

## Effect of Water Extract Prepared from Green Tea, Black Tea and Cinnamon on Obese Rats Suffering from Diabetes

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**Abstract:** Recently, considerable attention has been focused on dietary and medicinal antioxidants that inhibit or retard diseases caused by oxidative processes. The active components and polyphenols of green or black tea and cinnamon have antioxidant properties. The present work was carried out to study the potential effect of some doses of water extract which prepared from green tea, black tea and cinnamon on obese rats suffering from diabetes. Water extracts of green tea, black tea and cinnamon were prepared with traditional methods. Sixty six male albino rats (Sprague Dawley Strain) weighting an average of (125±5g) used in this study. The rats were divided into two main groups. The first main group (6 rats) was fed on basal diet as a (control negative group). The second main group (n = 60) fed on high fat diet for 4 weeks to induced obesity. After this period we made sure of induction, the second main group injected with (150 mg aloxane/kg body weight) to induce hyperglycemia. Then, this group was divided into ten subgroups (n=6) as a following: Subgroup (1) fed on high fat diet, as a control positive group. Subgroup (2, 3 and 4) fed on high fat diet and treated daily with 1, 2 and 4 ml water extract prepared from green tea / each rat/day/day. Subgroup (5, 6 and 7) fed on high fat diet and treated daily with 1, 2 and 4 ml water extract prepared from black tea/each rat. Subgroup (8, 9 and 10) fed on high fat diet and treated daily with 1, 2 and 4 ml water extract prepared from cinnamon/each rat/day. The results revealed that, final weight, body weight gain %, liver weight /body weight% and serum (glucose, cholesterol, triglyceride, LDL-c, VLDL-c, uric acid, urea nitrogen, creatinine, AST, ALT and ALP) decreased in all treated groups, while HDL-c increased significantly, as compared to the positive control group. The highest improvement in all parameters recorded for all obese diabetic groups which treated with high doses from water extracts, followed by medium and low doses, respectively. It could be concluded the most effective treatment was observed on all treated groups with high doses from water extracts which prepared from (4ml green tea, black tea and cinnamon/ rat/ day). Obese diabetic group which treated with 4ml water extract prepared from green tea achieved the best results compared to other treated groups.

**Key words:** Rats • Obesity • Diabetes • Green tea • Black tea • Cinnamon lipid profile • Kidney functions • Liver enzymes and glucose

### INTRODUCTION

Diabetes mellitus (DM) is a complex and multifarious group of disorders that is a major source of ill health in the world [1]. DM is defined as a state in which homeostasis of carbohydrate and lipid metabolism is improperly regulated by insulin. DM exists in two major forms: type 1 or insulin dependent diabetes mellitus (IDDM) and type

2 or non-insulin dependent diabetes mellitus (NIDDM). Type 2 DM is the most common form of diabetes, accounting for around 90 to 95% of all diabetic patients. According to recent estimates, the human population worldwide appears to be in the midst of an epidemic of diabetes. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [2]. Diabetes mellitus is a syndrome which by

increasing the blood sugar causes abnormalities in the metabolism of fats, carbohydrates and proteins. It also raises the risk of possible vascular diseases [3]. The exact mechanism of diabetes mellitus is not yet well known, but the increased number of free radicals made by most of the mechanisms is harmful. Diabetes mellitus is known as an important endocrine disease which disrupts the carbohydrate's metabolic balance. These changes increase the numbers of free radicals and oxidized LDL [4]. In addition to drug treatment, dietary interventions were shown to represent an effective tool to prevent and/or treat insulin resistance and/or type 2 diabetes [5, 6]. The elevation in oxidative stress and changing level of anti-oxidants play a great role in the pathogenesis of diabetes mellitus [7, 8]. Overweight is defined by body mass index  $>25$  that exceed a standard body weight, however, the excess weight may also come from muscle, bone, fat, or body water [9]. Obesity specifically refers to having a high amount of body fat, which is usually accompanied by abnormalities in leptin and insulin secretion and their action, together with defects in lipid and carbohydrate metabolism [10, 11]. Cinnamon is one such a dietary component that has shown to have biologically active substances with insulin-mimetic properties. In vitro [12, 13] and in vivo [14, 15] studies have shown that cinnamon enhances glucose uptake by activating the insulin receptor kinase activity, autophosphorylation of the insulin receptor and glycogen synthase activity. Cinnamon extract contained cinnamic aldehyde, cinnamic acid, tannins and methyl hydroxy chalcone polymer as main components [13]. Cinnamon is one of the spices claimed to be a natural insulin sensitizer [16]. The insulin-sensitizing effect of cinnamon was established in vitro cell line studies with adipocytes [13] as well as in vivo animal studies [15]. The bioactive compound isolated from cinnamon was first classified as a methylhydroxychalcone polymer (MHCP), which acts as a mimetic of insulin [17]. Components of cinnamon may be important in the alleviation and prevention of the signs and symptoms of metabolic syndrome, type 2 diabetes and cardiovascular and related diseases [18]. Green tea is one of the most popular beverages consumed worldwide. Green tea and its components have many biological and biochemical effects such as anti-carcinogenesis [19], antioxidation [20], apoptosis-inducing [21] and anti-angiogenesis [22]. Moreover, epidemiological studies have implied that green tea drinking reduces blood cholesterol in Japanese [23]. Other study reported that the addition of 2% green tea powder (GTP) to the diet suppressed fat accumulation and body weight increase without reduction of food intake

in mice [24]. However, it is not clear what components of green tea are responsible for its anti-obesity activities. Health benefits of tea are believed to be largely due to the presence of high levels of polyphenols, primarily flavonoids. Tea can be classified as green and black. Black teas are produced by promoting the enzymatic oxidation of tea flavonoids. Enzymes involved in polyphenol oxidation are inactivated to produce green tea. Both green and black teas are rich in flavonoids. One cup of tea (2 g of tea leaves infused in hot water for 1 to 3 min) will provide 150 to 200 mg of flavonoids. As little as 2 to 3 cups/d of tea will supply the major contribution to total flavonoid intake in most individuals [25]. A higher intake of black tea [26, 27] and of polyphenols derived from black tea [28] has been associated with a lower risk of cardiovascular disease (CVD). The presence of anti-oxidants such as vitamins and flavonoids can have beneficial protecting effects on the diabetic patients [29].

The present work was conducted to study the effect of some doses of water extract which prepared from green tea, black tea and cinnamon on obese rats suffering from diabetes.

## MATERIALS AND METHODS

### Materials:

- Casein, all minerals, vitamins, cellulose, choline chloride and alloxan were obtained from El-Gomhoria Company, Cairo, Egypt.
- Cinnamon, black tea and green tea (*Camellia sinensis*) were purchased from local market, Cairo, Egypt.
- Normal male albino rats (66) Sprague Dawley Strain weighing ( $125 \pm 5$  g) obtained from Helwan farm, Cairo, Egypt.
- Corn oil, corn starch and vegetable ghee were obtained from local market.

### Methods

#### Water Extract of Green and Black Tea Preparation:

Water extract of green tea extract and black tea were prepared by adding each types of tea (5 g) to 100 ml of boiling water, steeped for 15-20 min. Infusion was cooled to room temperature and then filtered [30].

#### Water Extract of Cinnamon Preparation:

Cinnamon was prepared by the same method which used in preparing the two types of tea. Adding 5 g. of cinnamon to 100 ml. Water and boiled together for 2min., Infusion was cooled to room temperature and then filtered.

**Biological Part:** Sixty six male albino rats Sprague Dawley weighed ( $125 \pm 5$  g) were housed in wire cages in a room maintained at  $22 \pm 2^\circ\text{C}$ . The animals were kept under normal healthy conditions and fed on basal diet for one week for adaptation period). The basal diet consisted of 14% casein (protein  $>80\%$ ), corn oil 4%, choline chloride 0.25%, vitamin mixture 1%, salt mixture 3.5%, fiber 5% and the remainder corn starch [31], water was provided ad libitum. After the adaptation period, the rats were divided into two main groups. The first main group ( $n = 6$ ) was fed basal diet as negative control (healthy rats). The second main group ( $n = 60$ ) fed on high fat diet [casein 14% (protein  $>80\%$ ), Choline chloride 0.25%, vitamin mixture 1.0%, salt mixture 3.5%, fibers 5%, L-Cystine 0.18%, sucrose 10%, 20% fat (19% saturated fat + 1% unsaturated fat), bile salts (0.25%) and the reminder was corn starch] for 4 weeks to induced obesity in rats [32]. After this period, weight gain% and serum cholesterol, triglycerides and total lipids were determined in the first and second main groups, to ensure the induction. Body weight gain%, total cholesterol, triglycerides and total lipids were ( $21 \pm 5\%$ ,  $79.554 \pm 4.745$  mg/dl,  $43.709 \pm 3.882$  mg/dl and  $505.331 \pm 8.307$  mg/dl) and ( $43.533 \pm 7.234\%$ ,  $143.00 \pm 7.500$  mg/dl,  $81.202 \pm 6.663$  mg/dl and  $634.823 \pm 9.551$  mg/dl) for the first and second main groups, respectively. Then the second main group was injected with aloxane (150 mg/kg body weight) to induce hyperglycemia after fasting overnight [33]. After four days serum glucose was determined in the first and second main groups to ensure the induction. Serum glucose was ( $73.547 \pm 5.608$  mg/dl in healthy rats fed on basal diet vs.  $145.550 \pm 6.879$  mg/dl in the second main group fed on high fat diet). After this period, the second main group was divided into ten subgroups as a following:

**Subgroup (1):** Fed on high fat diet, as a control positive group.

**Subgroup (2, 3 and 4):** Fed on high fat diet and treated orally daily with 1, 2 and 4 ml water extract prepared from green tea/each rat/day/day.

**Subgroup (5, 6 and 7):** Fed on high fat diet and treated orally daily with 1, 2 and 4 ml water extract prepared from black tea/each rat.

**Subgroup (8, 9 and 10):** Fed on high fat diet and treated orally daily with 1, 2 and 4 ml water extract prepared from cinnamon/each rat/day.

During the experimental period (6 weeks), the diets consumed and body weights were recorded twice weekly. Biological evaluation for different groups was carried out by determination of feed intake, body weight gain% (BWG %) and liver weight/body weight% according to Chapman *et al.* [34]. At the end of the experiment, the rats were fasted overnight and then the rats were anaesthetized and sacrificed. Blood samples were collected from the aorta. The blood samples were centrifuged and serum was separated to estimate some biochemical parameters, i.e. serum glucose [35], total cholesterol [36], triglycerides [37], high-density lipoprotein cholesterol (HDL-C) [38], while low-density lipoprotein cholesterol (LDLC) and very low- density lipoprotein cholesterol (VLDL-C) were calculated according to the equation of Friedwald *et al.* [39]. Atherogenic Index (AI) was calculated according to this equation [ $\text{AI} = \text{LDL-cholesterol}/\text{HDL-cholesterol}$ ], while Coronary Risk Index (CRI) was calculated according to this equation [ $\text{CRI} = \text{total cholesterol}/\text{HDL-cholesterol}$ ] according to the methods described by Adeneye and Olagunju [40]. Serum samples were also used for determination of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities [41], serum alkaline phosphates [42], uric acid [43], urea nitrogen [44] and creatinine [45]. Liver was removed from each rat, careful dissection, washed with saline solution, dried with filter paper and weighed [46].

**Statistical Analysis:** The data obtained was analyzed statistically for standard deviation and one way ANOVA test [47].

## RESULTS AND DISCUSSION

**Effect of Water Extract Prepared from Green Tea, Black Tea and Cinnamon on Weight Gain and Liver Weight/body Weight% of Obese Rats Suffering from Diabetes:** The effect of different doses from water extract prepared from green tea, black tea and cinnamon on feed intake (g/day), weight (g), body weight gain % and liver weight/body weight% of obese rats suffering from diabetes presented in Table 1. The mean value of feed intake (g/day/each rat) of the control positive group decreased significantly  $p < 0.05$ , as compared to the negative control group ( $15.250 \pm 0.758$  vs.  $16.00 \pm 0.384$ ), respectively. Feed intake of all treated groups with the high doses (4ml/rat/day) from water extracts which prepared from green tea, black tea cinnamon decreased significantly  $p < 0.05$ , while the other treated groups

Table 1: Effect of water extract prepared from green tea, black tea and cinnamon on weight gain and liver weight/body weight% of obese rats suffering from diabetes

Parameters	Weight (g)				
	Feed Intake (g/day)	Initial	Final	BWG%	Liver weight / body weight %
Control negative	16.00 $\pm$ 0.384	152.166 $\pm$ 4.020	190.00 $\pm$ 3.405	24.894 $\pm$ 1.931	2.772 $\pm$ 0.078
Control positive	15.250 $\pm$ 0.758	220.708 $\pm$ 5.180	320.083 $\pm$ 3.470	45.065 $\pm$ 2.202	5.449 $\pm$ 0.272
One ml water extract of green tea	15.485 $\pm$ 0.435	220.925 $\pm$ 6.330	308.666 $\pm$ 3.829	39.772 $\pm$ 2.470	5.279 $\pm$ 0.239
Two ml water extract of green tea	15.226 $\pm$ 0.524	221.966 $\pm$ 6.274	290.666 $\pm$ 6.121	30.975 $\pm$ 1.314	4.479 $\pm$ 0.203
Four ml water extract of green tea	14.683 $\pm$ 0.421	221.333 $\pm$ 4.966	276.00 $\pm$ 4.427	24.723 $\pm$ 1.943	3.892 $\pm$ 0.190
One ml water extract of black tea	15.626 $\pm$ 0.378	220.718 $\pm$ 5.242	312.166 $\pm$ 3.868	41.466 $\pm$ 1.815	5.344 $\pm$ 0.209
Two ml water extract of black tea	15.365 $\pm$ 0.456	221.833 $\pm$ 7.250	295.666 $\pm$ 8.262	33.309 $\pm$ 1.747	4.657 $\pm$ 0.187
Four ml water extract of black tea	14.615 $\pm$ 0.429	221.166 $\pm$ 3.488	280.666 $\pm$ 7.312	26.886 $\pm$ 1.467	4.118 $\pm$ 0.185
One ml water extract of cinnamon	15.585 $\pm$ 0.612	220.416 $\pm$ 5.370	317.750 $\pm$ 5.654	44.180 $\pm$ 1.453	5.468 $\pm$ 0.180
Two ml water extract of cinnamon	14.933 $\pm$ 0.367	221.833 $\pm$ 6.306	302.500 $\pm$ 8.916	36.382 $\pm$ 2.832	4.946 $\pm$ 0.211
Four ml water extract of cinnamon	14.397 $\pm$ 0.345	221.166 $\pm$ 4.708	298.166 $\pm$ 8.035	34.802 $\pm$ 0.989	4.300 $\pm$ 0.242

- Values are expressed as mean  $\pm$  SD. - Significant at  $p < 0.05$  using one way ANOVA test

- Values which have different letters in each column differ significantly, while those with have similar or partially are not significant

showed non-significant changes in feed intake, as compared to the positive control group. Data presented Table 1 also showed that, initial weight of healthy rats fed on basal diet decreased significantly  $p < 0.05$ , as compared to other treated and non-treated groups. Final weight of the positive control group increase significantly as compared to the negative control group.

All treated obese groups which were suffer from diabetes with the three doses from water extracts which prepared from (green tea, black tea or cinnamon) showed significant decrease  $p < 0.05$  in final weight, as compared to the positive control group, except the group which treated with one ml water extract of cinnamon. The highest decrease in weight at the end of the experiment recorded for the groups which treated with (4 ml water extract prepared from green tea or black tea/rat/day), because these groups showed significant decrease, as compared to other treated groups. The mean value of body weight gain % of the positive control group increased significantly  $p < 0.05$ , as compared to the negative control group. Body weight gain % of all treated groups, except the group which treated with (1ml water extract prepared from cinnamon/rat/day) decrease significantly  $p < 0.05$ , as compared to the negative control group. The highest decrease in body weight gain % recorded for the groups which treated with (4ml water extract prepared from green tea or black tea/rat/day), these treatments showed non-significant differences in body weight gain %, as compared to the negative control group.

The mean value of liver weight/body weight % increased significantly in the positive control group, as compared to the negative control group. All treated obese diabetic groups with the medium and high doses from water extract prepared from green tea, black tea and

cinnamon showed significant decrease, as compared to the positive control group, while the low doses from them recorded non-significant differences. The best results in liver weight/body weight % recorded for the treated group with 4ml water extracts prepared green tea, followed by the group which treated with 4ml water extract prepared black tea, respectively.

In this respect, Wickelgren [48] defined the obesity, as an increase in mass of adipose tissue, confers a higher risk for metabolic diseases such as non-insulin-dependent diabetes, cardiovascular disease and stroke and an increased incidence of morbidity. Caffeine decreased food intake and increased thermogenesis and that the thermogenic effect induced the body weight reduction [49, 50]. Moreover, the thermogenesis by caffeine was synergistically enhanced with catechins in rat adipose tissues [51]. Caffeine ingestion elevated the metabolic rate and fat oxidation in vivo through lipolysis in fat cells and the release of catecholamines [52]. Feeding mice on diets supplemented with green tea at levels from 1% to 4% had significantly decreased food intake, body weight gain and fat mass. Serum leptin levels were also lower and that decreases appetite [53]. A diet containing tea catechins at 0.2% showed an anti-obesity action in mice at 27 weeks of feeding although the body weight was significantly lower in mice fed a 0.5% tea catechins diet at 12 weeks of feeding [54]. On the other hand, green tea can reduce body weight in obese Thai subjects by increasing energy expenditure and fat oxidation [55]. Also, both catechin polyphenols and caffeine which were presented in tea may be effective promoters of thermogenesis and fat oxidation, resulting in the reduction of body weight in Caucasians, Chinese and Japanese [56]. The body weights of rats have been significantly reduced by

Table 2: Effect of water extract prepared from green tea, black tea and cinnamon on lipid profile of obese rats suffering from diabetes

Parameters	Cholesterol	Triglycerides	HDL-c	LDL-c	VLDL-c
Groups	mg/dl				
Control negative	84.742 ± 4.060	47.943 ± 2.200	48.835 ± 2.654	26.733 ± 2.537	9.588 ± 0.440
Control positive	203.934 ± 5.939	103.555 ± 4.755	21.658 ± 2.602	160.889 ± 2.895	20.710 ± 0.951
One ml water extract of green tea	187.563 ± 5.645	89.783 ± 4.205	27.583 ± 1.618	142.023 ± 5.166	17.956 ± 0.841
Two ml water extract of green tea	166.405 ± 4.386	78.917 ± 2.924	34.800 ± 1.618	115.820 ± 3.483	15.783 ± 0.984
Four ml water extract of green tea	136.163 ± 2.784	60.331 ± 4.473	39.831 ± 1.784	86.246 ± 4.259	12.066 ± 0.894
One ml water extract of black tea	192.159 ± 4.779	92.675 ± 4.981	24.833 ± 1.119	148.791 ± 3.251	18.535 ± 0.996
Two ml water extract of black tea	178.634 ± 3.002	83.603 ± 3.902	30.731 ± 1.570	131.182 ± 1.526	16.720 ± 0.780
Four ml water extract of black tea	147.057 ± 2.970	66.885 ± 4.256	36.952 ± 1.837	96.727 ± 1.474	13.377 ± 0.851
One ml water extract of cinnamon	194.768 ± 4.010	95.698 ± 3.096	23.045 ± 0.704	152.583 ± 2.849	19.139 ± 0.619
Two ml water extract of cinnamon	185.751 ± 3.370	87.319 ± 3.878	28.470 ± 1.684	139.818 ± 1.433	17.463 ± 0.775
Four ml water extract of cinnamon	158.575 ± 3.316	71.190 ± 2.228	34.066 ± 1.086	110.270 ± 2.018	14.238 ± 0.445

- HDL-c: High Density Lipoprotein-cholesterol. - LDL-c: Low Density Lipoprotein-cholesterol. - VLDL-c: Very Low Density Lipoprotein-cholesterol.

- Values are expressed as mean ± SD. - Significant at  $p < 0.05$  using one way ANOVA test. - Values which have different letters in each column differ significantly, while those with have similar or partially are not significant.

Table 3: Effect of water extract prepared from green tea, black tea and cinnamon on AI and CRI of obese rats suffering from diabetes

Parameters	Atherogenic Index (AI)	Coronary Risk Index (CRI)
Groups	mg/dl	
Control negative	0.548 ± 0.066 <sup>i</sup>	1.736 ± 0.074 <sup>i</sup>
Control positive	7.512 ± 0.858 <sup>a</sup>	9.507 ± 0.930 <sup>a</sup>
One ml water extract of green tea	5.162 ± 0.358 <sup>d</sup>	6.814 ± 0.371 <sup>d</sup>
Two ml water extract of green tea	3.332 ± 0.149 <sup>f</sup>	4.786 ± 0.150 <sup>f</sup>
Four ml water extract of green tea	2.169 ± 0.166 <sup>h</sup>	3.421 ± 0.098 <sup>h</sup>
One ml water extract of black tea	5.999 ± 0.242 <sup>c</sup>	7.745 ± 0.244 <sup>c</sup>
Two ml water extract of black tea	4.276 ± 0.196 <sup>e</sup>	5.821 ± 0.216 <sup>e</sup>
Four ml water extract of black tea	2.622 ± 0.131 <sup>g</sup>	3.984 ± 0.136 <sup>g</sup>
One ml water extract of cinnamon	6.623 ± 0.135 <sup>b</sup>	8.454 ± 0.146 <sup>b</sup>
Two ml water extract of cinnamon	4.923 ± 0.251 <sup>d</sup>	6.537 ± 0.281 <sup>d</sup>
Four ml water extract of cinnamon	3.238 ± 0.072 <sup>f</sup>	4.655 ± 0.075 <sup>f</sup>

- Values are expressed as mean ± SD.

- Significant at  $p < 0.05$  using one way ANOVA test.

- Values which have different letters in each column differ significantly, while those with have similar or partially are not significant

feeding green tea leaves to the animals [57]. Adding cinnamon had no significant influence on the observed changed in body weight related to diabetes [58].

#### Effect of Water Extract Prepared from Green Tea, Black Tea and Cinnamon on Lipid Profile of Obese Rats Suffering from Diabetes:

The effect of some doses from water extract which prepared from green tea, black tea and cinnamon on lipid profile, Atherogenic Index (AI) and Coronary Risk Index (CRI) of obese rats suffering from diabetes are presented in Tables 2 and 3. Finding in Table 2 presented the effect of some doses from water extracts which prepared from green tea, black tea and cinnamon on total cholesterol, triglycerides, high density lipoprotein (HDL-c), low and very low density lipoprotein (LDL-c and VLDL-c) of serum obese rats suffering from diabetes. The results in this Table indicated that, the mean values of serum cholesterol, triglycerides, LDL-c and

VLDL-c of positive control group increased significantly  $p < 0.05$ , while HDL-c decreased, as compared to the negative control group. Treating all obese groups which were suffering from diabetes daily with (1ml, 2ml and 4ml water extract prepared from green tea, black tea or cinnamon/rat) decreased serum cholesterol, triglycerides, LDL-c and VLDL-c significantly  $p < 0.05$ , while HDL-c increased, as compared to the control positive group.

The mean values of serum lipid fractions, except HDL-c decreased gradually with increasing the volume of water extract which used in this study. Treating obese rats which were suffering from diabetes orally with green tea extract (1, 2 and 4ml /rat/day) recorded the highest improvement in lipid profile, as compared to other types. The highest decrease in serum cholesterol, triglycerides, LDL-c and VLDL-c with increased HDL-c recorded for the group which treated orally with 4ml water extract of green tea/rat/day, followed by the groups which treated with 4ml

water extract of black tea and cinnamon, respectively. Data in Table 3 indicated that Atherogenic Index (AI) and Coronary Risk Index (CRI) were significantly increased in the obese diabetic control group than the normal control group. All treated groups with the different doses of water extract which prepared from green tea, black tea and cinnamon showed significant decrease  $p < 0.05$ , as compared to the positive control group. On the other hand, AI and CRI decreased gradually with increasing the dosage from each type of water extract which used in this study in treating the obese rats which suffer from diabetes.

The highest improvement in the mean values of AI and CRI recorded for the group which treated with the high dose from green tea extract, followed by the groups which treated also with high doses from water extractions which prepared from black tea and cinnamon, respectively. Feeding obese diabetic rats on high fat diet and treating with the three doses from water extractions prepared from green tea, black tea and cinnamon enhanced the mean values of serum lipid profile, AI and CRI particularly with high levels from the extractions. In this respect, Obesity plays a pivotal role in the pathophysiology of metabolic and cardiovascular disease [59]. These disorders include impaired glucose tolerance, Type 2 diabetes, hypertension and dyslipidemia. Obesity is a primary risk factor for coronary heart disease (CHD) and mortality [60]. Also, El-Missir *et al.* [61] supported these mentioned results as they found development of hypercholesterolemia in serum diabetic rats.

Four weeks of cinnamon supplementation decreased the mean value of triglycerides by about (36%), LDL (30%) and total cholesterol (30%) in diabetic animals [62]. Green tea catechins have a hypocholesterolemic effect and suppress the intestinal absorption of cholesterol [63, 64]. Green tea catechins affects lipid metabolism by different pathways and prevent the appearance of atherosclerotic plaque. Its intake decreases the absorption of triglycerides and cholesterol and these findings are in accordance with the fact that it increases the excretion of fat [65].

Epigallocatechin gallate (EGCG), a kind of catechin, had an inhibitory effect on acetyl-CoA carboxylase which is essential for fatty acid biosynthesis *in vitro* [66]. On the other hand, these components have anti-obesity effects at high doses in rats [67, 68]. The protective effect of tea (*Camellia sinensis*) against atherosclerosis has been attributed to the antioxidant activity of the flavonoids [69]. Green tea leaves in diet was associated with lower serum levels of total cholesterol, LDL-C and triglycerides

but higher serum levels of HDL-C [70, 71]. This effect is attributed to a reduction in cholesterol absorption and to an increased excretion of biliary acids and cholesterol, another proposed action is the inhibition of cholesterol synthesis in the liver [72]. The inclusion of a relatively small amount of cinnamon in the diet of people with type 2 diabetes likely represents a safe and effective way of reducing risk factors for the development of co morbidities associated with diabetes and cardiovascular disease [4]. The antioxidants which presented in cinnamon have a positive role in enhancing insulin effectiveness and reducing its resistance. Thus, regulating the levels of serum lipids and lipid fraction [73, 74].

#### **Effect of Water Extract Prepared from Green Tea, Black Tea and Cinnamon on Kidney Functions of Obese Rats Suffering from Diabetes:**

Table 4 presented the effect of different doses from water extracts prepared from (green tea, black tea and cinnamon) on kidney functions (mg/dl), including (uric acid, urea nitrogen and creatinine) of obese rats suffering from diabetes. The mean values of serum uric acid, urea nitrogen and creatinine of the control positive group showed significant increase  $p < 0.05$ , as compared to the control negative group. Feeding rats on high fat diet and treated with alloxan increased the mean value of serum uric acid, urea nitrogen and creatinine by about 85.685%, 111.294% and 275.106%, than that of healthy rats fed on basal diet. Feeding obese groups which were suffering from diabetes on high fat diet and treating daily with different doses (1 ml, 2ml and 4ml) from water extracts prepared from (green tea, black tea and cinnamon) showed significant reduction at ( $p < 0.05$ ) in the mean values of uric acid and urea nitrogen and creatinine, except uric acid and urea nitrogen in the group which treated with low level from cinnamon, as compared to the positive control group. The mean values of serum uric acid, urea nitrogen and creatinine decreased gradually with increasing the volumes of water extract which prepared from green tea, black tea and cinnamon. The lowest mean values of serum uric acid, urea nitrogen and creatinine recorded for the group which treated daily with (4ml water extract of green tea/rat), followed by the group which treated with (4ml water extract of black tea/rat), respectively. Then the best results of serum uric acid, urea nitrogen and creatinine recorded for the group which treated with the high level from green tea. This treatment decreased the mean values of serum uric acid, urea nitrogen and creatinine by about 31.37%, 44.753% and 44.753% respectively, than that of the positive control group.

Table 4: Effect of water extract prepared from green tea, black tea and cinnamon on kidney functions of obese rats suffering from diabetes

Parameters	Uric Acid	Urea Nitrogen	Creatinine
Groups	mg/dl		
Control negative	1.502 <sup>a</sup> ± 0.054	29.369 <sup>b</sup> ± 1.358	0.470 <sup>a</sup> ± 0.036
Control positive	2.789 <sup>a</sup> ± 0.145	62.055 <sup>a</sup> ± 4.903	1.763 <sup>a</sup> ± 0.125
One ml water extract of green tea.	2.485 <sup>c</sup> ± 0.127	53.227 <sup>b</sup> ± 3.181	1.514 <sup>c</sup> ± 0.097
Two ml water extract of green tea.	2.163 <sup>d</sup> ± 0.078	44.581 <sup>d</sup> ± 3.205	1.244 <sup>d</sup> ± 0.069
Four ml water extract of green tea.	1.914 <sup>e</sup> ± 0.096	34.283 <sup>a</sup> ± 2.946	0.974 <sup>e</sup> ± 0.114
One ml water extract of black tea.	2.604 <sup>b</sup> ± 0.051	55.610 <sup>b</sup> ± 3.170	1.608 <sup>b</sup> ± 0.049
Two ml water extract of black tea.	2.251 <sup>d</sup> ± 0.049	46.108 <sup>c</sup> ± 2.720	1.290 <sup>d</sup> ± 0.019
Four ml water extract of black tea.	2.066 <sup>c</sup> ± 0.097	39.026 <sup>e</sup> ± 2.315	1.185 <sup>c</sup> ± 0.059
One ml water extract of cinnamon.	2.686 <sup>a</sup> ± 0.063	59.613 <sup>a</sup> ± 1.831	1.661 <sup>b</sup> ± 0.046
Two ml water extract of cinnamon.	2.415 <sup>c</sup> ± 0.047	48.931 <sup>c</sup> ± 2.765	1.454 <sup>c</sup> ± 0.085
Four ml water extract of cinnamon.	2.195 <sup>d</sup> ± 0.110	41.317 <sup>e</sup> ± 2.139	1.313 <sup>d</sup> ± 0.067

- Values are expressed as mean ± SD.

- Significant at p<0.05 using one way ANOVA test.

- Values which have different letters in each column differ significantly, while those with have similar or partially are not significant

From these results it could be concluded that, water extract prepared from green tea, black tea and cinnamon with (low, medium and high doses) improved kidney functions of obese rats suffering from diabetes, especially when using high dose from them. Obesity and high-fat diets are linked with kidney dysfunction in rats and dogs [75]. Also, Jing *et al.* [76] confirm that high dietary fat worsens early disease progression in this model of renal disease. On the other hand, renal dysfunction due to oxidative damage associated with diabetes [77]. Also, blood urea nitrogen and uric acid were significantly increased as a result of injection with alloxan [78]. The inclusion of water soluble cinnamon compounds in the diet could reduce risk factors associated with diabetes and cardiovascular disease [79]. The lowest level of cinnamon is more effective than the highest level in reducing serum urea nitrogen and uric acid levels. This useful effect of cinnamon due to its ability in improving renal functions and protects renal glomeruli against oxidative damage via increasing both the levels and activities of antioxidant status [80]. Green tea catechins and their derivatives have been characterized as antioxidants that scavenge free radicals to protect cells in normal and pathological states [81]. Among all tea polyphenols, epigallocatechin-3-gallate has been shown to be responsible for much of the health promoting ability of green tea. Green tea has been shown to improve kidney function in diabetic rats [82]. Green tea polyphenol is effective against renal failure in rats. Green tea polyphenol administered to rats at a daily dose of 50 or 100 mg/kg body weight for 30 days with a 2% arginine diet decreased serum levels of creatinine and urea nitrogen [83]. Green tea has been shown to mitigate gentamicin-nephrotoxicity by lowering the level of serum urea, creatinine and tissue

lipid peroxidation LPO content [84]. Also, green tea ameliorates gentamicin elicited nephrotoxicity and oxidative damage by improving antioxidant defense, tissue integrity and energy metabolism [30]. Oral administration of green tea extract to rats at the dose levels of 25, 50, 100 mg/kg to investigate its effect on cisplatin (3mg/kg) induced nephrotoxicity restored the level of creatinine, urea, BUN and uric acid in serum of animals treated with cisplatin as compared to the animals treated with cisplatin alone [85].

**Effect of Water Extract Prepared from Green Tea, Black Tea and Cinnamon on Serum Glucose and Liver Enzymes of Obese Rats Suffering from Diabetes:** Data in Table 5 presented the effect of three doses from water extract prepared from green tea, black tea and cinnamon (1ml, 2ml and 4ml/each rat/day) on serum glucose (mg/dl), Aspartate Amino Transferase AST, Alanine Amino Transferase ALT and alkaline phosphates ALP (u/l) of obese rats suffering from diabetes. Feeding rats on high fat diet and injected with 150mg alloxan/kg body weight (control positive) led to significant increase p<0.05 in serum glucose, AST, ALT and ALP, as compared to rats fed on basal diet (control negative). Serum glucose increased by about 106.651%, while AST, ALT and ALP increased by about 155.331%, 209.939% and 52.010%, respectively in the positive control group, than that of the negative control group. Treating obese rats which were suffering from diabetes with different doses from water extract prepared from green tea, black tea and cinnamon (1ml, 2ml and 4ml/rat/day) improved the mean values of serum glucose and liver enzymes, as compared to non-treated rats (negative control group). Serum glucose, AST, ALT and ALP decreased gradually with increasing

Table 5: Effect of water extract prepared from green tea, black tea and cinnamon on serum glucose and liver enzymes of obese rats suffering from diabetes.

Parameters		AST	ALT	ALP
Groups	Glucose mg/dl)	u/l		
Control negative	89.705 <sup>b</sup> ± 4.187	62.155 <sup>b</sup> ± 4.224	24.528 <sup>a</sup> ± 1.837	78.221 ± 3.158
Control positive	185.377 <sup>a</sup> ± 5.308	158.701 <sup>a</sup> ± 4.015	76.022 <sup>a</sup> ± 3.890	197.125 <sup>a</sup> ± 6.681
One ml water extract of green tea	148.087 <sup>c</sup> ± 5.345	146.412 <sup>c</sup> ± 3.713	66.048 <sup>c</sup> ± 3.288	182.617 <sup>c</sup> ± 6.323
Two ml water extract of green tea	120.253 <sup>c</sup> ± 6.534	130.513 <sup>c</sup> ± 4.256	55.656 <sup>d</sup> ± 2.690	160.841 <sup>c</sup> ± 4.356
Four ml water extract of green tea	102.553 <sup>a</sup> ± 7.279	113.297 <sup>c</sup> ± 3.894	41.976 <sup>c</sup> ± 2.437	136.949 <sup>a</sup> ± 5.238
One ml water extract of black tea	150.631 <sup>c</sup> ± 5.895	151.124 <sup>b</sup> ± 3.068	69.462 <sup>b</sup> ± 3.049	187.334 <sup>b</sup> ± 3.733
Two ml water extract of black tea	134.541 <sup>d</sup> ± 4.593	139.583 <sup>d</sup> ± 3.902	64.725 <sup>c</sup> ± 2.605	168.063 <sup>c</sup> ± 4.896
Four ml water extract of black tea	111.00 ± 1.159	122.142 <sup>c</sup> ± 3.309	47.887 <sup>c</sup> ± 3.460	145.033 <sup>b</sup> ± 4.530
One ml water extract of cinnamon	161.440 <sup>b</sup> ± 4.601	153.369 <sup>b</sup> ± 2.741	70.042 <sup>b</sup> ± 2.691	189.195 <sup>b</sup> ± 3.331
Two ml water extract of cinnamon	146.762 <sup>c</sup> ± 6.136	143.563 <sup>c</sup> ± 3.188	65.042 <sup>c</sup> ± 1.412	174.692 <sup>c</sup> ± 3.467
Four ml water extract of cinnamon	131.399 <sup>d</sup> ± 4.799	129.358 <sup>c</sup> ± 1.522	53.502 <sup>d</sup> ± 3.868	151.549 <sup>a</sup> ± 4.348

- Values are expressed as mean ± SD. - Significant at p<0.05 using one way ANOVA test.

- Values which have different letters in each column differ significantly, while those with have similar or partially are not significant

the dosage of water extract which used in treating obese diabetic rats. The highest decrease in serum glucose recorded for the group fed on high fat diet and treated daily with 4ml water extract of green tea/rat. This treatment decreased serum glucose by about 44.840%, than that on the positive control group. On the other hand the same treatment recorded the best results in liver enzymes, because this treatment showed significant decrease  $p < 0.05$  in the mean value of AST, ALT and ALP, as compared to other treated groups.

From these results it could be concluded that, treating obese rats with different doses from water extract prepared from green tea, black tea and cinnamon with (1ml, 2ml and 4ml) improved serum glucose and liver enzymes, especially when using high doses from them. In this respect, plasma glucose increased and insulin levels diminished insulin sensitivity of people suffering from overweight and obesity [86]. On the other hand, untreated diabetic rats revealed a highly significant increase in the mean value of serum glucose, this increase due to the defects in insulin secretion, insulin action, or both in diabetics [77, 87]. The liver dysfunction associated with diabetes was reported by Vidro *et al.* [88]. Also, injection with alloxan induced decrease in both liver glycogen and total serum protein contents [89]. The presence of anti-oxidants such as vitamins and flavonoids can have beneficial protecting effects on the diabetic patients [29]. Administrated cinnamon extract to Wistar rats and found decreasing of blood glucose [15]. In patients with diabetes, cinnamon extracts have been reported to have beneficial effects in reducing fasting plasma glucose [90]. Cinnamon increased the insulin sensitivity and glucose uptake in adipocytes [13]. Cinnamon exhibits the potential to increase the amounts of proteins involved in insulin

signaling, glucose transport and anti-inflammatory/anti-angiogenesis response [91]. Serum glucose significantly decreases as a result of administering of cinnamon biscuit or cinnamon aqueous extract (15% of either) compared with diabetic control rats [92]. cinnamaldehyde (a predominant component of cinnamon) which resulted from the potentiating of insulin from existing B. cells of the islets of Langerhans [93]. Oolong tea was shown to be an effective adjunct to oral hypoglycemic agents in the treatment of patients with type 2 diabetes [94]. The green tea flavonoid has been shown to have insulin-like activities [95], as well as insulin-enhancing activity [96]. Green tea catechin may reduce hepatic fibrosis by suppressing oxidative stress and controlling the transcription factor expression involved in stellate cell activation [97]. The antioxidant property of flavonoidal compounds of GT extract contributes to decrease the oxidative stress in liver and increase the levels of antioxidant enzymes, superoxide dismutase, catalase and glutathione [98]. Epidemiologic studies suggest that green tea consumption reduces serum aminotransferases [99], commonly used markers of liver injury. The hepatoprotective activities of green tea are attributed to its catechins that scavenge ROS/RNS *in vitro* [100]. The drinking of green tea with high catechin content may help to prevent and/or attenuate the development of a certain type of hepatitis [101]. Both black and green tea possesses preventive effects against carbon tetrachloride CCl<sub>4</sub> induced liver damage in rats [102].

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