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Effects of parsley (*Petroselinum crispum*) extract versus glibornuride on the liver of streptozotocin-induced diabetic rats

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Abstract

Parsley (*Petroselinum crispum*) is one of the medicinal herbs used by diabetics in Turkey. The aim of this study is to investigate the effects of parsley (2 g/kg) and glibornuride (5 mg/kg) on the liver tissue of streptozotocin-induced diabetic rats. Swiss albino rats were divided into six groups: control; control + parsley; control + glibornuride; diabetic; diabetic + parsley; diabetic + glibornuride. Diabetes was induced by intraperitoneal injection of 65 mg/kg streptozotocin (STZ). Parsley extract and glibornuride were given daily to both diabetic and control rats separately, until the end of the experiment, at day 42. The drugs were administered to one diabetic and one control group from days 14 to 42. On day 42, liver tissues were taken from each rat. In STZ-diabetic group, blood glucose levels, serum alkaline phosphatase activity, uric acid, sialic acid, sodium and potassium levels, liver lipid peroxidation (LPO), and non-enzymatic glycosylation (NEG) levels increased, while liver glutathione (GSH) levels and body weight decreased. In the diabetic group given parsley, blood glucose, serum alkaline phosphatase activity, sialic acid, uric acid, potassium and sodium levels, and liver LPO and NEG levels decreased, but GSH levels increased. The diabetic group, given glibornuride, blood glucose, serum alkaline phosphatase activity, serum sialic acid, uric acid, potassium, and liver NEG levels decreased, but liver LPO, GSH, serum sodium levels, and body weight increased. It was concluded that probably, due to its antioxidant property, parsley extract has a protective effect comparable to glibornuride against hepatotoxicity caused by diabetes.

Keywords: Parsley; Glibornuride; Streptozotocin; Liver; Serum

1. Introduction

Diabetes mellitus is a major endocrine disorder, affecting nearly 10% of the population all over the world. In spite of the introduction of hypoglycemic agents, diabetes and the related complications continue to be a major medical problem (Nammi et al., 2003). Diabetes is associated with the generation of reactive oxygen species (ROS), causing oxidative damage particularly to various tissues (Mohamed et al., 1999). Glucose level was found to increase the production of free radicals, as determined by cell damage markers, such as malonaldehyde and conjugated dienes (Cuncio et al., 1995). Hyperglycemia can cause oxidative stress, which, in turn, may result in cellular tissue damage. The harmful influence of diabetes on metabolism of tissues and organs is well known. Likewise, uncontrolled hyperglycemia can lead to disturbances in the structure and functions of organs (Gupta et al., 2004). Insulin and oral hypoglycemic agent are the main ways to treat diabetes mellitus and are effective in controlling hyperglycemia, but these kinds of drugs also have prominent side effects. The main reason to look for new antidiabetic agents is the fact that currently many

Abbreviations: ALP, alkaline phosphatase; ANOVA, analysis of variance; GSH, glutathione; LPO, lipid peroxidation; MDA, malondialdehyde; NEG, non-enzymatic glycosylation; ROS, reactive oxygen species; STZ, streptozotocin; TBARS, thiobarbituric acid-reactive substances; WHO, World Health Organization

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patients are poorly controlled, resulting in the development of long-term macrovascular and microvascular complications. Plants have always been utilizable sources of drug and many of the currently available drugs have been directly or indirectly obtained from plants. In accordance to the recommendations of the WHO Expert Committee on Diabetes Mellitus, it seems important to investigate the hypoglycemic agents from plant origin, which were used in traditional medicine (Alarcon-Aguilera et al., 1998). Parsley (*Petroselinum crispum*) is a member of the Umbelliferae family that has been employed in the food, pharmaceutical, perfume, and cosmetic industries (Lopez et al., 1999). Parsley is widely distributed in Turkey and this plant is grown in gardens and fields. As a traditional medicine for diabetes, parsley has been used in Turkey (Yanardag et al., 2003a) and the world (Noel et al., 1997). Parsley is used as a hypoglycemic agent by diabetic patients in Turkey. In folk medicine, parsley is used to treat a wide variety of conditions (Yanardag et al., 2003a). Parsley seeds have a strong diuretic activity due to its high essential oil content (Darias et al., 2001). The hypoglycemic activity of parsley has been investigated in many studies (Yanardag and Ozsoy, 2000). Phytochemical screening of parsley has revealed the presence of flavonoids (apiin, luteolin, and apigenin-glycosides) (Fejes et al., 2000), carotenoids (Francis and Isaksen, 1989), ascorbic acid (Davey et al., 1996), tocopherol (Fiad and El Hamidi, 1993), volatile compounds (myristicin, apiole), coumarines (bergapten, imperatorin) (Fejes et al., 2000), phthalides, furanocoumarins, and sesquiterpenes (Spraul et al., 1991). Glibornuride is a sulphonylurea derivative, which has been used as a hypoglycemic agent in diabetes mellitus (Logie and Stowers, 1975). The main action of sulphonylureas is stimulation of insulin secretion, although extra-pancreatic effects may contribute. This drug, when given orally, is rapidly and almost completely (98%) absorbed from intestines and is highly but reversibly protein-bound (95%) in the circulation. It is non-toxic, safe and effective in the treatment of maturity onset diabetes (Logie and Stowers, 1975).

The purpose of this study was to investigate the biochemical effects of administration of parsley extract and glibornuride on the liver of normal and STZ-induced diabetic rats.

2. Materials and methods

2.1. Plant material

Parsley leaves were collected from Buyukçekmece, Istanbul (Turkey), and carefully washed with tap water and left to dry in the dark at room temperature. They were stored in well-closed cellophane bags.

2.2. Preparation of aqueous plant extract

The air-dried leaves (100 g) were extracted by adding 1000 mL of distilled water and boiled for 30 min. The extract was then filtered, and the filtrates were evaporated, using a rotary evaporator under reduced pressure to dryness. The extract was dissolved in distilled water before the administration to normal and STZ-diabetic rats.

Table 1
Diet composition

Ingredients	%
Wheat	10
Corn	22
Barley	15
Wheat bran	8
Soybean	26
Fish flour	8
Meat-bone flour	4
Pelted	5
Salt	0.8
Vitamin mineral mix	0.2

2.3. Administration of parsley extract and glibornuride

Fourteen days after the experimental animals were rendered STZ-diabetic, the parsley extract was given by gavage technique to rats at a dose 2 g/kg, to one of the diabetic groups and also one of the control groups, daily for 28 days. Fourteen days after the experimental animals were made diabetic, 5 mg/kg body weight glibornuride (Roche, Turkey) dissolved in distilled water was given by gavage method, to one of the diabetic groups and also one of the control groups, daily for 28 days.

2.4. Preparation of diabetic rats

Diabetes was induced by intraperitoneal of STZ in a single dose of 65 mg/kg body weight. STZ was dissolved in a freshly prepared 0.01 M citrate buffer (pH 4.5).

2.5. Animals

The experiments were reviewed and approved by the Institute's Animal Care and Use Committee of Istanbul University; 6–6.5-month-old male Swiss Albino rats, weighing 150–200 g, were used. The animals were fed laboratory pellet chows (Table 1) and given water ad libitum. All rats were clinically healthy. The animals were divided into six groups—Group I: untreated, non-diabetic animals; Group II: control animals given parsley extract; Group III: control animals given glibornuride; Group IV: diabetic animals; Group V: diabetic animals given parsley extract; Group VI: diabetic animals given glibornuride.

2.6. Biochemical assays

In this study, biochemical investigations were made in blood, serum and liver tissue. Blood samples from rats were collected from the tail vein at days 0, 14, and 42. Fasting blood glucose levels (after 18 h period of fasting) were determined by *o*-toluidine methods (Relander and Raiha, 1963).

At day 42, serum ALP activity was estimated by two-point (Walter and Schütt, 1974) methods. ALP catalyzes the hydrolysis of *p*-nitro phenyl-phosphate forming phosphate and free *p*-nitrophenol, which are colorless in dilute acid solutions. Under alkaline conditions, this is converted to the nitrophenolate ion, which assumes a quinoid structure with a very intense yellow

color. The reaction is permitted to proceed for exactly 30 min and is then stopped by adding sodium hydroxide, which inactivates the enzyme and at the same time dilutes the nitrophenolate color, which is measured by its absorbance at 405 nm.

Total serum sialic acid levels were estimated by Warren's method with slight modifications (Lorentz et al., 1986). Prior to determination, serum was incubated at 80 °C for 1 h in sulfuric acid in order to liberate to bind sialic acid. After various procedures, cyclohexanone was added and then shaken. The absorbance of the cyclohexanone layer was measured at 546 nm.

Serum uric acid levels were determined by Caraway method (Caraway, 1955). In alkaline solution, uric acid reduces a complex phosphotungstate with the production of a blue color, which is photometrically measured at 710 nm.

Sodium and potassium levels were assayed in serum by flame photometry (Helrich, 1990).

At the end of the experimental period, liver tissues were taken from animals, sacrificed under ether anesthesia, after an overnight fast. For biochemical analyses, liver tissue samples were washed with physiological saline and kept frozen until the day of experiment. Livers were homogenized in cold 0.9% NaCl with a glass homogenizer to make up to 10% homogenate (w/v). The homogenates were centrifuged, and the clear supernatants were used for protein, glutathione (GSH), and non-enzymatic glycosylation (NEG), and lipid peroxidation (LPO).

Reduced glutathione was determined according to Beutler's method (1975) using Ellman's reagent. The procedure is based on the reduction of Ellman's reagent by SH groups to form 5,5′-dithiobis (2-nitrobenzoic acid) with an intense yellow color, measured spectrophotometrically at 412 nm using a Shimadzu Spectrophotometer. Results were expressed as nmol GSH/mg protein.

NEG levels were determined by thiobarbituric acid method (Parker et al., 1981). The glucose moiety of glycosylated hemoglobin is converted to 5-hydroxymethylfurfural by heating with oxalic acid. The adduct formed by reacting 2-thiobarbituric acid with hydroxymethylfurfural is measured photometrically and results are expressed as nmol fructose/mg protein.

LPO levels in liver homogenates were estimated by Ledwozyw's method (Ledwozyw et al., 1986). In brief, the adduct formed, following boiled tissue homogenate with thiobarbituric acid, is extracted with *n*-butanol. The difference in optical density at 532 nm is measured in terms of the liver malondialdehyde (MDA) content, also of TBARS, which is undertaken as an index of lipid peroxidation. Results were expressed as nmol MDA/mg protein.

The protein content in the supernatant was estimated by Lowry's method using bovine serum albumin as standard (Lowry et al., 1951).

2.7. Statistical analysis

All the grouped data were statistically evaluated with SPSS/10 software. All data are expressed as mean ± S.D. Variance analysis was used for comparison of the group. Using a post hoc multiple comparison test, one-way ANOVA was applied to find the difference between the groups. Dunnett's and Tukey's multiple range tests were used to find the significant difference among means. Results are considered significantly different at the level of $P < 0.05$.

3. Results

The mean body weights of the groups are given in Table 2. Body weight was significantly lower in rats with STZ-diabetes than in the control group during the experiment (Table 2). Administration of glibornuride for 28 days caused an increase in body weights in the diabetic groups. In diabetic + parsley group, body weight did not change significantly.

Mean blood glucose levels of the groups are given in Table 3. Prior to induction of diabetes, the blood glucose levels of all groups were similar ($P_{ANOVA} = 0.528$). Fourteen days after administration of STZ, the diabetic, diabetic + parsley, diabetic + glibornuride groups had significantly higher blood

Table 2
Mean levels of body weight for all groups

Groups	*n*	Body weight (g)
Control	15	259.03 ± 22.54
Control + parsley	20	257.42 ± 35.17
Control + glibornuride	13	237.66 ± 46.92
Diabetic	20	190.10 ± 31.87[a]
Diabetic + parsley	20	189.54 ± 31.19
Diabetic + glibornuride	14	219.07 ± 45.43
P_{ANOVA}		0.0001

n = number of animals. Values are mean ± S.D.
[a] $P < 0.0001$ vs. control group.

Table 3
Mean levels of blood glucose for all groups (mg/dL)

Groups	*n*	Day 0	Day 14	Day 42
Control	15	71.49 ± 17.71	77.20 ± 15.29	73.85 ± 11.96
Control + parsley	20	66.13 ± 22.94	75.05 ± 17.30	66.66 ± 10.16
Control + glibornuride	13	70.10 ± 6.39	87.41 ± 15.37	70.58 ± 24.93
Diabetic	20	71.05 ± 21.06	181.02 ± 57.67[a]	158.08 ± 85.11[a]
Diabetic + parsley	20	63.24 ± 14.30	167.29 ± 49.25	110.89 ± 45.15
Diabetic + glibornuride	14	64.72 ± 14.11	178.93 ± 45.16	125.95 ± 37.46
P_{ANOVA}		0.528	0.0001	0.0001

n = number of animals. Values are mean ± S.D.
[a] $P < 0.0001$ vs. control group.

Table 4
Mean levels of serum ALP activities for all groups

Groups	n	ALP (U/L)
Control	15	77.35 ± 28.29
Control + parsley	20	50.42 ± 16.37
Control + glibornuride	13	54.62 ± 22.55
Diabetic	20	282.63 ± 74.43[a]
Diabetic + parsley	20	171.65 ± 50.24[b]
Diabetic + glibornuride	14	158.15 ± 76.91[b]
P_{ANOVA}		0.0001

n = number of animals. Values are mean ± S.D.
[a] $P < 0.0001$ vs. control group.
[b] $P < 0.0001$ vs. diabetic group.

Table 5
Mean levels of serum sialic acid and uric acid for all groups

Groups	n	Sialic acid (mmol/L)	Uric acid (mg/dL)
Control	15	5.86 ± 0.78	2.30 ± 0.32
Control + parsley	20	6.93 ± 1.10	2.30 ± 0.36
Control + glibornuride	13	2.29 ± 0.56[a]	2.48 ± 0.34
Diabetic	20	8.20 ± 0.74[a]	2.67 ± 0.19
Diabetic + parsley	20	5.67 ± 0.91[b]	2.31 ± 0.49
Diabetic + glibornuride	14	2.03 ± 0.18[b]	2.64 ± 0.40
P_{ANOVA}		0.0001	0.164

n = number of animals. Values are mean ± S.D.
[a] $P < 0.0001$ vs. control group.
[b] $P < 0.0001$ vs. diabetic group.

glucose levels than on day 0. At day 42, blood glucose levels were still high in the diabetic animals, but in the diabetic + parsley and diabetic + glibornuride group, it decreased 33.71 and 29.61%, respectively. The control, control + parsley, control + glibornuride rats did not show any significant variation in the blood glucose throughout the experimental period (Table 3).

The changes in serum ALP activities at 42 day are given in Table 4. There was a significant difference in the serum ALP activities between groups (Table 4). A remarkable increase was observed in the values for the diabetic groups ($P_{ANOVA} = 0.0001$). The ALP activities in the diabetic + parsley, diabetic + glibornuride exhibited a notable decrease compared to the diabetic group ($^{b}P < 0.0001$) (Table 4).

The serum sialic and uric acid levels in the STZ treated and non-diabetic control groups are shown in Table 5. In the diabetic rats, a significant increase in serum sialic acid levels was observed. Treatment with parsley extract and glibornuride for 28 day decreased the serum sialic acid levels in diabetic rats considerably (Table 5) ($^{b}P < 0.0001$). In the diabetic rats, an increase in serum uric acid levels was observed. Treatment with parsley extract and glibornuride for 28 days decreased the serum uric acid levels in diabetic rats. Parsley extract was more effective than glibornuride (Table 5).

The serum sodium and potasium levels in the STZ-diabetic rats and non-diabetic control groups are shown in Table 6. In the STZ-diabetic groups, a significant increase in serum sodium and potassium levels was observed. Treatment with parsley extract and glibornuride for 28 days, decreased the serum sodium and potassium levels in STZ-diabetic rats insignificantly (Table 6).

Table 6
Mean levels of serum sodium and potassium for all groups

Groups	n	Sodium (mEq/L)	Potassium (mEq/L)
Control	15	150.48 ± 6.72	4.82 ± 0.74
Control + parsley	20	145.85 ± 9.54	4.99 ± 0.65
Control + glibornuride	13	164.00 ± 4.66[a]	4.79 ± 0.48
Diabetic	20	155.66 ± 3.81	5.49 ± 0.54
Diabetic + parsley	20	152.70 ± 7.80	5.36 ± 0.42
Diabetic + glibornuride	14	155.88 ± 5.48	5.38 ± 0.54
P_{ANOVA}		0.0001	0.010

n = number of animals. Values are mean ± S.D.
[a] $P < 0.001$ vs. control group.

Table 7 shows the effects of parsley and glibornuride on liver GSH, NEG, and LPO. The glutathione levels were significantly reduced in the diabetic animals, as compared to the other groups ($P_{ANOVA} = 0.0001$). In the diabetic rats treated with parsley extract, the liver GSH levels significantly increased when compared to the untreated diabetic rats ($^{b}P < 0.0001$). Administration of glibornuride for 28 days significantly increased the liver GSH levels in diabetic rats ($^{c}P < 0.001$). Parsley extract was again more effective than glibornuride. In the diabetic rats, NEG values were significantly increased in comparison to control rats ($^{a}P < 0.0001$). Compared to the diabetic groups, NEG

Table 7
Mean levels of liver GSH, NEG and LPO for all groups

Groups	n	GSH (nmol GSH/mg protein)	NEG (nmol fructose/mg protein)	LPO (nmol MDA/mg protein)
Control	15	11.71 ± 0.58	16.76 ± 1.68	0.88 ± 0.08
Control + parsley	20	7.99 ± 0.65	18.49 ± 0.50	0.62 ± 0.08
Control + glibornuride	13	12.93 ± 0.35	17.42 ± 0.62	0.78 ± 0.06
Diabetic	20	6.25 ± 0.92[a]	53.63 ± 2.74[a]	0.95 ± 0.05
Diabetic + parsley	20	10.15 ± 0.76[b]	39.49 ± 1.33[b]	0.92 ± 0.07
Diabetic + glibornuride	14	8.25 ± 0.53[c]	27.99 ± 2.88[b]	1.08 ± 0.09[d]
P_{ANOVA}		0.0001	0.0001	0.0001

n = number of animals. Values are mean ± S.D.
[a] $P < 0.0001$ vs. control group.
[b] $P < 0.0001$ vs. diabetic group.
[c] $P < 0.001$ vs. diabetic group.
[d] $P < 0.086$ vs. diabetic group.

values were decreased in groups given parsley extract and glibornuride, respectively ($^{b}P < 0.0001$) (Table 7).

The concentration of malondialdehyde, a terminal compound of lipid peroxidation, are commonly used as an index of oxidative injury induced by oxygen-free radicals. STZ administration resulted in an elevation of hepatic LPO. Upon administration of parsley extract, the liver LPO levels decreased when compared to the untreated diabetic rats. However, administration of glibornuride for 28 days, insignificantly increased the liver LPO levels in diabetic rats ($^{d}P < 0.086$) (Table 7).

4. Discussion

Traditionally, plant medicines are used throughout the world for a range of diabetic complications. Plant drugs are frequently considered to be less toxic and free of side effects than synthetic ones (Ozsoy-Sacan et al., 2004). The study of such medicines might offer a natural key to unlock a diabetologist's pharmacy for the future. In our previous study, parsley showed a hypoglycemic effect on diabetic rabbits (Yanardag and Ozsoy, 2000). The observed significant increase in the level of blood glucose in STZ-induced diabetic rats could be due to the destruction of pancreatic β cells by streptozotocin. In another study, in which pancreas was examined by light and electron microscopies, we noted that parsley extract did not increase insulin release from β cells of pancreas, but it decreased blood glucose levels by facilitating glucose usage via extra-pancreatic ways (Yanardag et al., 2003a).

In our study, diabetic rats showed a significant decrease in body weight compared to control rats. Decreased body weight observed in diabetic rats is due to excessive breakdown of tissue proteins (Ravi et al., 2004). These results are in accordance with results previously reported after streptozotocin treatment of diabetic rats (Yanardag et al., 2003a). In our study, administration of glibornuride for 28 days caused an increase in body weights in the diabetic groups. In diabetic + parsley group, body weight did not change significantly. This may be a result of the diuretic effect of parsley (Darias et al., 2001).

Liver is the most important organ in the metabolism of drugs and other substances. Liver cell destruction shows its effects mostly as impairment in the liver cell membrane permeability, which results in the leaking out of tissue contents into the blood stream. In STZ-diabetic rats, the activity of serum ALP was significantly increased by relative 265.39% to their normal levels (Table 4). Supporting our findings, it has been found that the liver was necrotized in STZ-diabetic rats. Therefore, the increase of the activity of ALP in serum is mainly due to the leakage of these enzymes from the liver cytosol into the blood stream (Mansour et al., 2002), which gives an indication on the hepatotoxic effect of streptozotocin. On the other hand, the administration of parsley extract and glibornuride to STZ-diabetic rats reduced ALP activity towards its normal values. In turn, parsley extract was more effective than glibornuride. The increase in ALP activity in serum is an indicator of liver destruction. In our study, serum ALP activity was controlled by parsley treatment. The decrease in ALP activity in STZ-diabetic rats given parsley extract shows that parsley presented liver damage.

Sialic acid is a terminal component of the non-reducing end of carbohydrate chains of glycoproteins and glycolipids, which are essential constituents of many hormones and enzymes present in serum and tissues. Serum sialic acid is almost completely bound to glycoproteins and lipids. Total sialic acid in the serum has received considerable attention as a possible marker for cardiovascular disease and mortality (Mohamed et al., 2004). In diabetes mellitus, the serum concentration of serum sialic acid was found to increase significantly (Gavella et al., 2003). In our diabetic rats, a significant increase in serum total sialic acid levels was observed when compared with the control group. Various factors might cause an elevation in the concentration of serum sialic acid. Among these factors, the first is an increase in the synthesis of sialic acid in insulin-independent tissues, such as the liver and the brain, and the second is an increase in the activity of sialytransferase, which transfers the sialic acid residues to the glycolipids and glycoproteins. In our study, administration of parsley extract and glibornuride decreased the content of sialic acid in serum of STZ-diabetic rats. The inhibitor action of parsley and glibornuride on serum sialic acid level increases in STZ-treated rats was associated with a marked fall in hyperglycemia.

Several studies have shown elevated levels of uric acid, potassium, and sodium in serum of diabetic rats (Karam et al., 2004; Nagahama et al., 2004). In our study, serum uric acid, sodium, and potassium level increased, but serum uric acid sodium and potassium levels decreased in the groups given parsley extract and glibornuride; GSH acts as an antioxidant, functions as free radical scavenger and in the repair of radically caused biological damage (Ananthan et al., 2004), and its level reduced in diabetes mellitus (Latha and Pari, 2003). During diabetes, we also observed a significant decrease in GSH levels in liver tissue. The decrease in GSH levels represents increased utilization due to oxidative stress (Venkateswaran and Pari, 2003). Administration of parsley extract and glibornuride increased the content of GSH in livers of diabetic rats. The elevated level of GSH protects cellular proteins against oxidation through the glutathione redox cycle and also directly detoxifies reactive oxygen species generated from exposure to STZ (Latha and Pari, 2003).

Carbohydrates appear to play a central role in the development of chronic diabetic complications. Indeed, glucose and other reducing sugars participate in one of the major pathogenic mechanisms, i.e., glycation. Along with oxidative stress, protein glycation is one of the major pathogenic mechanisms leading to non-enzymatic formation of advanced glycation end products (Sailaja et al., 2004). In addition to this, enzymatic glycation results in the formation of glycoproteins and glycolipids. Non-enzymatic glycosylation of proteins in tissues is correlated to the increase in blood glucose levels; in this way, the increase in NEG of liver proteins is also a well-known marker of diabetic damage (Can et al., 2004). In this study, the increase in liver tissue NEG levels provoked by diabetes was considerably lowered by parsley extract and glibornuride (Table 7).

The liver damage caused by diabetes is probably due to lipid peroxidation subsequent to free radical production. Several studies have shown increased lipid peroxidation in clinical and experimental diabetes. The results show increased lipid peroxidation

in tissues of the diabetic group. The increase in oxygen-free radicals in diabetes could be due to an increase in levels of blood glucose, which generates free radicals upon autoxidation. STZ has been shown to produce oxygen-free radicals. Lipid peroxide-mediated tissue damages have been observed in the development of types I and II diabetes mellitus. Previous studies have reported that there was an increased lipid peroxidation in liver (Can et al., 2004), kidney (Yanardag et al., 2003b), skin, lenses (Yarat et al., 2001), heart, and aorta (Sener et al., 2003) of diabetic rats. Our study showed that administration of parsley extract tends to bring the liver peroxides back to near normal levels. This indicates that parsley extract may inhibit oxidative damage of hepatic tissue. Antioxidant effects have been reported for some plants that contain flavonoids, phenolic compounds, ascorbic acid, and tocopherol (Andallu and Varadacharyulu, 2003). Phytochemical results showed that parsley extracts are rich in flavonoids (Fejes et al., 2000), phenolic compounds (Duthie, 1999), ascorbic acid (Davey et al., 1996), and tocopherol (Fiad and El Hamidi, 1993). It is possible that the antioxidant effect is related to this component.

As a result, it may be concluded that, probably due to its antioxidant effects, parsley extract is more effective in comparison to glibornuride in the protection of liver tissue from the damage of STZ-induced diabetic rats and that the parsley extract may be of use as a hypoglycemic agent.

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