JJBS

Volume 7, Number 1, March .2014
ISSN 1995-6673
Pages 7 - 12

Jordan Journal of Biological Sciences

Effect of Green Tea and Green Tea Rich with Catechin on Blood Glucose Levels, Serum Lipid Profile and Liver and Kidney Functions in Diabetic Rats

Usama El-Sayed Mostafa*

Ain Shams University, Faculty of Specific Education, Home Economics Department, Cairo, Egypt

Received: September 2, 2013 *Revised: September 26, 2013* *Accepted: October 1, 2013*

Abstract

Diabetes is a major health problem in the developed and developing world. This study aims at investigating the effects of continuous ingestion of green tea and green tea plus different doses of catechin in rats (with type 2 diabetes) that were not receiving insulin on the serum glucose, lipid profile and both liver and kidney functions. The results indicated that the sharpest decrease of serum glucose was observed in the group treated with green-tea plus 100 mg of powder catechin. Blood glucose level was significantly low in all treated group 2 h after the administration of green tea and green tea plus both doses of powder catechin suspension, whereas the level of blood glucose level remained high in diabetic rats. Treating diabetic groups fed on basal diet with different levels of green tea, green tea plus 30 mg of powder catechin and green tea plus 100 mg of powder catechin led to a significant decrease in the mean value of serum cholesterol, triglyceride, LDL and VLDL as compared to the positive control group. Green tea plus high dose of catechin tended to improve liver functions manifested by the reduction of the serum levels of (AST and ALT), as well as kidney functions manifested by the reduction in the serum levels of (uric acid, urea nitrogen and Creatinine). The tea supported with catechin, drunk for many weeks, may be beneficial for people suffering from moderate diabetes or hyperlipidemia, reducing its complications such as liver and kidney disorders.

Keywords: Green Tea, Catechin, Lipid Profile, Liver and Kidney Function, Blood Glucose.

1. Introduction

Tea is the most widely consumed beverage in the world, second only to water. The three kinds of true tea-green, black, and oolong-are all derived from the Camellia sinensis plant. At harvest, tea leaves contain high levels of catechins, a particular class of polyphenols (Cabrera *et al.,* 2006). Green tea (GT), however, is produced by heat-treating leaves soon after harvest, thereby preserving the catechins from oxidation. An average serving of 250 ml of GT contains between 50 and 100 mg of catechins. In addition, GT contains a variable amount (typically around 30 mg/serving) of caffeine (Wolfram *et al.,* 2006).

Green tea extracts are nonoxidized/nonfermented derivatives of the leaves of Camellia sinensis, which belongs to the aceae family. Polyphenols (flavonols or catechins), found in the tea, make up 30 to 40% percent of the extractable solids of dried green tea leaves. The main catechins in green tea are epicatechin, epicatechin-3-gallate, epigallocatechin, and epigallocatechin- 3-gallate (EGCG), with EGCG being the highest in concentration. These polyphenols have been shown to exhibit some potential antioxidant, anticarcinogenic, anti-inflammatory, thermogenic, probiotic, and antimicrobial properties (Graham, 1992).

Vivo studies, using rodents, have shown that green tea extract and catechins isolated from green tea can induce a variety of health effects, including anti-obesity, hypoglycemic and hypolipidemic activities (Suzuki *et al.,* 2012).

Most research has focused on the function of the antioxidant components found in tea and the potential of these to reduce the risk of cardiovascular diseases and cancer (Wolfram *et al.,* 2006). In addition, a number of reports have been published showing that regular consumption of GT, or catechins extracted from GT (with or without added caffeine), may influence energy metabolism, body weight and body fat content (Hongqiang *et al.,* 2010).

Several studies reported that alloxan produces oxygen radicals which destroy pancreatic β-cells and cause severe hypoinsulinaemia (type I diabetes) that is responsible for the hyperglycemia seen in alloxan-treated animals. However, its action is not directed to pancreatic β-cells only, as other organs, such as the liver, kidney and bone marrow, are also affected by the

* Corresponding author. e-mail: usama127@yahoo.com.

alloxan administration as seen from the elevation of plasma markers reflecting renal cell damage (urea and creatinine levels) and the reduction of hematological parameters ((Jabber, 2013).

The present study aims at examining the effects of green tea alone or green tea supported with different levels of catechin on serum glucose, lipid profile and some liver and kidney functions in normal and diabetic rats.

2. Material and Methods

2.1. Materials

Green tea was purchased from Cairo, Egypt local market. Catechin and other chemicals were purchased from Sigma-Aldrich (St. Louis, MO). Kits for biochemical analysis of serum glucose, cholesterol, triglyceride, HDL-c, AST, ALT, uric acid, urea nitrogen, and creatinine were obtained from the Gamma Trade Company for Pharmaceutical and Chemicals, Dokki, Egypt.

2.2. Preparation of Green Tea Extract (GTE)

For animal studies, 20 g of green tea leaves were added to 1000 ml of nanopure water. After being stirred for 5 min at 80 °C, the tea leaves were removed by filtration, using filter paper (Advantec 2 filter paper, Hyundai micro Co., Seoul, Korea). The extract was dried using under-vacuum machine (temperature at 50°C, under-vacuum of 0.3 bar). A total of 3 g of dried GTE was harvested and dissolved in 10 ml of water. An equal amount of the GTE solution was mixed with different amount of powder catechin (Park *et al.*, 2009).

2.3. Animal Care

The present study was approved by the local Animal Ethics Committee. The investigation conformed to the National Institutes of Health (NIH) Guide for the Care and Use of Laboratory Animals [DHHS Publication No. (NIH) 85-23, Revised 1985, Office of Science and Health Reports, Bethesda, MD 20892]. All animals were maintained on a 12 h lights and 12 h dark cycle and a temperature of 23 ± 1°C. All animals received modified basal diets (Reeves, 2004) and water ad libitum. Male Sprague-Dawley rats with average weights of about 200 g (10 wk old) were purchased from Laboratory Animal Colony, Ministry of Health and Population, Helwan, Cairo, Egypt. They were housed 5 rats/cage. All rats, except rats in group 1, were injected with alloxan in a dose of 150mg/kg of body weight as a single dose, subcutaneously to induce diabetes according to the method described by Hiroshi *et al*. (1996). Of eighty rats treated with alloxan, twenty five per cent died within the first and second weeks of alloxanization. Blood was extracted from the tail vein for glucose analysis; rats with fasting glucose ranging from 210-220 mg/dl were considered diabetic and were analyzed 48 hours after alloxan treatment. Rats were divided into the following experimental groups (n = 10 rats in each group):

- Group I: Negative control, normal healthy rats, receiving regular diet with no treatment.
- Group II: positive control, diabetic rats receiving regular diet with no treatment.
- Group III: diabetic rats receiving regular diet and receiving oral 25 ml of green tea extract.
- Group IV: diabetic rats receiving regular diet and receiving oral 25 ml of green tea extract plus 30 mg of powder catechin /kg/day.
- Group V: diabetic rats receiving regular diet and receiving oral 25 ml of green tea extract plus 100 mg of powder catechin /kg/day.

It should be noted that the green tea extract containing catechins was freshly prepared every other day. The daily dose of GTE plus powder catechin was calculated according to rat weight. This amount was divided into three portions daily; first portion was given orally in the morning after rats being fasted about 12 hours; second portion was given orally 6 hours after the first portion; third portion was orally given after 6 hours from the second portion. Oral dosing volumes should not exceed 10ml/kg.

2.4. Determination of Serum Glucose

Serum glucose concentration was determined according to the methods described by Young, (2001) using Spectrophotometer DU7400 adjusted at 500 nm.

2.5. Intraperitoneal Glucose Tolerance Test (IPGTT) and OGTT in Animals

After a 12 h fast, rats were randomly divided into 5 groups: first group (positive control) orally fed on 300 µl phosphate buffered saline (PBS), second group (negative control) (diabetic control) orally fed on 300 µl of PBS, third group orally fed on 25 ml of GTE, fourth group fed on orally 25 ml of GTE plus 30 mg of powder catechin dissolved in 300 µl PBS, and fifth group orally fed on 25 ml of GTE plus 100 mg of powder catechin dissolved in 300 µl PBS. The maximum volume that can be administered to the animal is to be calculated; oral dosing volumes should not exceed 10ml/kg. Then the distance from the oral cavity to the end of the xyphoid process (caudal point of the sternum) with the feeding needle on the outside of the restrained animal is to be measured. With the feeding needle attached to the filled syringe, the end of the feeding needle along the roof of the animal's oral cavity towards the animal's left side is to be slid. Once the feeding needle is in to the premeasured distance, the solution is to be injected, slowly as to minimize the fluid coming back up the esophagus.

Thirty minutes after the oral feeding, each rat was orally given 1 ml distilled water containing 2 g glucose/kg. For the assay of blood glucose levels, blood was drawn from the tail vein at the indicated times (Park *et al.*, 2009).

2.6. Estimation of Serum Lipid Profile

Total serum cholesterol (Cohn *et al.*, 1988), triglycerides (Foster and Dumns, 1973), HDL-c (Young, 2001), LDL-c and VLDL-c were calculated by the methods described by (FriedWald *et al.*, 1972).

2.7. Estimation of Liver and Kidney Functions

Liver functions, such as Aspartate amino transferase (AST), alanine amino transferase (ALT), and kidney functions, such as Uric acid, urea nitrogen and creatinine were determined according to methods described by Young (2001).

2.8. Statistical Analyses

The results are expressed as mean ±SEM. The SPSS (release10.0) software package (SPSS Inc., Chicago, IL) was used for the statistical analyses. For comparisons of more than two groups, significance was tested using an analysis of variance (ANOVA). Differences between groups were considered significant when $P<0.05$.

3. Results and Discussion

In the healthy control negative group, blood glucose level (BGL) slightly changed. Also, hyperglycemic rats control positive group (injected with alloxan), the BGLslightly changed, after 8 weeks. No statistical significance was observed between them. The BGL for rats injected with alloxan was much higher than the healthy group. This may be due to alloxan producing oxygen radicals that destroy pancreatic β-cells and cause severe hypoinsulinaemia that is responsible for the hyperglycemia seen in alloxan-treated animals (Jabber, 2013).

Table 1. Effect of some levels from green tea and green tea rich with different doses of catechin on serum glucose of hyperglycemic rats.

Parameter		mg/dl.	
Groups		Initial Glucose	Final Glucose
Healthy rats. Control (-)		92.51 ± 4.653 [a]	93.22 ± 4.436 [a] (NS)
Hyperglycemic rats. Control (+)		305.52 ± 7.292 [e]	301.33 ± 6.653 [e] (NS)
Hyperglycemic rats fed on basal diet and treated with	Green tea.	295.14 ± 7.221 [e]	260.66 ± 4.083 [d] (S)
	Green tea + 30 mg of powder catechin	285.55 ± 8.053 [e]	205.167 ± 5.231 [c] (S)
	Green tea + 100 mg of powder catechin	283.55 ± 7.231 [e]	160.53 ± 4.719 [b] (S)

Values are expressed as mean ± SD. Significance at $P<0.05$
[a, b, c, d], means that values which don't share the same letter in each column are significantly different at $P<0.05$.
a is the best result followed by b and c and so on (NS) none significant in the same row (S) significant in the same row.

Whereas in the green-tea and catechin treated group, BGL markedly changed after 8 weeks. The sharpest decrease was observed in diabetic rats treated with green-tea plus 100 mg of powder catechin after 8 weeks from consumption. As shown in table 1, green tea tended to lower BGL at 25 ml of GTE, and significantly lowered it at 25 ml of GTE of green tea plus 30 and 100 mg of powder catechin. These results are in agreement with Suzuki results (Suzuki *et al.*, 2012). The efforts to manage type 2 diabetes and obesity by natural green tea treatment appear to be taken cautiously because the systemically absorbed GTE blocks the cellular glucose uptake and thereby increases blood glucose (Park *et al.*, 2009).

The effect of green tea was compared among the different groups of rats, i.e., rats injected with alloxan-diabetic rats (control +), rats injected with alloxan-diabetic rats treated with oral 25 ml of GTE, rats injected with alloxan-diabetic rats treated with oral 25 ml of GTE plus 30 mg of powder catechin and rats injected with alloxan-diabetic rats treated with oral 25 ml of GTE plus100 mg of powder catechin. (Figure1). BGLs significantly went down in treated group 2 h after administration of green tea and green tea plus both doses of powder catechin suspension, whereas the level of BGL remained high in rats injected with alloxan - diabetic rats (control +).

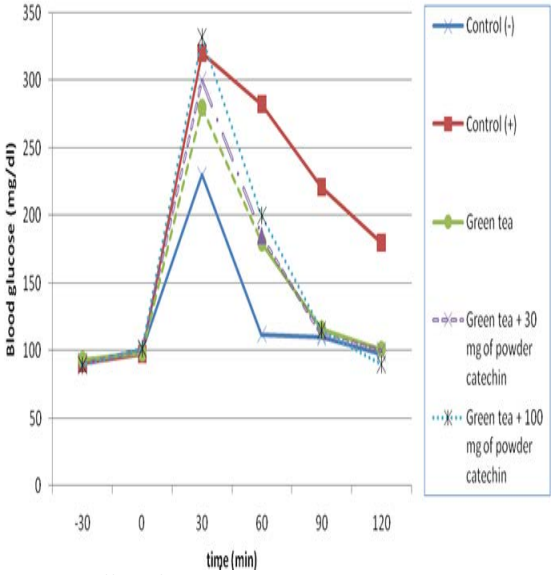

Figure 1. effect of green tea and green tea rich in catechin on glucose tolerance of hyperglycemic rats.

All tested groups showed more elevated blood glucose levels 30 min after glucose loading, compared to control negative group ($P<0.05$). This result may be due to the effect of green tea extract and catechin on glucose tolerance which may be mainly due to the two epicatechin (EC), Epigallocatechin-3-gallate (EGCG) and epicatechin-3-gallate (ECG) (Park *et al.*, 2009).

Treating diabetic groups fed on basal diet with different levels of green tea, green tea plus 30 mg of powder catechin and green tea plus 100 mg of powder catechin led to a significant decrease in the mean value of serum cholesterol and triglyceride as compared to the positive control group. Data in table 2 revealed that the mean value of total serum cholesterol and triglyceride in rats suffering from hyperglycemia decreased gradually with increasing the level of GTE enriched with catechin. Statistical analysis in this table showed that no significant change in serum cholesterol and triglycerides was observed between the groups treated with oral 25 ml of GTE and green tea plus 30 mg of catechin.

Table 2. Effect of some levels from green tea and green tea rich with different doses of catechin on cholesterol and triglycerides of hyperglycemic rats.

Parameter / Groups		mg/dl. Cholesterol	Triglycerides
Healthy rats. Control (-)		106.30 ± 4.35 [c]	60.667 ± 4.58 [c]
Hyperglycemic rats. Control (+)		162.63 ± 6.022 [a]	82.507 ± 6.04 [a]
Hyperglycemic rats fed on basal diet and treated with	Green tea.	126.83 ± 4.622 [b]	75.000 ± 4.00 [b]
	Green tea + 30 mg of powder catechin	119.66 ± 4.262 [b]	70.333 ± 3.20 [ab]
	Green tea + 100 mg of powder catechin	109.28 ± 1.966 [c]	62.000 ± 1.26 [c]

Values are expressed as mean ± SD. Significance at $P<0.05$

[a, b, c, d,] means that values which don't share the same letter in each column are significantly different at $P<0.05$.

[a] is the best result followed by [b] and [c] and so on

The best results in serum cholesterol were observed in hyperglycemic group fed on basal diet and treated with green tea plus high levels of catechin, because this treatment showed no significant differences in serum cholesterol and triglyceride as compared to the negative control group. The current results completely agreed with Ikeda (2008) who reported that green tea and catechin preparations significantly lowered serum and liver cholesterol concentrations. Moreover, another study reported that serum cholesterol concentration was 5% lower in the groups fed with GTE than in the placebo control group (Kajimoto *et al.*, 2003; Suzuki *et al.*, 2012). The reduction of serum cholesterol may be due to the inhibition of intestinal absorption of cholesterol by green tea and catechin, leading, therefore, to reducing the serum cholesterol concentrations (Ikeda, 2008). The lowering of triglyceride observed in this study was in agreement with other study which confirmed that both green tea and heat-treated tea catechins have the same triacylglycerol lowering activity (Ikeda *et al.*, 2005). The reduction of triglyceride observed in this study may be due to catechin suppress postprandial hypertriacylglycerolemia through the inhibition of pancreatic lipase, which, therefore, delayed the absorption of fat (Ikeda *et al.*, 2005).

Table 3 showed the change in serum lipid. Significant difference in HDL-c, LDL-c and VLDL-c has been observed between control positive group and control negative group. The similar finding was reported by Kajimoto *et al.* (2005) and Suzuki *et al.* (2012).

Table 3. Effect of some levels of green tea and green tea rich with different doses of on serum lipoproteins of hyperglycemic rats.

Parameter / Groups		mg/dl. HDL-C	LDL-c	VLDL-c
Healthy rats. Control (-)		63.167 [a] ± 2.978	36.950 [a] ± 5.231	12.133 [a] ± 0.918
Hyperglycemic rats. Control (+)		23.106 [e] ± 2.595	128.726 [d] ± 2.909	16.502 [b] ± 1.209
Hyperglycemic rats fed on basal diet and treated with	Green tea.	33.833 [d] ± 4.119	101.567 [c] ± 2.320	15.600 [b] ± 0.809
	Green tea + 30 mg of powder catechin	38.667 [c] ± 2.066	87.500 [b] ± 1.002	14.500 [ab] ± 0.724
	Green tea + 100 mg of powder catechin	58.833 [b] ± 1.169	35.100 [a] ± 1.079	12.400 [a] ± 0.253

Values are expressed as mean ± SD.Significance at $P<0.05$

[a, b, c, d,] means that values which don't share the same letter in each column are significantly different at $P<0.05$.

[a] is the best result followed by [b] and [c] and so on

Data showed that high-density lipoprotein of hyperglycemic rats, treated with green tea plus high levels from catechin, increased significantly at $P<0.05$, as compared to hyperglycemic groups treated with green tea plus medium level of catechin and treated with green tea alone. This result was in agreement with Kajimoto *et al.* (2005) who reported similar results.

In general, the three treated groups showed decreased serum LDL-c in rats suffering from hyperglycemia. The highest decrease in serum LDL-c recorded for hyperglycemic group, which was treated with oral 25 ml of GTE plus 100 mg of powder catechin, followed by the group treated with green tea plus low level of catechin. Decrease of LDL-c was observed in the present trial, and this result further confirmed the result of the study of Suzuki *et al.* (2012).

The data in this table showed that VLDL-c in serum diabetic rats increased significantly at $P<0.05$, as compared to non-diabetic rats (healthy group). All treated groups tended to have VLDL-c lower than hyperglycemic rats (control +). No statistical significant was observed between groups treated with green tea plus low or high level of catechin for serum VLDL-c.

Maron *et al.* (2003) reported that 120 subjects consumed green tea extract (150 mg of green tea catechins) for 12 weeks, and the green tea extracts decreased serum LDL-cholesterol by 11.3%. This study showed the decrease of LDL and VLDL-c by the consumption of green tea rich with catechin. This is in agreement with several previous observations of the experimental animals and humans (Loest *et al.*, 2002; and Maron *et al.*, 2003). This may be contributed to the excretion of cholesterol into feces (Muramatsu *et al.*, 1986), the activities of lipid enzymes (Lin *et al.*, 2002), the apoB secretion (Yee *et al.*, 2002) and uptake by cells (Bursill *et al.*, 2001).

As mentioned above, results showed that alloxan induced diabetic rats showed significant hypercholestremia as compared to control. The level of serum lipid is usually elevated in diabetes meilleitus, and such an elevation represents a risk factor for coronary heart diseases (Ikeda *et al.,* 2005). From the data mentioned above, it could be concluded that a daily consumption of green tea rich with catechin significantly reduces risk factors for coronary artery diseases, including total cholesterol, LDL-cholesterol, and triacylglyerides, while it increased the protective HDL cholesterol. Catechins in green tea have been shown to reduce the risk of coronary heart diseases in epidemiological studies. Also, it has been reported that catechins have hypolipidemic and antioxidant effects (Gomikawa *et al.,* 2008).

Table 4. Effect of some levels of green tea and green tea rich with different doses on liver enzymes of hyperglycemic rats.

Parameter		U/L	
Groups		AST	ALT
Healthy rats. Control (-)		94.750 [a] ± 1.118	37.42 ± 1.08 [a]
Hyperglycemic rats. Control (+)		181.000 [a] ± 7.899	71.18 ± 6.52 [d]
Hyperglycemic rats fed on basal diet and	Green tea.	157.167 [d] ± 4.579	64.15 ± 3.742 [c]
	Green tea + 30 mg of powder catechin	112.833 [c] ± 4.355	42.63 ± 3.53 [b]
	Green tea + 100 mg of powder catechin	105.667 [bc] ± 3.445	35.05 ± 1.33 [a]

Values are expressed as mean ± SD.Significance at $P<0.05$

[a, b, c, d,] means that values which don't share the same letter in each column are significantly different at $P<0.05$.

[a] is the best result followed by [b] and [c] and so on

Rats treated with the three oral solutions produced a significant decrease in the levels of serum AST, ALT as compared to control positive group ($P<0.05$). (table 4). The best results in serum AST and ALT observed in hyperglycemic group fed on basal diet and treated with green tea plus high levels from catechin, because this treatment showed no significant differences in serum AST and ALT as compared to the negative control group. The reduction of the serum activities of AST and ALT by green tea and catechin indicates the ability of green tea to stabilize plasma membrane and repair hepatic tissue damages caused by oxidative stress. The protective effect of green tea is due to its antioxidant properties that scavengering free radicals formed in alloxan induced diabetic rats. It has been shown that green tea contains volatile oils antioxidant vitamins like (B, C, E and folic acid), tannins and amino acid (theanine) which is a major available amino acid in green tea. Additionally, polyphenols may also function indirectly as antioxidants (Al-Khashaly, 1997).

According to the results of this study, it could be concluded that green tea alone or green tea plus catechin have the ability, through a mechanism related to direct and/or indirect antioxidant property, to provide protective effects against diabetic rats with induced hepatotoxicity through the reduction of hepatic oxidative stress with a subsequent improvement in liver functions manifested by reducing the serum levels of AST and ALT that improve the damage in liver tissues and makes it a good candidate to be tried clinically in this respect.

Table 5. Effect of some levels from green tea and green tea rich with different doses on kidney functions of hyperglycemic rats.

Parameter		mg/dl.		
Groups		Uric acid	Urea nitrogen	Creatinine
Healthy rats. Control (-)		1.82 ± 0.62 [a]	31.54 ± 3.08 [a]	0.71 ± 0.05 [a]
Hyperglycemic rats. Control (+)		2.95 ± 0.22 [c]	56.47 ± 3.33 [c]	1.22 ± 0.06 [c]
Hyperglycemic rats fed on basal diet and treated with	Green tea	2.36 ± 0.21 [b]	54.41 ± 2.74 [b c]	1.29 ± 0.06 [c]
	Green tea + 30 mg of powder catechin	2.03 ± 0.23 [ab]	50.17 ± 3.01 [b]	0.93 ± 0.06 [b]
	Green tea + 100 mg of powder catechin	1.91 ± 0.18 [a]	31.58 ± 2.16 [a]	0.69 ± 0.05 [a]

[a, b, c, d,] means that values which don't share the same letter in each column are significantly different at $P<0.05$.

[a] is the best result followed by [b] and [c] and so on

Table 5 illustrates the changes in serum levels of uric acid, urea nitrogen and creatinine (mg/dl) as a result of the treatments with green tea and green tea plus two doses of catechin for rats suffering from hyperglycemia. From presented data, it could be observed that alloxan injection led to abnormal changes in kidney functions. Serum uric acid, urea nitrogen and creatinine have increased significantly at $P< 0.05$ in diabetic group fed on basal diet, as compared to healthy group fed on the same diet. Serum uric acid, urea nitrogen and creatinine decreased significantly in all treated groups, as compared to control positive group. Using the high levels of catechin plus green tea showed the highest decrease in all investigated kidney functions; no statistically significant differences have been observed between these groups and control negative groups (healthy rats). These results are in agreement with a recent study reporting that the catechins present in green tea possess antioxidant potency and enable the kidney malfunctions resulting from diabetes to return to normal state (Jabber, 2013). This action may be due to its antioxidant properties. Green tea and catechin contains many antioxidant components, which have scavengering free radicals, especially superoxide anions and may thereby protect cells from oxidative stress. The use of antioxidants appears rational in the improvement of kidney diseases therapy (Graham, 1992). Antioxidant therapy has been well documented to help in the improvement of organ functions. The beneficial effect of green tea and catechin may be related to its antioxidant properties (Gomikawas *et al.,* 2008). All diabetic treated groups had much better kidney functions

than those of the non-treated groups. It may be due to the fact that the kidney of diabetic rats showed aggregation of inflammatory, neutrophil and monocytes around the blood vessels. While kidney of GT treated diabetic rats showed degeneration of the cells lining the kidney tubules, vaculation of glomerulus, and weak fatty degeneration in cells of kidney tubules (Jabber, 2013). Alloxan-induced diabetes caused increasing plasma levels of creatinine and urea. Alloxan produces oxygen radicals and oxidative stress in the body that could be helpful in this aspect (Halliwell and Gutteridge 1985).

4. Conclusion

This investigation showed that the continuous ingestion of green tea rich with catechins, especially in high amounts, reduces serum cholesterol levels, and blood glucose without the need for any lifestyle changes. Accordingly, the ingestion of a green tea extract rich with catechins might prevent or decrease the risk of cardiovascular disease and anti-diabetic. At the doses used in this study, green tea or catechin did not induce abnormal changes in hepatic and renal functions. In contrast, doses of green tea or catechin used in this study tended to improve both kidney and liver functions, especially at a high dose of catechin plus green tea.

References

Al-Khashaly DK. 1997. A Study on the mechanism of toxicity by an organochlorine insecticide "DDT". *PhD. Sci. thesis*. *College of Pharmacy/ University of Baghdad*.

Bursill C, Roach PD, Bottema CDK and Pal S. 2001. Green tea upregulates the low-density lipoprotein receptor through the sterol-regulated element binding protein in HepG2 Cells. *J Agric Food Chem.,* **49**: 5639-5645.

Cabrera C, Artacho R and Giménez R. 2006. Beneficial effects of green tea--a review. *J Am Coll Nutr* ., **25**:79–99.

Chantre P and Lairon D. 2002. Recent findings of green tea extract AR25 (Exolise) and its activity for the treatment of obesity. *Phytomedicine*, **9**:3-8.

Cohn J S, Mcnamara JR and Schaefer E J. 1988. Lipoprotein cholesterol concentrations in the plasma of human subjects as measured in the fed and fasted states. *Clin Chem.,* **34**: 2456-2459.

Foster L. B and Dumns RT. 1973. Stable reagents for determination of serum triglycerides by colorimetric condensation method. *Clin Chem Acta*, **19**: 338-340.

Friedwald WT, Levy RI and Fredrickson DS. 1972. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use the preparative ultracentrifuge. *Clin. Chem.*, **18**: 499-502.

Gomikawas S, Ishikawa Y, Hayase W, Haratake Y, Hirano N, Matuura H, Mizowaki A, Murakami A and Mao Y. 2008. Effect of Ground Green Tea Drinking for 2 Weeks on the Susceptibility of Plasma and LDL to the Oxidation ex vivo in Healthy Volunteers. *Kobe J Med Sci*, **54(1)**: E62-E72,

Graham HN. 1992. Green tea composition, consumption, and polyphenol chemistry. *Prev Med*., **21**:334-350.

Halliwell B and Gutteridge JMC. 1985. **Free Radicals in Biology and Medicine**,Clarendon press, Oxford, London, 22-35.

Hiroshi T, Mitsuyo I, Miki T, Jin-Bin W, Toshiyasu S and Ikuko K. 2004. Effect of green tea on blood glucose levels and serum proteomic patterns in diabetic (db/db) mice and on glucose metabolism in healthy humans. *BMC Pharmacol.*, **4(18):** 401-410.

Hongqiang W, Yibo W, Yaping D, Xiuyuan Y, Hongwei G, Jane A., Niels B, Eva M. and David J, 2010. Effects of catechin enriched green tea on body composition.*Obesity*, **18**: 773–779.

Ikeda I. 2008. Multifunctional effects of green tea catechins on prevention of the metabolic syndrome. *Asia Pac J Clin Nutr*; **17 (S1):**273-274

Ikeda I, Tsuda K, Suzuki Y, Kobayashi M, Unno T, Tomoyori H, Goto H, Kawata Y, Imaizumi K, Nozawa A, Kakuda T. 2005. Tea catechins with a galloyl moiety suppress postprandial hypertriacylglycerolemia by delaying lymphatic transport of dietary fat in rats. *J Nutr*.,**135**:155-159.

Jabber HY. 2013. Effect of green tea extract on histological structure of kidney, pancreas and adrenal gland in alloxan-induced diabetic male albino rats. *J Al-Nahrain University* **16 (1):**156-165.

Kajimoto O, Kajimoto Y, Yabune M, Nozawa A, Nagata K and Kakuda T. 2003. Tea catechins reduce serum cholesterol levels in mild and borderline hypercholesterolemia patients. *J Clin Biochem Nutr*., **33**:101-11.

Lin JC, Chan P, Hsu FL, Chen YJ, Hsieh MH, Lo MY and Lin JY. 2002. The *in vitro* inhibitory effects of crude extracts of traditional Chinese herbs on 3-hydroxy-3-methylylutaryl-coenzyme A reductase on Vero cells. *Am J Chin Med.,* **30**: 629-636.

Loest HB, Noh SK and Koo SI. 2002. Green tea extract inhibits the lymphatic absorption of cholesterol and α-tochopherol in ovariectomized rat. *J Nutr*., **132**: 1282-1288.

Maron DJ, Lu GP, Cai NS, Wu ZG, Li YH, Chen H, Zhu JQ, Jin XJ, Wouters BC and Zhao J. 2003. Cholesterol -lowering effect of a theaflavin-enriched green tea extract. randomized controlled trial. *Arch Intern Med.*, **163**: 1448-1453.

Muramatsu K, Fukuyo M and Hara Y. 1986. Effect of green tea catechin on plasma cholesterol levels in cholesterol-fed rats. *J Nutr Sci Vitaminol*, **32:** 613-622.

Park JH, Jin JY, Baek WK, Park SH, Sung HY, Kim YK, Lee J and Song DK. 2009. Ambivalent role of gallated catechins in glucose tolerance humans: A novel insight into non-absorbable gallated catechin-derived inhibitors of glucose absorption. *J Physiol Pharmacol*., **60 (4):** 101-109.

Reeves PG 1997. Components of the AIN-93 diets as improvements in the AIN-76A diet. *J Nutr.*, **127**:838S-841S.

Suzuki T, Takagi A and Takahashi M. 2012. Catechin-rich green tea extract increases serum cholesterol levels in normal diet- and high fat diet-fed rats; *BMC Proceedings*, **6(Suppl 3):**P47

YeeW, Wang Q, Agdinaoay T, Dang K, Chang H, Grandinetti A, Franke AA and Theriault, A. 2002. Green tea catechins decrease apolipoprotein B-100 secretion from HepG2 cells. *Mol Cell Biochem.*, **229:** 85-92.

Young D S and Friedman RB. 2001. **Effects of Disease on Clinical Labratory Tests**, 4th ed, Washington, AACC Press.

Wolfram S, Wang Y and Thielecke F. 2006. Anti-obesity effects of green tea: from bedside to bench. *Mol Nutr Food Res.*,**50**:176–187.