for male comparing to female and there was significant ($P<0.05$) effect of cinnamon doses on the concentration of cholesterol level in type 2 diabetic for female comparing to male.*

Conclusion: *In the light of this research, it is recommended that individuals who have high fasting blood glucose, triglyceride, cholesterol and blood pressure levels should use cinnamon in their food preparations on regular basis.*

Key words: *Cinnamon, Type 2 Diabetes, Fasting Serum Glucose, Diastolic Blood Pressure.*

الملخص

هدفت هذه الدراسة إلى مقارنة تأثير القرفة على سكر الدم الصائم والدهون الثلاثية والكوليسترول وضغط الدم الانقباضي والانبساطي بين الذكور والإناث المصابين بمرض السكري نوع 2. شملت الدراسة 44 مريض سكري نوع 2 من كلا الجنسين (الذكور والإناث) وتم تقسيمهم إلى مجموعتين كل مجموعة مكونة من 22 شخص، تم تعيين الاختيار بشكل عشوائي إما كبسولات القرفة أو الدواء الوهمي لتناولها مرتين في اليوم (2جرام/يوم) لمدة 60 يوم في دراسة تامة التعشية. بعد 60 يوما من استهلاك 2 جرام من القرفة انخفضت نسبة سكر الدم الصائم إلى (-11.7% و -35.5%)، الدهون الثلاثية إلى (-21.9% و -23.4%)، الكوليسترول إلى (-31.52% و -24.29%)، ضغط الدم الانقباضي إلى (-10.68% و -17.7%)، ضغط الدم الانبساطي إلى (-4.1% و -0.22%) للإناث والذكور على التوالي; ولا توجد فروق معنوية على مجموعة الدواء الوهمي.

كانت هناك فروق معنوية ($p<0.05$) للذكور مقارنة بالإناث عند استخدام القرفة لمدة 60 يوم في جلوكوز الدم الصائم وهناك أيضا فروق معنوية ($p<0.05$) للإناث مقارنة بالذكور في مستوى الكوليسترول لمرضى السكري نوع 2. وعلى ضوء هذا البحث، يوصى الأشخاص الذين لديهم ارتفاع في سكر الدم الصائم والدهون الثلاثية والكوليسترول، باستخدام القرفة مع وجباتهم الغذائية بشكل منتظم.

INTRODUCTION

Cinnamon is the bark of cinnamomum, known from ancient times in the Mediterranean region, Sri Lanka and India, has been used for cooking to improve taste and aroma of food.

The genus cinnamomum includes more than 250 evergreen shrubs and trees. Of 98 common foods analyzed, cinnamon contains the highest level of procyanidins compounds (8.1% wet weight basis) (Singh et al, 2007). Cinnamon also has medicinal properties that may be beneficial in the prevention and/or treatment of chronic diseases (World Health Organization, 1999).

Improvements in markers of oxidative stress, blood pressure, blood lipids, blood glucose, and insulin sensitivity have been observed with ingestion of cinnamon, usually as a ground solid or an aqueous extract of cassia cinnamon (Roussel et al, 2009; Akilen el al, 2010; Khan, 2003a; Solomon and Blannin, 2009). There are likely a number of cinnamon constituents responsible for these positive health effects. One well-described group of compounds is cinnamon polyphenols (Anderson et al, 2004). In vitro and animal studies indicate these water-soluble polymers promote phosphorylation of the beta subunit of the insulin receptor (Jarvill-Taylor et al, 2001), enhancing insulin signaling (Cao et al, 2007), glucose transport, and glycogen storage (Jarvill-Taylor et al, 2001; Cao et al, 2010).

Cinnamon is the bark of the Cinnamomi cassiae (Lauraceae), it contains cinnamic aldehyde, cinnamic acid, tannin and Methyl-Hydroxychalcone Polymer (MHCP) as main components. Cinnamon Extract (CE) contains biologically active substances with insulin-mimetic properties (Kim et al, 2006).

The cause of type 2 diabetes is multifactor. Diet can play a major role in the incidence and progression of the disease (Carter et al, 1996). Drug treatment and dietary interventions are known to be effective tools to prevent type 2 diabetes (Willett et al, 2002; Jenkins et al, 2002).

Disorder of glucose metabolism resulting from dysfunction of pancreatic beta cells and insulin resistance is seen in diabetes mellitus. Medicinal herbs are expected to have a similar degree of efficacy without the troublesome side effects associated with conventional drug treatment.

Currently, there is a growing interest in herbal remedies due to the side effects associated with the therapeutic agents (oral hypoglycemic agents and insulin) for the treatment of diabetes mellitus (Holman and Turner, 1991; Kameswara-Rao et al, 1997). Most of the cinnamon extracts are safe and having little side effects. It also possesses anti-diabetic property (Broadhurst et al, 2000). Cinnamon has many pharmacological properties, such as antioxidants activity, antibacterial effects, natural insulin sensitizer (Lopez et al, 2005), and bioactive product that improve glucose and insulin metabolism and it is useful for treatment of type2 diabetic patients (Khan et al, 1990).

Previous research provides a preliminary, but incomplete, understanding of cinnamon's effect on glycemic control in healthy adults and in those with type 2 diabetes. In 2003a, Khan et al. reported that subjects with type 2 diabetes given 1, 3 or 6 g of ground cinnamon per day for 40 days showed significant reductions in fasting serum glucose (18-29%), triglycerides (23-30%), LDL cholesterol (7-27%), and total cholesterol (12-26%) with no

significant changes in the placebo group.

In addition, intake of 2g of cinnamon for 12 weeks significantly reduces the glycated hemoglobin HbA1c, systolic and diastolic blood pressure (SBP and DBP) (Akilen el al, 2010) and improving body composition in men and women (Ziegenfuss et al, 2006) among poorly controlled type 2 diabetes patients.

Cinnamon supplementation could be considered as an additional dietary supplement option to regulate blood glucose and blood pressure levels along with conventional medications to treat type 2 diabetes mellitus.

In 2017, Gowri et al. reported that the prescribed cinnamon tea resulted in an improvement reduction of weight among late obese adolescent. Out of 30 samples in pretest, 70% of them had overweight and 30% of them had Class I obesity with the body mass index mean value of 28.75 and 2.72 standard deviation. In post-test, 20% of them were normal weight, 66.67% of them were overweight, and 13.33% of them were Class I obesity.

The post-test body mass index mean was 27.45 with 3.34 standard deviation. Paired t-test revealed that cinnamon tea was found to be effective in reducing weight at the level of ($p<0.05$).

The purpose of the current study was to compare men and women with type 2 diabetes concerning the effects of cinnamon on fast blood glucose, triglyceride and total cholesterol levels, and in addition, Systolic and diastolic blood pressure .

Materials and Methods

Location, sample size and criteria for registration of the study:

The study was conducted in the department of Nutrition Therapy, Al-Said University Taiz, Yemen. Sixty type 2 diabetic individuals of both sexes and of age 30 years or older, who were residing in Taiz 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, whose fasting blood glucose were in the range of 140 - 360mg/dl, were included in the study.

Preparation of cinnamon and placebo capsules:

Cinnamon and maize flour were used for the preparation of cinnamon and placebo capsules. The required amount of cinnamon and maize flour were purchased from the local market and ground finely. Cinnamon powder was obtained from cinnamon bark which contained cinnamonaldehyde. The cinnamon powder was produced by crushing sun-dried cinnamon bark in a grinder machine. The cinnamon powder and maize flour were given to Department of Pharmaceutical , Science and Technology University, Alhuban, Taiz for preparation of the capsules.

Capsules were prepared and each capsule had 1000 mg of cinnamon or maize flour. Packages of 120 (2g or 2 capsules/day for 60 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 in two groups. Each group had 30 individuals. Group 1 was assigned to have cinnamon and group 2 was assigned to have placebo. The individuals were allowed to take their routine diet and usual diabetic medicine. Group 1 was given 2g

cinnamon/day for 60 days. On similar pattern, 2g placebo/day were given to group 2 for 60 days. The 2g doses of cinnamon and placebo were spread over the day as 1g (1 capsule) at the time of breakfast and 1g (1 capsule) at the time of dinner. The individuals were told to take the capsules immediately after breakfast and dinner.

A total of 60 individuals with type 2 diabetes, 30 men and 30 women, were selected for the present study. Sixteen subjects were excluded, e.g. 8 subjects were excluded owing to withdrawal of consent (placebo, n=5 and cinnamon, n=3) and 8 subjects were excluded due to an irregular intake of the study preparation (placebo, n=5 and cinnamon, n=3). Thus the data of 44 subjects were included in the evaluation (placebo, n=22 and cinnamon, n=22). There was also an equal number of men and women in the placebo and cinnamon groups.

Collection of blood samples and biochemical analysis

Approximately 10 ml fasting blood samples were taken before breakfast from each individual on days 0, 30, and 60. Blood samples were transferred to sterilized centrifuge tubes and allowed for clotting at room temperature. Fasting plasma glucose was analyzed immediately; the blood samples were centrifuged for 10 minutes in a centrifuge at 4000 rpm for serum separation. Serum samples were analyzed of TGL and total cholesterol.

Determination of Fasting plasma glucose

Glucose was determined by Trinder method, based on enzymatic colorimetric reactions (Trinder, 1969). The oxidation of glucose to gluconic acid and H2O2 was catalyzed by glucose oxidase. Then, the H2O2 produced is quantified by a chromogenic reaction with peroxidase (POD), as the enzyme that catalyzes the reaction with the reduced dye.

The oxidized dye changes color to pink or red according to the glucose concentration. A produced color was well absorbed at 540 nm.

Determination of Triglycerides (TGL)

Triglycerides were determined by the enzymatic calorimetric method (Werner et al, 1981). The triglycerides in the sample are hydrolyzed to glycerol and fatty acids by lipoprotein lipase (LPL). Glycerine is then phosphorylated by glycerol kinase (GK) in the presence of ATP and Mg++ ions. In the next step, glycerol-3-P was oxidized by glycerol-3-phosphate oxidase (GPO) in the presence of molecular oxygen (O2).

The produced color which has a well absorbance at 505 nm (490-550 nm) is formed from hydrogen-peroxide, 4-aminoantipyrine and phenol-derivative in the presence of the peroxidase (POD).

Determination of cholesterol

Cholesterol was determined by enzymatic calorimetric method of (Allain et al, 1974) An enzymatic method is described for determination of the total serum cholesterol by use of a single aqueous reagent. The method requires no prior treatment of sample and the calibration curve is linear to 600 mg/dl. Cholesterol esters are hydrolyzed to free cholesterol by cholesterol ester hydrolase (EC 3.1.1.13).

The free cholesterol produced is oxidized by cholesterol oxidase to cholest-4-en-3-one with the simultaneous production of hydrogen peroxide, which oxidatively couples with 4-aminoantipyrine and phenol in

the presence of peroxidase to yield a chromogen with maximum absorption at 500 nm.

Determination of systolic and diastolic blood pressure

Systolic and diastolic blood pressure were measured three times on the left arm, with the subject in a sitting position, and were measured a second time, after 5 min rest using an aneroid sphygmomanometer and stethoscope. The average of the last two measurements was used as the blood pressure. Hypertension was defined as a systolic blood pressure of 140 mmHg or above, a diastolic blood pressure of 90 mmHg or above, or both (American Diabetes Association, 2005; 2006).

Statistical analyses

Data were analyzed using SPSS Version 21 (SPSS Inc., Chicago, IL, USA) and the data are shown as mean ± standard deviation. Two-ways ANOVA and randomized complete block design were used for statistical analysis. Statistically significant level for all tests P<0/05 was considered.

Results and discussion

Effect of cinnamon and placebo on fasting serum glucose:

The effect of cinnamon and placebo on serum glucose in type 2 diabetic individuals is given in Table 1. The mean glucose values on day 0 in Table 1 indicate the fasting serum glucose of diabetic individuals before the start of intake of supplementations.

Table 1: Effect of cinnamon and placebo on fasting serum glucose mg/dl in type 2 diabetic individuals

	Gender	Day 0	Day 30	Day 60	Percentage of reducing at Day 60
Group1 (Cinnamon)	Female	178 ± 40.4	154.09 ± 34.4^{b}	157.09 ± 25.2^{b}	-11.7%
	Male	183.36 ± 60.1	135.73 ± 13.6^{b}	118.18 ± 10.5^{a}	-35.5%
Group2 (Placebo)	Female	209.09 ± 59.7	205.36 ± 33.3^{c}	206.82 ± 33.5^{c}	-1.1%
	Male	203.64 ± 51.4	195.55 ±37.6^{c}	195.55 ± 38.4^{c}	-4.0%

Data are means ± SD. Means followed by different letters in the Columns are significantly different at p<0.05 as determined by analysis of variance

On the starting day of the experiment (day 0), the mean fasting serum glucose concentration of the diabetic individual of group 1, assigned for 2g cinnamon dose/day was 178 ± 40.4 mg/dl 183.36 ± 60.1 mg/dl for female and male respectively. When Diabetic individuals of this group used the above dose of cinnamon for 30 days, their mean fasting serum glucose level was reduced to 154.09 ± 34.4 mg/dl and 135.73 ± 13.6 mg/dl for female and male respectively. After 60 days the mean fasting glucose reduced to – 11.7 % and – 35.5% for female and male respectively . To verify that the drop in the fasting blood glucose in (group1 and group 2) was not due to psychological effect of the cinnamon capsules, placebo capsules were given to group 2 in the same pattern as the cinnamon. Values of 30 and 60 days blood samples were collected and analyzed which showed that placebo dose did not affect the glucose level.

Values of 60 days were significantly (p<0.05) in male receiving 2g of cinnamon (Table 1). This reduction in glucose was significant at (p<0.05). That's likely due to postmenopausal patients with type 2 diabetes as (Vanschoonbeek et al, 2006) reported that cinnamon

supplementation improve fasting blood glucose, oral glucose tolerance, or measures of whole-body insulin sensitivity in overweight, postmenopausal patients with type 2 diabetes.

Mechanisms by which cinnamon or cinnamon extract supplements lower glucose, insulin and estimates of insulin resistance are not yet completely clear, but food composition analyses, in vitro, animal, and human studies suggest possibilities. Proanthocyanidins, which are high in cinnamon, are plant metabolites with antioxidant activity (Beecher, 2003). Cinnamon has a particularly high hydrophilic oxygen radical absorbance capacity (ORAC)/total phenolics ratio (Wu et al, 2004). Furthermore, cinnamon bark extracts inhibited the formation in vitro of advanced glycation end products (AGEs) which contribute to diabetic complications. This inhibition has been attributed to the ability of phenolic compounds in the extracts to trap reactive carbonyl species (Peng et al, 2008).

Several steps in insulin signaling pathways are affected by cinnamon extracts. Various cinnamon compounds effect protein phosphorylation-dephosphorylation reactions in adipocytes (Imparl-Radosevich et al, 1998; Jarvill-Taylor et al, 2001). Another study suggested that a cinnamon extract affects a tyrosine phosphatase that would otherwise inactivate the insulin receptor (Imparl-Radosevich et al, 1998) and (Cao et al, 2007) reported that a water extract of cinnamon (Cinnamomum cassia, 1.5 g/d) did not transporter 4 (GLUT4). In addition (Cheng et al, 2012) reported that water soluble cinnamon polyphenols inhibited glucose production that was accompanied by decreased expression of phosphoenolpyruvate carboxykinase and glucose-6-phosphatase, major regulators of hepatic gluconeogenesis.

Effect of cinnamon and placebo on triglycerides (TGL)

The effect of cinnamon and placebo on triglycerides in type 2 diabetic individuals is given in Table 2. The triglycerides values on day 0 in Table 2 indicate the fasting serum triglycerides of diabetic individuals before the start of intake of supplementations.

On the starting day of the experiment (day 0), the mean fasting serum triglycerides of the diabetic individual of group 1, assigned for 2 g cinnamon dose/day was 218.45 ± 97.1 mg/dl 216.45 ± 89 mg/dl for female and male respectively. When the diabetic individuals of this group used 2 g cinnamon dose/day for 30 days, their mean fasting serum triglycerides level significantly reduced to 173.36 ± 42.3 mg/dl and 159.91 ± 31 mg/dl for female and male respectively at ($p<0.05$). After 60 days the TGL reduced to – 21.9 % and – 23.4% for female and male respectively .

To verify that the drop in the fasting serum triglycerides was not due to psychological effect of the cinnamon capsules, placebo capsules were given to group 2 in the same pattern as the cinnamon. After 30 and 60 days, blood samples were collected

and analyzed which showed that placebo dose have no effect on the serum triglycerides in diabetic individual.

There was no significant (P<0.05) effect of cinnamon doses on the concentration of TGL between type 2 diabetic female and male.

Table 2: Effect of cinnamon and placebo on serum triglyceride level (mg/dl) in type 2 diabetic individuals

	Gender	Day 0	Day 30	Day 60	Percentage of reducing at Day 60
Group1 (Cinnamon)	Female	218.45 ± 97.1 [c]	173.36 ± 42.3 [b]	170.55 ± 28.2 [b]	-21.9%
	Male	216.45 ± 89 [c]	159.91 ± 31 [a]	165.73 ± 24.1 [a]	-23.4%
Group2 (Placebo)	Female	196.27 ± 15.9 [c]	194.73 ± 16 [d]	193.27 ± 12.2 [c]	-1.5%
	Male	208.45 ± 22.8 [c]	201.9 ± 24.6 [c]	200.64 ± 22.3 [d]	-3.7%

Data are means ± SD. Means followed by different letters in the Columns are significantly different at p<0.05 as determined by analysis of variance

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, 2003b). 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 (Preuss et al, 2006).

Effect of cinnamon and placebo on serum cholesterol

Effect of cinnamon and placebo on serum cholesterol in Type 2 diabetic individuals is shown in Table 3. The cholesterol values on day 0 in Table 3 indicate the fasting serum cholesterol concentration of diabetic individuals before the start of intake of supplementations.

On the starting day of the experiment (day 0), the mean fasting serum cholesterol concentration of the diabetic individual of group 1, assigned for 2 g cinnamon dose/day was 197.29 ± 30.8 mg/dl and 227.52 ± 77.5 mg/dl for female and male respectively. When the diabetic individuals of this group used 2 g cinnamon dose/day for 30 days, their mean fasting serum cholesterol concentration dropped significantly (p<0.05) to 155.73 ± 21.9 mg/dl and 217.27 ± 55 mg/dl for female and male respectively. After 60 days the serum cholesterol reduced to –31.52% and –24.29% for female and male respectively. To know that this drop in the fasting blood cholesterol was not due to psychological effect of the cinnamon capsules, placebo capsules were given to group 2 in the same pattern as the cinnamon. The placebo dose did not affect the cholesterol concentration in the diabetic individuals.

Table 3: Effect of cinnamon and placebo on serum cholesterol level (mg/dl) in type 2 diabetic individuals					
	Gender	**Day 0**	**Day 30**	**Day 60**	**Percentage of reducing at Day 60**
Group1 (Cinnamon)	**Female**	**197.29 ± 30.8 ^{c}**	**155.73 ± 21.9 ^{a}**	**135.09 ± 17.1 ^{a}**	**-31.52%**
	Male	**227.55 ± 56.3 ^{c}**	**217.27 ± 55 ^{b}**	**172.27 ± 21.2 ^{b}**	**-24.29%**
Group2 (Placebo)	**Female**	**221 ± 19.7 ^{c}**	**228.9 ± 24.7 ^{d}**	**225 ± 25.5 ^{c}**	**1.8%**
	Male	**232.45 ± 35 ^{c}**	**213.36 ± 17.5 ^{c}**	**229.8 ± 20.4 ^{c}**	**-1.1%**
Data are means ± SD. Means followed by different letters in the Columns are significantly different at p<0.05 as determined by analysis of variance					

There was significant (P<0.05) effect of cinnamon doses on the concentration of cholesterol level in type 2 diabetic for female comparing to male.

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 help reducing cholesterol level. Those individuals who have high cholesterol levels may adopt regular eating of 1-3g cinnamon daily to lower their cholesterol levels (Khan et al, 2003a).

Effect of cinnamon and placebo on Systolic and Diastolic blood pressure (SBP and DBP) :

Effect of cinnamon and placebo on serum systolic and diastolic blood pressure in Type 2 diabetic individuals are shown in Tables 4 and 5 respectively. On (day 0) in Table 4;5 indicate the SBP and DBP of diabetic individuals before the start of intake of supplementations.

Table 4: Effect of cinnamon and placebo on Systolic blood pressure (mmHg) in type 2 diabetic individuals					
	Gender	**Day 0**	**Day 30**	**Day 60**	**Percentage of reducing at Day 60**
Group1 (Cinnamon)	**Female**	**134.73 ± 16.6 ^{c}**	**126.18 ± 7.7 ^{b}**	**120.09 ± 6.8 ^{b}**	**-10.86%**
	Male	**139.09 ± 36.4 ^{c}**	**120.55 ± 13.6 ^{a}**	**114.36 ± 4.8 ^{a}**	**-17.7%**
Group2 (Placebo)	**Female**	**132.36 ± 18 ^{c}**	**146.82 ± 9.9 ^{d}**	**141 ± 13.3 ^{d}**	**6.5%**
	Male	**131.09 ± 14.7 ^{c}**	**139.91 ± 9.2 ^{c}**	**135.64 ± 17.3 ^{c}**	**3.5%**
Data are means ± SD. Means followed by different letters in the Columns are significantly different at p<0.05 as determined by analysis of variance					

On the starting day of the experiment (day 0), the mean SBP and DBP of the diabetic individuals of group 1 assigned for 2 g cinnamon dose/day was 134.73 ± 16.6 / 82.1 ± 13.5 mmHg and 139.09 ± 36.4 / 80.73 ± 8.5 mmHg for female and male respectively.

When the diabetic individuals of this group used 2 g cinnamon dose/day for 30 days, their mean SBP dropped significantly (p<0.05) to

126.18 ± 7.7 / 83.27 ± 9.8 mmHg and 120.55 ± 13.6 / 82.18 ± 8.5 mmHg for female and male respectively. After 60 days the SBP reduced to (–10.86% and –17.7%) and DBP reduced to (-4.1% and -0.22%) for female and male respectively .To know that this drop in the SBP was not due to psychological effect of the cinnamon capsules, placebo capsules were given to group 2 in the same pattern as the cinnamon. The placebo dose did not affect the SBP and DBP in the diabetic individuals.

Table 5: Effect of cinnamon and placebo on Diastolic blood pressure (mmHg) in type 2 diabetic individuals

	Gender	Day 0	Day 30	Day 60	Percentage of reducing at Day 60
Group1 (Cinnamon)	Female	82.1 ± 13.5 ^{c}	83.27 ± 9.8 ^{b}	78.73 ± 8 ^{a}	-4.1%
	Male	80.73 ± 8.5 ^{c}	82.18 ± 8.5 ^{b}	80.55 ± 7.5 ^{a}	-0.22%
Group2 (Placebo)	Female	85.18 ± 7.6 ^{c}	82.73 ± 6.9 ^{b}	81.91 ± 6.7 ^{a}	-3.8%
	Male	85.64 ± 7.2 ^{c}	87.45 ± 6.3 ^{b}	86 ± 6.5 ^{a}	0.4%

Data are means ± SD. Means followed by different letters in the Columns are significantly different at $p<0.05$ as determined by analysis of variance

According to the current guidelines recommended for the treatment of diabetes, normal or near normal blood pressure with a systolic blood pressure of < 130 mmHg and a diastolic blood pressure of < 80 mmHg should be achieved (Khan et al, 2003a; American Diabetes Association, 2006).

Therefore, patients with elevated baseline blood pressure(~134 ⁄ 86 mmHg) in our study demonstrate that improvements in systolic blood pressure and diastolic blood pressure may be found with higher baseline values. This again suggests that subjects with a higher baseline blood pressure level may benefit more from cinnamon intake.

Additionally, attainment of better glycaemic control may also improve blood pressure. Results from the study by (Ziegenfuss et al, 2006) also demonstrate that the effect of cinnamon on blood pressure was greater with higher baseline systolic blood pressure. The results of studies on animals have also proposed that cinnamon has the ability to regulate blood pressure levels through peripheral vasodilatation (Preuss et al, 2006). However, the exact blood pressure-lowering mechanism of cinnamon is still unknown and further studies needs to elucidate this issue. None of the previous human trials reported a beneficial effect of cinnamon on blood pressure.

Conclusion

This study documents the beneficial effects of 2 g of a cinnamon powder per day on Yemeni adults (men and women) with elevated blood glucose. The results of this study demonstrate that intake of 2g of cinnamon per day reduces fasting serum glucose, triglyceride, blood pressure levels, 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. However, we need further studies with larger samples to investigate the effect of cinnamon in reducing the different factors like serum glucose, triglyceride, blood pressure levels, and total cholesterol by age, gender and various doses of cinnamon.

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