Protective effect of *Panax ginseng* on carbon tetrachloride induced liver, heart and kidney injury in rats

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SUMMARY

*Panax ginseng* is a Chinese medicinal herb whose antioxidant properties would attenuate the intensity of the oxidative stress often involved in the pathogenesis of various diseases. The objective of the present study is to investigate its potential protective effects on CCl₄ toxicity in rats. Four equal groups (n = 10) of adult Wistar albino rats were randomly constituted: group C (healthy controls), group G (rats were orally treated with *Panax ginseng* (300 mg/kg) for 7 days), group CCl₄ (rats received a single intra-peritoneous CCl₄ injection (10 mL/kg)) and group G + CCl₄ (animals were supplemented with *Panax ginseng* before CCl₄ administration). Mortality and body weight variations were monitored on days 7 and 8 (sacrifice day) while MDA, NO and GSH contents, SOD and GPX activities were measured in liver, heart and kidney and classical histological examination of liver was performed. CCl₄ induced a severe oxidative stress in liver, heart and kidney characterized by strong increases of tissue MDA and NO contents and by marked decreases of GSH concentrations and antioxidant enzyme activities. The high mortality rate and the intense cell degenerescence and fibrosis in liver corroborated the CCl₄ toxicity. By contrast, *Panax ginseng* elicited protective effects evidenced by decreases of tissue concentrations of oxidative stress markers and the reduction of CCl₄-induced antioxidant depletion and by histological attenuation of CCl₄-induced liver injury. These results showed the beneficial antioxidant effects of *Panax ginseng* on experimentally induced oxidative stress in rats.

Keywords: *Panax ginseng*, CCl₄, oxidative stress, liver, heart, kidney, rat.

RÉSUMÉ

Effets protecteurs du *Panax ginseng* sur les lésions hépatiques, cardiaques et rénales induites par le tétrachlorure de carbone chez le rat

Le *Panax ginseng* est une herbe médicinale chinoise dont les propriétés anti-oxydantes seraient susceptibles de limiter l’intensité du stress oxydatif très souvent impliqué dans la pathogénie de nombreuses affections. L’objectif de cette étude a été d’en vérifier les effets protecteurs chez le rat lors d’une intoxication par le CCl₄. Pour cela, 4 groupes égaux de 10 rats Wistar albinos adultes ont été constitués: un groupe contrôle, un groupe de rats traités oralement par le *Panax ginseng* avant l’injection de CCl₄ (groupe G + CCl₄). La mortalité et les variations de poids corporels ont été enregistrées à J7 et J8 (jour du sacrifice) et les quantités de MDA, de NO et de GSH ainsi que les activités de la SOD et de la GPX ont été mesurées dans le foie, le cœur et les reins. Une analyse histologique conventionnelle du foie a été réalisée en parallèle. Le CCl₄ a induit un stress oxydatif sévère dans ces tissus caractérisé par une forte augmentation des teneurs tissulaires en MDA et NO et par une importante diminution des teneurs en GSH et des activités enzymatiques anti-oxydantes. La mortalité élevée et les lésions hépatiques de dégénérescence cellulaire et de fibrose ont également révélé la toxicité du CCl₄. En revanche, le traitement préalable des rats par le *Panax ginseng* a conduit à une protection partielle mise en évidence par une diminution des concentrations tissulaires de MDA et de NO, par une réduction de la déplétion en anti-oxydants induite par le CCl₄ et par une diminution de l’intensité des lésions histologiques. Ces résultats montrent que le *Panax ginseng* exerce des effets anti-oxydants bénéfiques lors d’une situation de stress oxydatif induite expérimentalement chez le rat.

Mots clés : *Panax ginseng*, CCl₄, stress oxydatif, foie, cœur, rein, rat.

Introduction

Various studies have demonstrated that CCl₄ causes free radical generation in many tissues such as liver, kidney, heart, lung, testis, brain and blood [7, 27]. Oxidative stress parameters observed in these tissues included defects in enzymatic antioxidant mechanisms and increases of thiobarbituric reactive substances concentrations [3].

Ginseng is an important herb of the Chinese traditional system of medicine. The extracts of ginseng have been found to possess cardioprotective, antiasthmatic, anti-diabetic and potent central nervous system activities including enhancement of memory, concentration, mental alertness and decrease of mental fatigue, besides other beneficial activities [8, 17]. It is well known that the ginseng antioxidiant properties are due to scavenge free radicals and to neutralize ferry ion-induced peroxidation [9] and some studies have shown that these antioxidant actions contribute to prevention and treatment of diseases associated with oxidative stress [10, 19]. These ginseng properties are thought to provide many beneficial effects against acute tissues damage. Therefore, the purpose of this study was to investigate the protective effect of ginseng on acute liver, heart and kidney damage induced by CCl₄ in rats.
Materials and Methods

ANIMALS AND EXPERIMENTAL DESIGN

Forty adult Wistar albino rats weighing about 200-250 g were used. The rats were housed in individual stainless steel cages (360 x 200 x 190 mm³) under standard laboratory conditions (light period 07.00 a.m. to 8.00 p.m., 21 ± 2 °C, relative humidity 55%), each cage containing 2 or 3 animals from 15 days before the start of the experiment. The animals were given standard rat pellets and tap water ad libitum and received humane care according to the criteria outlined in the Guide for the Care and Use of Laboratory Animals prepared by the National Academy of Sciences and published by the National Institute of Health [23]. All animals were provided by the Center of Experimental Research and Practice in Atatürk University, and the experiments were approved by the Ethical Committee of the Atatürk University.

Rats were divided into four equal groups (n = 10): the first group (group C) served as a control group and was injected intraperitoneally (i.p.) with physiological saline for 7 consecutive days, the second group (group CCl4) received a single i.p. dose of CCl4 (10 mL/kg), the third group (group G) received only Panax ginseng (300 mg/kg, purchased from local herbal store, Ankara, Turkey) for 7 consecutive days by the oral route using an orogastric tube and the fourth group (group G + CCl4) was orally treated by Panax ginseng (300 mg/kg) for 7 consecutive days prior to CCl4 intraperitoneal injection (10 mL/kg). The dose and duration for Panax ginseng treatment were chosen according to our previous study [31].

SAMPLE COLLECTION AND BIOCHEMICAL ASSAYS

Rats were anesthetized with intramuscular injection of ketamine (50 mg/kg) and xylazine (10 mg/kg) 24 h after the CCl4 administration, then liver, heart and kidney samples were removed and stored at -80°C until biochemical examination. All tissues were maintained at 4°C throughout preparation. A portion of each liver, kidney and heart tissues (1:9, w/v) for all assays were homogenized in 0.9% NaCl solution with an OMNI porticer homogenizer (Warrenton, VA, USA). Tissue homogenates were centrifuged for 15 min at 15,000 g, and then the clear upper supernatants were removed for analyses.

Determination of Glutathione peroxidase (GPX) activity

The GPX activity in tissues was measured by the method of PAGLIA and VALENTINE [25]. Briefly, sample (50 µL) was mixed with NADPH 8 mM (100 µL), reduced glutathione 150 mM (100 µL), glutathione reductase (30 units/mL, 20 µL), sodium azide solution 0.12 M (20 µL) and potassium phosphate buffer (50 mM, pH 7.0, 5 mM EDTA) (2.65 mL) and the tubes were incubated for 30 min at 37°C. The reaction was initiated with the addition of H2O2 solution 2 mM (100 µL), mixed rapidly by inversion, and the conversion of NADPH to NADP+ was measured spectrophotometrically for 5 min at 340 nm. The enzyme activity was expressed as units per g protein using an extinction coefficient for NADPH at 340 nm of 6.22x10^-6.

Determination of Superoxide dismutase (SOD) activity

The Cu, Zn-SOD activity in tissues was detected by the method of SUN et al. [32]. The assay reagent [0.3 mM xanthine, 0.6 mM Na2EDTA, 0.15 mM Nitro blue tetrazolium (NBT), 0.4 M Na2CO3, 1 g/L bovine serum albumin (BSA)] (2.45 mL) was combined with tissue homogenate (100 µL). Xanthine oxidase (50 µL, 167 U/L) was then added to initiate the reaction and the reduction of NBT by superoxide anion radicals, which are produced by the xanthine - xanthine oxidase system, was determined by measuring the absorbance at 560 nm. The Cu, Zn-SOD activity was expressed in units per mg protein, where 1 U is defined as that amount of enzyme causing half-maximal inhibition of the NBT reduction.

Determination of the reduced glutathione (GSH) tissue concentration

The tissue GSH concentrations were assessed according to the method of TIETZE [34] and ANDERSON [1]. Briefly, sample (100 µL) was placed into a 3 mL cuvette and 750 µL of 10 mM 5,5’-dithio-bis-2-nitrobenzoic acid (DTNB) solution (100 mM KH2PO4 plus 5 mM Na2EDTA, pH 7.5 and GSH reductase, 625 U/L) was added and incubated for 3 min at room temperature. After addition of NADPH (1.47 mM, 150 µL) rapidly mixed by inversion, the rate of the 5-thio-2-nitrobenzoic acid formation (proportional to the sum of reduced and oxidized glutathione) was measured spectrophotometrically for 2 min at 412 nm. The reference cuvette contained equal concentrations of DTNB and NADPH but no sample, and values were presented as µmol per gram protein.

Determination of NO tissue concentrations

The tissue NO contents were measured using the Griess reagent with the method of MOSHAGE et al. [21]. The totals of produced nitrite and nitrate were considered as indicators of tissue NO content. The Griess reagent consists of sulphanilamide and N-1-naphthylethylenediamine. In a first step, nitrates are converted to nitrites by nitrate reductase, and thereafter the Griess reagent addition allows the nitrite conversion into a deep purple azo-compound; the photometric measurement at 540 nm determines the nitrite concentration (sodium nitrate is used as a standard). Nitric Oxide amounts are expressed as µmol/g protein.

Determination of the malondialdehyde (MDA) tissue concentrations

The MDA levels in tissues were spectrophotometrically determined according to the method described by OHKAWA et al. [24]. A mixture of 8.1% sodium dodecyl sulphate, 20% acetic acid, 0.9% thiobarbituric acid was added to sample (200 µL), and distilled water was added to the mixture to bring the total volume up to 4 mL. This mixture was incubated at 95°C for 1 hour. After incubation, the tubes were left to cool under cold water and 1 mL distilled water plus 5 mL n-butanol/pyridine (15:1, v/v) was added, followed by mixing up. The samples were centrifuged at 4 000g for 10 min. The...
supernatants were removed and absorbances were measured with respect to a blank at 532 nm. The 1,1,3,3-tetraethoxypropane was used as the standard. The lipid peroxide contents were expressed as nmol/L MDA.

HISTOLOGICAL ANALYSIS

Small liver specimens were extracted, placed in formalin solution, and processed routinely by embedding in paraffin. Tissue sections (4-5 μm) were stained with haematoxylin-eosin and examined under light microscope (Olympus, Japan). An experienced histologist who was unaware of the treatment conditions made histological assessments. Changes in the histopathological parameters for liver tissue such as inflammation, necrosis and fibrosis were graded as follows: (-) showing no changes, and (+), (++), and (+++) indicating minimum, moderate and maximum changes, respectively.

STATISTICAL ANALYSIS

The data were expressed as means ± standard errors (SEM). Differences between group means were estimated using a one-way analysis of variance followed by Tukey’s test using the SPSS 12.0 for Windows. A p value of < 0.05 was considered to be significant.

Results

SURVIVAL RATES AND BODY WEIGHTS OF RATS

Mortality in all groups was recorded on each day since the first drug or vehicle administration. No death was recorded in controls and in rats treated by Panax ginseng alone whereas survival rates were reduced after the CCl₄ injection: one rat died in the group G + CCl₄ and 4 animals in the CCl₄ group (Table I).

No statistically significant difference of initial body weights and of body weights measured on day 7 was observed between groups (Table II). By contrast, rats treated with CCl₄ alone (group CCl₄) or in combination with Panax ginseng (group G + CCl₄) exhibited significantly lower final body weights than those of the 2 other groups (p < 0.05); the relative difference with the initial body weight remained depressed in these groups (2.68% in the CCl₄ group and 5.50% in the G + CCl₄ group) whereas it reached 12.73% in the G group and 13.95% in the C group.

MACROSCOPIC AND HISTOPATHOLOGICAL FINDINGS

None macroscopic lesion was detected in control rats and in rats treated with Panax ginseng alone. On the other hand, in rats receiving CCl₄ alone, transudation was noticed in the abdominal cavity and the liver appeared pale and hypertrophic. However, pre-treatment with Panax ginseng seemed to alleviate liver injury.

Whereas livers of controls and of rats treated with Panax ginseng alone showed normal histology (Figure 1A and 1B, Table III), those of animals treated with CCl₄ alone (Figure 1C, Table III) exhibited a severe degree of centrilobular and vacuolar degeneration, fatty infiltration and intense necrosis in all cases. When rats were prior treated with the medicinal herb, cellular degenerescence and necrotic lesions were attenuated (Figure 1D, Table III); the perilobular areas showed mild to moderate diffused vacuolar degeneration. Moreover, mild (+, 5 rats) to moderate (2+, 3 rats) hepatic regeneration was evidenced except for one animal in which only severe damage were recorded.
Rats treated with *Panax ginseng* alone (Table IV) exhibited comparable MDA and NO contents (considered as makers for oxidative stress) with controls in liver, heart and kidney. Furthermore, their antioxidant status appeared weakly improved as significant increased SOD activities compared to controls were observed in liver (p < 0.05), in heart (p < 0.01) and in kidney (p < 0.001), although the GSH concentrations in heart were slightly reduced (p < 0.001).

By contrast, tissue MDA and NO contents were markedly increased (p < 0.001) in liver, kidney and heart from rats receiving a single injection of CCl₄ compared to controls (Table IV). In parallel, GSH concentrations were significantly depressed in liver (p < 0.05) and in heart and kidney (p < 0.001) and antioxidant enzyme GPX and SOD activities were also dramatically reduced in the same organs in the CCl₄ group (for GPX: p < 0.001, for SOD: p < 0.05 in liver, p < 0.01 in heart and p < 0.001 in kidney) (Table IV).

**TABLE III:** Intensity of hepatic lesions observed in rats treated with physiological saline (group C), *Panax ginseng* (oral doses of 300 mg/kg for 7 consecutive days, group G), CCl₄ (10 mL/kg intraperitoneally, group CCl₄) and *Panax ginseng* + CCl₄ (*Panax ginseng*: oral doses of 300 mg/kg for 7 consecutive days then CCl₄, 10 mL/kg, intraperitoneally, group G + CCl₄). Light microscopy was used to evaluate inflammation, necrosis and fibrosis and was graded as follows: (-) showing no changes, and (+), (++), and (+++) indicating minimum, moderate and maximum changes, respectively.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Grade of hepatic lesions</th>
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<tbody>
<tr>
<td></td>
<td>- 1+ 2+ 3+</td>
</tr>
<tr>
<td>Group C (n = 10)</td>
<td>10 0 0 0</td>
</tr>
<tr>
<td>Group G (n = 10)</td>
<td>9 1 0 0</td>
</tr>
<tr>
<td>Group CCl₄ (n = 6)</td>
<td>0 0 1 5</td>
</tr>
<tr>
<td>Group G + CCl₄ (n = 9)</td>
<td>0 5 3 1</td>
</tr>
</tbody>
</table>

**BIOCHEMICAL RESULTS**

Rats treated with *Panax ginseng* alone (Table IV) exhibited comparable MDA and NO contents (considered as makers for oxidative stress) with controls in liver, heart and kidney. Furthermore, their antioxidant status appeared weakly improved as significant increased SOD activities compared to controls were observed in liver (p < 0.05), in heart (p < 0.01) and in kidney (p < 0.001), although the GSH concentrations in heart were slightly reduced (p < 0.001).
PROTECTIVE EFFECTS OF PANAX GINSENG ON CCL4 TOXICITY IN RATS

On the other hand, except for cardiac NO concentrations, the contents of lipid peroxidation markers (MDA and NO) in tissues were markedly reduced in rats orally pre-treated with Panax ginseng (group G + CCl4) compared to animals receiving CCl4 injection alone (p < 0.001). Besides, hepatic MDA and NO amounts and renal NO amounts became similar to those observed in controls. In the same way, significant increases of GSH concentrations and tissue GPX and SOD activities were recorded in the G + CCl4 group compared to the CCl4 group (in liver: p < 0.001 for GPX activity and p < 0.05 for SOD activity and GSH concentration; in heart: p < 0.001 for GPX activity and GSH concentration and p < 0.01 for SOD activity; in kidney: p < 0.001). Nevertheless, the GPX activities remained significantly depressed compared to controls (p < 0.001) as GSH concentrations in heart and in kidney (p < 0.001) whereas SOD activities in heart (p < 0.01) and in kidney (p < 0.001) became closely related to those of control rats.

**Discussion**

CCL4, a typical toxic agent, exerts its toxic effects by the generation of free radicals. By the activation of liver cytochromes P450, CCL4 generates methyltrichloride radicals (CCl3·), which immediately react with cell membrane [7]. They form covalent bonds with unsaturated fatty acids or take a hydrogen atom from the unsaturated fatty acids in membrane, leading to the production of chloroform and lipid radicals [12, 27]. These radicals initiate a chain of lipid peroxidation reactions by abstracting hydrogen from polyunsaturated fatty acids (PUFA). Peroxidation of lipids can dramatically change the properties of biological membranes, resulting in severe cell damage and consequently play a significant role in pathogenesis of diseases. Membrane lipid peroxidation induces cross linking in proteins throughout MDA genesis during PUFA degradation [36, 37].

**Table IV:** Lipid peroxidation and antioxidant enzyme activities in the heart, kidney and liver from rats treated with physiological saline (group C), Panax ginseng (oral doses of 300 mg/kg for 7 consecutive days, group G), CCl4 (10 mL/kg intraperitoneally, group CCl4) and Panax ginseng + CCl4 (Panax ginseng: oral doses of 300 mg/kg for 7 consecutive days then CCl4, 10 mL/kg, intraperitoneally, group G + CCl4).

<table>
<thead>
<tr>
<th>Biochemical parameters</th>
<th>Groups (control)</th>
<th>(Panax ginseng alone)</th>
<th>CCl4 (CCl4 alone)</th>
<th>(Panax ginseng + CCl4)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDA (nmol/ g protein)</td>
<td></td>
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<tr>
<td>Liver</td>
<td>0.36 ± 0.04a</td>
<td>0.42 ± 0.08a</td>
<td>0.59 ± 0.07b</td>
<td>0.48 ± 0.10a</td>
<td>&lt; 0.001</td>
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<tr>
<td>Heart</td>
<td>0.58 ± 0.05a</td>
<td>0.55 ± 0.07a</td>
<td>0.87 ± 0.10c</td>
<td>0.64 ± 0.06b</td>
<td>&lt; 0.001</td>
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<tr>
<td>Kidney</td>
<td>0.45 ± 0.03a</td>
<td>0.42 ± 0.04a</td>
<td>0.79 ± 0.05c</td>
<td>0.58 ± 0.06b</td>
<td>&lt; 0.001</td>
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<tr>
<td>GSH (µmol/ g protein)</td>
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<td></td>
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<tr>
<td>Liver</td>
<td>2.03 ± 0.17a</td>
<td>2.64 ± 0.15a</td>
<td>1.23 ± 0.12b</td>
<td>2.07 ± 0.19a</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Heart</td>
<td>1.88 ± 0.16a</td>
<td>1.55 ± 0.10b</td>
<td>1.25 ± 0.12c</td>
<td>1.37 ± 0.09c</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Kidney</td>
<td>1.73 ± 0.09a</td>
<td>1.64 ± 0.08a</td>
<td>1.03 ± 0.07c</td>
<td>1.27 ± 0.05b</td>
<td>&lt; 0.001</td>
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<tr>
<td>GPX (U/ g protein)</td>
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<tr>
<td>Liver</td>
<td>2.56 ± 0.43a</td>
<td>2.66 ± 0.25a</td>
<td>1.04 ± 0.35c</td>
<td>1.78 ± 0.55b</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Heart</td>
<td>2.15 ± 0.14a</td>
<td>2.05 ± 0.18a</td>
<td>1.42 ± 0.20c</td>
<td>1.75 ± 0.15b</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Kidney</td>
<td>2.20 ± 0.08a</td>
<td>2.25 ± 0.10a</td>
<td>1.24 ± 0.15c</td>
<td>1.88 ± 0.14b</td>
<td>&lt; 0.001</td>
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<tr>
<td>SOD (U/ g protein)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Liver</td>
<td>134.4 ± 34.8a</td>
<td>206.8 ± 40.8d</td>
<td>86.2 ± 35.5c</td>
<td>108.8 ± 38.5b</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Heart</td>
<td>115.0 ± 9.1a</td>
<td>144.2 ± 11.3c</td>
<td>86.3 ± 10.2b</td>
<td>99.8 ± 8.8a</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Kidney</td>
<td>102.3 ± 6.8a</td>
<td>126.2 ± 8.5c</td>
<td>76.2 ± 5.6b</td>
<td>99.8 ± 7.2a</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>NO (µmol/ g protein)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>0.38 ± 0.06a</td>
<td>0.42 ± 0.08a</td>
<td>0.58 ± 0.07b</td>
<td>0.47 ± 0.07a</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Heart</td>
<td>0.33 ± 0.08a</td>
<td>0.38 ± 0.10a</td>
<td>0.53 ± 0.07b</td>
<td>0.46 ± 0.09b</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Kidney</td>
<td>0.30 ± 0.05a</td>
<td>0.35 ± 0.04a</td>
<td>0.50 ± 0.08b</td>
<td>0.40 ± 0.06a</td>
<td>&lt; 0.001</td>
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</table>

Different superscripts a,b,c in the same line indicate significant difference.
Glutathione is an important intracellular reducing agent by protecting cells against free radicals, peroxides and other toxic compounds. GSH depletion and consequent organ injury can be induced by various conditions like acetaminophen or excessive alcohol consumption in liver, smoking in lung and intense physical activities in muscles [16]. RECKMAGE et al. [29] stated that GSH played a key role in the detoxification of the reactive toxic CCl4 metabolites and that liver necrosis was initiated when reserves of GSH were markedly depleted. The GPX, partially located within the cellular membrane, is a selenium metallo-enzyme that can remove hydrogen peroxide by converting reduced glutathione into its oxidized form. Glutathione peroxidase can also terminate the chain reaction of lipid peroxidation by removing lipid hydroperoxides from the cell membrane [20]. SOD is a scavenger of peroxide anion radicals, which could inhibit the lipid peroxidation initiation by free radicals [18]. In eukaryotic cells, the process of dismutation is catalyzed by two distinct enzymes: the Mn SOD is found in the matrix of mitochondria, whereas the Cu-Zn SOD occurs primarily in the cytosol. The pattern of the liver enzyme activities has been reported to vary during ontogeny and with aging and to be altered by heat and cold stress, and in vitamin E deficiency [28]. In this study, the SOD and GPX activities in liver, kidney and heart from CCl4 treated rats were dramatically decreased compared to the SOD and catalase genes [15]. Ginseng has a potent pro-oxidative effect by increasing NO [33]. Furthermore, ZHANG et al. [38] stated that ginseng administration exerted cellular protection and of tissue GSH concentrations were greatly attenuated by prior oral Panax ginseng administration. JEONG et al. [10] stated that ginseng ameliorated hepatic damage in CCl4-induced toxicity and KIM et al. [14] reported that ginseng has a potent protective action against CCl4-induced lipid peroxidation. Panax ginseng would exert these antioxidant effects by, in one way, inhibiting cytochrome-P450 associated monooxygenase activities as demonstrated by KIM et al. [14] and also by sparing the intracellular antioxidant systems in a first attempt throughout the supply of exogenous radical scavengers (phenolic acids, flavonoids and saponins). The antioxidant intracellular mechanisms would then in turn contribute to limit endogenous oxygen radical species production.

Furthermore, these biochemical observations are supported by histopathological examination of the rat livers in which CCl4 caused severe vacuolar degeneration and fibrosis, whereas Panax ginseng administration exerted cellular protection and promoted cell regeneration. These hepato-protective actions, combined with antioxidant activities, would synergistically act in preventing initiation and limiting development of hepatocellular diseases.

As a conclusion, this study demonstrated that CCl4 induces marked oxidative stress in rat heart, kidney and liver and that Panax ginseng is effective against CCl4-induced oxidative damage. The potential beneficial effects of this medicinal herb in the prevention and the treatment of hepatic, renal or cardiac injury would be investigated in further studies.

Acknowledgments

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References


