# ANTIOXIDANT, ANTIDIABETIC AND LIPID LOWERING EFFECTS OF CINNAMON AND VITAMIN C IN HYPERGLYCEMIC RABBITS

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## ABSTRACT

The study was done to evaluate the antioxidant effects of cinnamon and vitamin C in controlling hyperglycemia and their effect on lipid profile in male rabbits in comparison with the effects of insulin therapy and control animals.

Twenty four diabetic rabbits by the injection of alloxan 100 mg/kg body weight in the marginal vein of the ear. These diabetic rabbits were divided randomly into 4 groups Number of animals in each group = 6:

**Group 1:** Was given 2 I.U/ animal of insulin subcutaneously daily. **Group 2:** Was given ground cinnamon orally 300 mg/kg body weight dissolved in 5 ml normal saline daily. **Group 3:** Was given vitamin C orally 200 mg/kg body weight dissolved in 5 ml normal saline daily. **Group 4:** Received orally 5 ml normal saline (0.9% Nacl) daily and considered as control group. All animal groups were treated for five weeks. Blood samples were taken from these groups weekly for biochemical analysis to estimate: Blood glucose, Lipid profile (include total cholesterol (TC), triglyglyceride (TG), high density lipoprotein (HDL), low density lipoprotein (LDL) and very low density lipoprotein(VLDL) and serum malondialdehyde (MDA).

The results showed high glucose and lipid concentration associated with an increased oxidant stress alloxan induces on diabetic animals.

The statistically analysis showed that a cinnamon and vitamin C significant ($P< 0.05$) reduction in glucose and lipid profile (TC, TG, HDL, LDL and VLDL) in concordance with a significant elevation in HDL ($P<0.05$). The level of MDA was also significantly reduced ($P<0.05$) in all period comparison with period before treated with vit. C and Cinnamon extract.

It may conclude that, cinnamon and vitamin C have antioxidant activities to cause an important role in reduction of blood glucose level and lipid profile in hyperglycemic animals.

## INTRODUCTION

Some studies have shown that many plants were used as an antidiabetic therapy or prevent and reduce the diabetic complication ( 1). In addition, the mineral, vitamins and other substance also were used for treating diabetes (2). Consequently this study was aimed to investigate the effect of oral administration of cinnamon and vitamin C on blood glucose, lipid profile and malondialdehyde levels in diabetic rabbit.

## MATERIALS AND METHODS

**The Plant Materials:** Cinnamon bark was bought from a local market in Basrah city, Iraq. Voucher specimens of plants were deposited to be identified and authenticated at College of Science/ University of Basrah. The cinnamon bark was cleaned finely grounded into powder form by using electric mill for 3 minutes. The powder of

cinnamon bark was immediately used after being dissolved in five milliliters of normal saline for 15 minutes at 25 C°.

**Breeding and housing of rabbits:** Twenty four adult male domestic rabbits (*Lepus cuniculus*) weighted between 1-1.5 kg and aged 6 months were bought from a local market of Basrah City. They were managed and housed in the animal housed of the College of Veterinary Medicine/ University of Basrah and were housed 6 rabbits per cage measuring 1000×500×500 cm at temperature 25 ± C° and 12/12-light/dark cycle under controlled environment. The rabbits were left four weeks for acclimatization. The rabbits were fed with standard pellet diet and water *ad libitium*. The Rabbits were given anti-coccidiosis (Amprollium) through the drinking water with the concentration 1 gm/ litter at the duration of 2 weeks to prevent the infection with coccidiosis.

**The Experimental Design:** The male rabbits were rendered diabetic by a single intravenously injection of alloxan 100 mg/ kg body weight in the marginal vein of the ear (3). After an overnight fasting, alloxan mono-hydrate in freshly prepared normal saline 1ml is used. On the day of injection alloxan, rabbits were given 5% glucose solution for 24hrs with drinking water and were given (5 ml) 20% glucose solution intraperitonial and (10 ml) subcutaneously to prevent initial drug-induced hypoglycemic mortality (4).

The animals were randomly and equally divided into four groups of 6 rabbit each, given the following treatment: **Group 1**, this group of hyperglycemic 6 rabbits were injected subcutaneously by insulin 2IU/animal for 5 weeks. **Group 2:** this group were orally administrated 300 mg/kg B.W of cinnamon dissolved in 5 ml normal saline for 5 weeks. The dose was chosen as described by (5). **Group 3:** This group of hyperglycemic rabbits were orally administrated 200 mg/kg B.W of vitamin C dissolved in 5 ml normal saline for 5 weeks. The dose was chosen as described by (6). **Group 4:** hyperglycemic rabbits were orally administrated normal saline 0.9% NaCl 5 ml. This group is used as diabetic control for 5 weeks.

**The Collection of Blood Samples:** The blood samples of experimental rabbits were collected weekly from ear margin vein and transferred into test tubes immediately. Blood then was centrifuged at 3000 rpm for 10 minutes. Serum was separated and stored at-20Cº temperature. Measurement of glucose and other chemical constituents in serum was done at 24 hr period at zero time, wk1, wk 2, wk 3, wk 4, and wk 5 (4).

**The Biochemical Measurements:** After serum separation, some biochemical measurement was done by using special enzymatic kits which include:

1-The Blood Glucose Determination: (7).

2-The Total Cholesterol Determination (TC): (8).

A. The Serum High Density Lipoprotein-cholesterol Determination:d of (9)

B. The Serum Low-density Lipoprotein Cholesterol (LDL): (10).

**LDL-c = Total cholesterol – [(HDL-c) + Triglyceride / 5]**

C. The Serum Very Low-density Lipoprotein (VLDL): (11).

**VLDL = Triglyceride/ 5**

3-The Serum Malondialdehyde (MDA): was measured by Bueg and Aust (12)

**The Statistical Analyses:** The results of the present study were analyzed by using two way covariance (ANOVA) test in all study except Malondialdehyde student " t " test was used. The Statistical analysis was performed by using the program.

The data were expressed as a means ± standard error ($\bar{X}$ ± SE). Least significant different test (LSD) was calculated to test difference between means (groups) for (ANOVA) SPSS (1998).

# RESULTS

**Effect of insulin, cinnamon and vitamin c on blood glucose levels:**

Table (1) shows the average blood glucose concentration of the diabetic animals treated by insulin (2 I.U/ animal), cinnamon (300 mg/kg), and vitamin C (200 mg/kg), and the control diabetic animals received the normal saline. The results show a significant reduction ($P< 0.05$) on serum glucose level in the diabetic animal treated with insulin, cinnamon and vitamin C compared with control after one week of the injection and during the all the period of the experiment. This reduction was proportional with the time. The cinnamon was found to be significantly ($P< 0.05$) more effective than vitamin C. while the average blood glucose in the insulin treated group was less ($p<0.05$) than cinnamon treated rabbits after five weeks of treatment.

**Effect of insulin, cinnamon and vitamin c on lipid profile:**

**Serum total cholesterol level:** Table (2) shows the average of the total cholesterol concentration of the diabetic animals treated by insulin (2 I.U/animal), cinnamon (300 mg/kg) and vitamin C (200 mg/kg), and control diabetic animals that received normal saline. The results show a significant decrease ($P< 0.05$) in serum total cholesterol level in the diabetic animal treated by insulin, cinnamon and vitamin C compared with the control group. Also there is a significant difference between the group which treated with vitamin C and the group treated with cinnamon. While the group that treated with insulin showed a significant reduction ($P< 0.05$) in total cholesterol concentration compared with the group treated with cinnamon, however this significance disappeared after 3 weeks of treatment.

**Serum Triglyceride:** table (3) shows the average serum triglyceride concentration of the diabetic animals treated by insulin (2 I.U/animal), cinnamon (300 mg/kg), vitamin C (200 mg/kg) and control diabetic animals that received normal saline. the results show a significant decrease ($P< 0.05$) in serum triglyceride concentration in diabetic treated by insulin, cinnamon and vitamin C after three, four and five weeks of the administration. While the average triglyceride in the first and second weeks failed to reach significant level compared with the control group. The results also indicate that there is no significant difference between the group which treated with insulin and that treated with cinnamon. While there is significant ($P< 0.05$) difference between the group that treated with vitamin C and the group treated with insulin or cinnamon.

**Serum High Density Lipoprotein:** Table (4) show the average serum (HDL) concentration of diabetic animals treated by insulin (2 I.U/animal), cinnamon (300 mg/kg), vitamin C (200 mg/kg) and the control diabetic animals that received normal saline. The results show that the group of rabbits which treated with insulin for one week the HDL was elevated significantly ($P< 0.05$) as compared with other group. After two week of the treatment, the groups which treated with insulin or cinnamon, the HDL increase significantly ($P< 0.05$) as compared with the control group, while in this week the group which treated with vitamin C does not.

**Serum Low density lipoprotein:** Table (5) shows the average serum LDL concentration of the diabetic animals treated by the insulin (2 I.U/animal), cinnamon (300 mg/kg), vitamin C (200 mg/kg) and the control diabetic animal that received normal saline. Throughout the study, the results show a significant decrease ($P< 0.05$) in serum LDL concentration in the animals treated by insulin, cinnamon and vitamin C compared with the control group. Whereas the average serum LDL concentrations in the control diabetic animal were elevate in all weeks of treatment. Also there is no significant difference among the treatment groups (i.e insulin, cinnamon and vitamin C).

**Serum Very Low Density Lipoprotein:** The results of average serum VLDL concentration of the diabetic animals in groups that treated by insulin (2 I.U/animal), cinnamon (300 mg/kg), vitamin C (200 mg/kg) and control diabetic animal that received normal saline is shown in table (6). The results indicate that there is a significant decrease ($P< 0.05$) in serum VLDL concentration in animals treated by insulin, cinnamon and vitamin C compared with control group. from the results also there is no significant difference in VLDL level in group treated with cinnamon and insulin.

**Serum malondialdehyde:** Table (7) shows the average malondialdehyde concentration (MDA) of the diabetic animals treated by cinnamon solution or vitamin C. The results show that there is significant ($P< 0.05$) reduction in the MDA when the animals treated with cinnamon. Similar finding is show when the animal treated with vitamin C.

**Table (1): Blood glucose levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. ( n = 6/ group)**

| Groups | Fasting blood glucose concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 229.99 ± 4.85 G | 247.11 ± 2.64 E a | 254.43 ± 6.35 D a | 264.95 ±13.27 C a | 276.85 ± 21.07 B a | 296.7 ± 29.83 A a |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 230.2 ± 2.17 G | 209.65 ± 1.92 H c | 188.31 ± 0.9 I c | 139.51 ± 0.57 L c | 119.53 ± 0.81 M b c | 100.46 ± 0.6 O b |
| Insulin 2 I. U/ animal to diabetic rabbits | 235.47 ± 0.58 F | 210.51 ± 0.59 H c | 169.05 ± 0.69 K d | 122.73 ± 1.42 M c | 104.84 ± 1.96 O c | 89.97 ± 0.75 P b |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 237.31 ± 1.5 F | 227.31 ± 4.28 G b | 211.18 ± 5.1 H b | 174.62 ± 7.21 J b | 143.02 ± 5.23 L b | 114.79 ± 3.1 N b |

LSD = 5.088

Values are expressed as mean ± SE

The difference in the small letter means a significant difference at the ($p < 0.05$) level as compared with control group.

The difference in the capital letter means a significant difference ($p < 0.05$) in the

Table (2): Total cholesterol levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. (n =6/group)

| Groups | Total cholesterol concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 272.72 ± 16.68 D | 303.88 ± 3.16 C a | 321.25 ± 1.56 B a | 337.56 ± 1.01 A a | 341.65 ± 1.44 A a | 341.65 ± 1.49 A a |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 299.12 ± 4.36 C | 272.49 ± 4.88 D c | 220.86 ± 7.28 G c | 163.84 ± 2.59 F c | 139.56 ± 0.66 K c | 136.64 ± 0.73 K c |
| Insulin 2 I. U/ animal to diabetic rabbits | 299.08 ± 1.8 C | 285.49 ± 2.11 E b | 257.04 ± 2.49 F b | 159.6 ± 7.99 F c | 143.75 ± 3.14 K d | 137.64 ± 1.45 K c |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 300.2 ± 0.86 C | 288.72 ± 0.82 E b | 252.61 ± 1 F b | 203.41 ± 1.24 H b | 156.47 ± 2.69 F b | 142.76 ± 1.99 K b |

LSD = 14.187

Values are expressed as mean ± SE

The difference in the small letter means a significant difference at the ( P< 0.05) level as compared with control.

The difference in the capital letter means a significant difference (p < 0.05) in the period.

Table (3): Triglyceride levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. (n 6/group)

| Groups | Triglyceride concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 186.24 ± 1.49 E | 193.87 ± 1.5 D | 208.35 ± 2.35 C a | 222.3 ± 1.05 B a | 227.04 ± 1.3 A a | 228 ± 1.27 A a |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 189.78 ± E 1.13 | 177.83 ± 2.05 G | 166.76 ± 2.8 H b | 111.75 ± 3.57 L b | 107.17 ±2.42 I b | 97.9 ± 3.04 G b |
| Insulin 2 I. U/ animal to diabetic rabbits | 189.87 ± 1.93 E | 181.53 ± 2.31 G | 173.72 ± 2.5 G c | 154.7 ± 8.7 P b | 143.83 ± 7 O b | 133.54 ± 7.71 N b |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 192.61 ± 1.57 F | 181.72 ± 1.18 G | 160.6 ± 1.12 K d | 122.86 ± 1.91 M c | 113.9 ± 2.1 L c | 106.6 ± 2.65 I c |

LSD = 5.979

Values are expressed as mean ± SE

The difference in the small letter means there is significant difference at the ($p < 0.05$) level as compared with control.

The difference in the capital letter means a significant difference ($p < 0.05$) in the period

**Table (4):** High density lipoprotein levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. (n ⟶ 6/group)

| Groups | High density lipoprotein concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 36.48 ± 0.5 D | 36.27 ± 0.49 D ab | 35.68 ± 0.33 C b | 32.98 ± 0.55 A c | 33.02 ± 0.49 B c | 32.9 ± 0.54 A c |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 33.06 ± 1.22 B | 33.14 ± 1.2 B c | 33.32 ± 1.13 B c | 33.52 ± 1.13 B cb | 33.6 ± 1.13 B cb | 33.64 ± 1.13 B cb |
| Insulin 2 I. U/ animal to diabetic rabbits | 36.76 ± 0.61 D | 38.31 ± 0.46 E a | 39.51 ± 0.45 F a | 41.75 ± 0.39 G a | 43.8 ± 0.57 H a | 43.83 ± 0.59 H a |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 35.5 ± 0.79 C | 35.5 ± 0.75 C b | 35.5 ± 0.76 C b | 35.71 ± 0.78 C b | 35.73 ± 0.77 C b | 35.73 ± 0.77 C b |

LSD = 1.753

Values are expressed as mean ± SE

The difference in the small letter means there is significant difference at the($p < 0.05$) level as compared with control.

The difference in the capital letter means a significant difference ($p < 0.05$) in the period.

**Table (5):** Low density lipoprotein levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. (n —— 6/group)

| Groups | Low density lipoprotein concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 201.5 ± 14.3 F | 225.82 ± 4.14 E a | 234.78 ± 9.21 D a | 242.08 ± 18.48 C a | 239.27 ± 24.39 B a | 237.43 ± 26.09 A a |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 229.11 ± 6.49 G | 202.63 ± 5.63 F b | 150.07 ± 3.61 H c | 111.25 ± 3.06 L b | 85.42 ± 1.09 K b | 84.53 ± 1.73 K b |
| Insulin 2 I. U/ animal to diabetic rabbits | 225.56 ± 0.46 E | 212.7 ± 1.53 I b | 187.27 ± 1.73 G b | 85.66 ± 1.14 P c | 73.77 ± 1.13 O b | 70.6 ± 0.45 X b |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 225.83 ± 1.23 E | 212.15 ± 3.97 I b | 173.51 ± 7.88 M b | 129.83 ± 5.18 N b | 89.13 ± 2.69 W b | 80.41 ± 2.69 Y b |

LSD = 14.534

Values are expressed as mean ± SE

The difference in the small letter means there is significant difference at the($p < 0.05$) level as compared with control.

The difference in the capital letter means a significant difference ($p < 0.05$) in the period.

**Table (6): Very low density lipoprotein levels in serum from diabetic rabbits given insulin, cinnamon and vitamin C. (n ⟶ 6/group)**

LSD = 1.426

Values are expressed as mean ± SE

| Groups | Very low density lipoprotein concentration mg/dL | | | | | |
|---|---|---|---|---|---|---|
| | 0 wk | 1 wk | 2 wk | 3 wk | 4 wk | 5 wk |
| Control 0.9% N.S diabetic rabbits | 37.35 ± 0.27 E | 38.39 ± 0.46 D a | 40.57 ± 1.16 C a | 42.68 ± 1.77 B a | 43.2 ± 2.21 A a | 43.08 ± 2.52 A a |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 38.04 ± 0.25 D | 35.58 ± 0.5 F b | 33.74 ± 0.49 H b c | 22.09 ± 0.82 L c | 21.28 ± 0.56 G c | 19.13 ± 0.43 K c |
| Insulin 2 I. U/ animal to diabetic rabbits | 38.35 ± 0.3 D | 36.19 ± 0.24 I b | 32 ± 0.21 G c | 24.4 ± 0.35 P c | 22.67 ± 0.35 L c | 21.43 ± 0.44 G c |
| Vitamin C 200 mg/kg B.W to diabetic rabbits | 37.96 ± 0.45 E | 36.32 ± 0.54 I b | 34.84 ± 0.57 O b | 30.68 ± 1.72 M b | 28.55 ± 1.63 N b | 26.48 ± 1.8 Y b |

The difference in the small letter means there is significant difference at the($p < 0.05$) level as compared with control.

The difference in the capital letter means a significant difference ($p < 0.05$) in the period.

**Table (7):** Malondialdehyde levels in serum from diabetic rabbits given cinnamon and vitamin C. (n ⟶ 6/group)

| | Malondialdehyde concentration µ mol/ L | |
|---|---|---|
| Groups | MDA 0 wk before treatment | MDA 5 wk after treatment |
| Cinnamon 300 mg/kg B.W to diabetic rabbits | 1.40 ± 0.13 a | 0.34 ± 10.0076 b |
| Vitamin C 200 mg/kg B.W to diabetic rabbit | 1.48 ± 0.12 a | 0.37 ± 0.014 b |

Values are expressed as mean ± SE,

## DISCUSSION

Out of the results, a significant decrease in the levels of the glucose concentration in the diabetic rabbits after the treatment with cinnamon, vitamin C and insulin was observed, after 1-5 wks. However, control animals (i.e. untreated) maintained high glucose levels throughout the experiment. This indicates an effective hypoglycemic activity of cinnamon and vitamin C. This is consistent with other studies concerned with the cinnamon extract the effect can be explained that cinnamon might have brought some biochemical/ physiological changes in the sites of resistance to insulin, enzyme system of carbohydrate metabolism, transfer of glucose through cell membrane and receptor sites. (13) showed that hypoglycemia effected cinnamon extract is due to the presence of water-soluble antioxidant polyphenol compound (methyl hydroxyl chalcone polymers (MHCP), however (14) concluded that due to the presence of diterpenoids which posses hypoglycemic effect for both the normal and hyperglycemic rabbits. Other studies also have shown that cinnamon would prevent the development of insulin resistance at least partially by enhancing the insulin signaling and possibly via the nitric oxide pathway in skeletal muscle (15). Groups of researchers found that phenolic acid, a major component of cinnamon extract, lowers the blood glucose levels by enhancing glucose transport (16).

(17) have shown that cinnamon extract has a strong antioxidant activity and has a potential to help and maintain the blood glucose health in diabetic. This effect is due to the presence of the coumarin compound which was demonstrated by elevating activity of the enzymatic antioxidant (GPX, CAT, SOD) for the inhibition of formatting and scavenging the free radicals. The enzymes are responsible for the detoxification of deleterious oxygen radicals (18; 13).

The present results indicate that vitamin C has a hypoglycemic effect in the diabetic rabbits. A similar finding was reported by (3) who showed that vitamin C, when administrated alone to diabetic rats, reduced the blood glucose levels which

produced an early onset of action in 1.5 hrs. This early onset may be due to an increase in the insulin secretion. Also may be due to the fact that vitamin C prevents the accumulation of sorbitol intracellularly by inhibiting the aldose reductase enzyme (19).

As well as may be due to the decreases of the resistance to insulin and the reduced oxidative damage in the tissue by reducing free radicals and the decreasing of glycosylation to protein (20). High blood sugar levels in diabetes cause sorbitol to be manufactured from glucose and vitamin C has been shown to reduce the level of sorbitol in diabetics (21).

Actually in diabetes, the oxidative stress is increased because of the deficiency in the antioxidant defense, so the intake of antioxidant such as vitamin C, (vitamin C powerful natural antioxidant) may reduce the oxidative stress associated with diabetes and hence help to restore the antioxidant defense system by reducing free radical. Vitamin C supplementation was able to normalize endothelial function and decrease oxidative stress to normal levels in type 1 and 2 diabetic patients (22; 23).

(24) stated that the oxidative stress impairs the insulin-induced GLUT4 translocation so the administration of antioxidant vitamins the improvement of total thiol content of the body should be reflected on the function of insulin to increase the cellular uptake of glucose.

The role of vitamin C in reducing the blood glucose through decreasing the oxidative stress has different ways including their direct free radicals scavenging ability and the termination of their damaging effect on the blood vessels and preventing the lipid peroxidation, their ability to regulate nitric oxide synthase that generates the nitric oxide apotent vasodilator that play a key role in controlling the cardiovascular system. There is an ability to decrease the activity of (NADPH) oxidase and (ROS) production, their ability to regulate the antioxidant enzyme including superoxide dismutase and glutathione and the increased tetrehydrobiopterin an important cofactor of nitric oxide synthase enzyme by preventing its oxidation (25).

Out of the results, there was a significant reduction in TC, TG, LDL, VLDL. This coincides with an elevation in HDL in diabetic animals treated with cinnamon, vitamin C and insulin after 1, 2, 3, 4 and 5 weeks of the treatment compared with the control (diabetic animals). The present results seem to be in concordance with the findings of other authors showed that giving cinnamon extract to diabetic individuals and animals improve the lipid profile through the reduction of TC, TG, LDL and VLDL levels associated with an elevation in HDL levels (26 ; 27). The capacity of the cinnamon extract to exhibit such changes may be attributed to the effect of the cinnamon extract in blocking the synthesis of cholesterol or facilitating the clearance of cholesterol from the body (28). On the other hand, it may enhances the hepatic bile acid synthesis and increase degeneration of cholesterol to faecal bile acid and neutral sterol, the presence of some constituents of the cinnamon like (fiber and calcium) which may bind with bile salt and can help in removing them. When the bile is removed the body will tend to break down cholesterol. This process might enhance lowering cholesterol levels (29; 30).

The cinnamon bark has strong lipolytic action. Therefore, the cinnamon extract reduces TG levels leading to inhibit of TG synthesis by the fat hydrolysis, which may maintain low value of TG (15).

(31) emphasized that the effect can be due to the presence of cinnamaldehyde. Also Leung and Foster, (32) contributed these reduction to the inhibitory effects of the production of fatty acids.

As it is mentioned previously, the treatment with the cinnamon extract caused an elevation in HDL levels. This effect may be due to the decreased conversion of HDL to VLDL in the liver and intestine, or it can be due to its ability to hydrolyze the fats that, in turn, leads to the increase in HDL level in blood (33).

(28) showed that the treatment with the cinnamon extract might have brought a change in synthesis/ metabolism of LDL, through an increased LDL receptor, thus, stimulating the hepatic uptake of LDL and binding activity apparently in a response to a decreased intracellular cholesterol concentration and a decrease in the serum TC and LDL concentration. Through cinnamon antioxidant properties found in providing the protection against oxidation of LDL and inhibiting glycation by Glutation peroxidase action. This lead to reducing LDL levels (34). The resistance of LDL oxidation via the effects of the antioxidant has been associated with a decreased vascular complication which might protect against the development of atherosclerosis (35). Also due to the suppression of the hepatic cholesterol synthesis and a decrease in the production of short chain fatty acids with a decrease in the TG formation (16). while, (26) contributed this effects to the key enzyme activities involved in the synthesis and the catabolism of VLDL which results in a decrease of VLDL production in the hepatic cells and an increased ability VLDL conversion to LDL in addition, to a decreased HDL conversion to VLDL that in turn leads to a reduction of VLDL levels and an elevation of the HDL levels. VLDL secretion which may be controlled by cholesteryl ester availability.

Table (6) shows that vitamin C has significantly reduced the average TC, TG, LDL and VLDL levels associated with an elevation in HDL level. These results are consistent with (6) who found that the given vitamin C at dose 200 mg/kg to diabetic rats for four weeks. Lowered serum TC, TG, LDL and VLDL levels associated with an elevation in the HDL level. Therefore, vitamin C supplementation in this model of the established diabetes mellitus might be a beneficial improvement of lipid profile. This may, at least, in part, reduce the risk of cardiovascular event seen in diabetic mellitus (36).

The hypocholesteroleamic effects of vitamin C could be due to its direct effect as an antioxidant, in addition to its cholesterol lowering potential due to the effect on cholesterol metabolism directly in the liver. In support of this hypothesis the serum cholesterol decreased and in vitro activities of hydroxyl methyl-glutaryl-CoA reductase and sterol-o acyl transferse, the key enzyme in cholesterol metabolism was inhibited by high dose of vitamin C (37). Also may inhibit the absorption of cholesterol and bile acid in the intestine and increase the excretion with wastes. This leads to a reduction in cholesterol levels by the liver (38). As well as may be due to an inhibition of TG synthesis by the increasing lipoprotein lipase activity, which is an insulin-dependent enzyme, since the lipoprotein lipase synthesis is defective in diabetic patient ( 39). Also contribute to the decreased synthesis of TG by liver through inhibiting fatty acid production (40).

The decreased serum LDL levels could be due to the performance of vitamin C scavenging free radicals which prevents lipid peroxidation because oxidation of LDL contribute to the developing vascular disorders including atherosclerosis (41). The inhibition of LDL oxidation by antioxidant might protect against the development of atherosclerosis (35).

The decreased ability of conversion of HDL to VLDL may lead to an increased HDL level. On the other hand the vitamin C supplementation reduces VLDL level which may be due to the increased ability of conversion of VLDL to LDL by the lipoprotein lipase activity (42). This may be the effect of the key enzyme activity involved in the synthesis and catabolism of VLDL (43). On the other hand, the cinnamon extract affects on the oxidative stress, may be due to the prevention of the

influx of glucose into the polyol pathway leading to an increased NADPH/ NADP ratio and prevent glycation end products. The cinnamon extract has the most powerful antioxidant properties on free radicals. It scavenges and neutralizes the free radicals and damaging chemicals which are elevated in diabetics. Also the improving function of small blood vessels, therefore, the cinnamon extract is capable of removing the free radicals from the blood exhibited by reducing the malon dialdehyde levels (1).

## تأثير مضادات الاكسدة والسكري والخافضة للكوليسترول للدارسين وفيتامين C على الارانب المصابة بفرط السكر

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### الخلاصة

اجريت هذه الدراسة لتقيم التاثير المضاد للاكسدة للدارسين وفيتامي C في السيطرة على فرط السكر. المجموعة الثالثة ن وتاثيرهما على صور الدهون في ذكور الفئران البالغة مقارنتاً مع تأثيرهما بالعلاج بالانسولين وحيوانات السيطرة.

بعد زرق الحيوانات بالالوكسان (100ملغم/كغم من وزن الجسم) في الوريد الجافي للاذن. هذه الارانب قسمت عشوائي الى اربعة مجاميع (كل مجموعة تحوي ستة حيوانات). المجموعة الاولى زرقت تحت الجلد (وحدتان دوليتان/حيوان) انسولين). المجموعة الثانية جرعت فموياً (300غم/ كغم) الدارسين المطحون المذاب بـ(5مل) من المحلول الفسيولوجي

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