

Protective Effect of Heat-processed Ginseng (Sun Ginseng) in the Adenine-induced Renal Failure Rats

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The effect of orally administered sun ginseng (SG), which is a ginseng processed by steaming, was examined in adenine-induced chronic renal failure rat. SG significantly decreased both blood urea nitrogen and serum creatinine levels, indicating an improvement of renal function. Also, SG significantly increased the urinary excretion of both urea and creatinine. Furthermore it lowered the blood pressure, and inhibited adenine-induced kidney hypertrophy and edema. Based on these findings, SG may ameliorate chronic renal failures.

Keywords: *Panax ginseng*, Sun ginseng, Adenine-induced renal failure, Blood urea nitrogen, Creatinine

INTRODUCTION

Chronic renal disease (CRD) causes a progressive loss in renal function over a period of months. CRD is diagnosed as a result of screening of people known to be at risk of kidney problems, such as those with high blood pressure or diabetes and those with a blood relative with chronic renal disease [1]. CRD may also be identified when it leads to one of its recognized complications, such as anemia, pericarditis or cardiovascular disease.

The incidence and prevalence of CRD have been increasing, whereas the outcomes are poor and the cost of treatment is high [2]. There is, therefore, an obvious need for alternative approaches that would reduce the cost of dialysis, drug therapy and renal transplantations [3]. One such approach is the use of oral sorbents, and the literature is replete with publications on the impact of

nutrition on kidney disease [4-7]. Recently, an alternative approach has recently been suggested by herb medicines such as Rhubarb [8,9].

Ginseng (the root of *Panax ginseng* Meyer, family Araliaceae) has been frequently used in Asian countries for cancer, inflammation, stress, etc [10]. To alter or enhance the pharmacological activities of ginseng, steaming and heating process have been adopted for ginseng. And these processes alter its chemical compositions and pharmacological ingredients. White ginseng is air-dried and red ginseng (RG) is produced by steaming raw ginseng at 98°C to 100°C for 2 to 3 h. RG is reportedly more pharmacologically active than white ginseng. In particular, when ginseng has been heated at a higher, it was reported that the yield of RG specific components can enhance

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[11,12]. Sun ginseng, a kind of the heat-processed ginseng, contains ginsenosides Rg3, Rg5 and Rk1 as a main constituent [13,14]. Of these ginsenosides, ginsenoside Rg5 showed anticancer, anti-inflammatory, antidermatitic, platelet anti-aggregating, radical scavenging, and neuroprotective activities [15,16]. However, its anti-CRD effect has not been studied. Therefore, we studied the efficacy of sun ginseng (SG) in adenine-induced chronic renal failure rats.

MATERIALS AND METHODS

Materials

Adenine and casein were obtained from Sigma Chemical Co. (St. Louis, Mo, USA). Alanine aminotransferase, aspartate aminotransferase, blood urea nitrogen, and creatinine assay kits were purchased from Asan Pharmaceutical (Seoul, Korea). Heat-processed ginseng (SG), which was prepared according to the previous method [12], was provided from Ginseng Science Co. (Seoul, Korea).

Animals

Male Sprague Dawley rats (190-210 g) were obtained from Samtako Biokorea (Seoul, Korea). All animals were fed on standard laboratory chow (Samyang Co., Seoul, Korea), housed in wire cages at $24\pm 2^{\circ}\text{C}$ and $50\pm 10\%$ humidity and allowed to water *ad libitum*. All experiments were performed in accordance with the National Institutes of Health and Kyung Hee University guides for Laboratory Animals Care and Use and approved by the Committee for the Care and Use of Laboratory Animals in the Kyung Hee Medical Center, Kyung Hee University.

Adenine-induced chronic renal failure rat model, which showed diffuse tubular injury with neutrophil polymorph infiltration, tubular necrosis, tubular atrophy, and diffuse intestinal fibrosis [17], was performed according to the method of Yokozawa et al. [18]. Briefly, the animals were fed on 18% casein diet containing 0.75% adenine. The composition of diet is as follow (in 100 g): casein 18 g, α -cornstarch 57.9 g, sucrose 15 g, soybean oil 2 g, salt mixture 4 g, vitamin mixture 1 g, cellulose powder 2 g, choline chloride 0.1 g, and adenine 0.75 g.

Rats were randomly divided into four groups of 7 rats in each group. Group I (normal) had free access to normal diet. The other three groups (group II, III, and IV) were fed with 18% casein diet containing 0.75% adenine. Group III (low dose-SG, LSG) rats were fed with adenine diet and a low dose of the SG (0.5 g/kg) daily for 20 d. Group IV (high dose-SG, HSG) rats were fed with adenine diet and a high dose of the SG (1.0 g/kg) daily for 20 d. The body weight

was recorded five times at intervals of four days after the administration of adenine.

Measurement of blood pressure and heart pulse rate

On the 20 d after the administration of adenine, blood pressure and heart pulse rate of rats were measured by a non-invasive method using an automatic blood pressure monitor. After being warm at constant temperature (37°C) for 15 min, a tail artery blood pressure and heart rate were measured and compared.

Measurement of kidneys weight

After being collected blood serum and urine samples, the rats were sacrificed with an overdose of diethyl ether. The harvested kidney was observed by measuring the weight.

Blood and urine collection

Blood samples of rats were obtained on the 10th and 20th days after the administration of adenine. Blood samples were collected by the cardiac puncture and centrifuged at $3,000 \times g$ for 20 min at 4°C . Urine sample of each rat was collected in metabolic cages for 24 h on the 19th day after the administration of adenine. Urea nitrogen, creatinine, calcium and phosphate were measured from the blood serum and urine samples.

Measurement of urea nitrogen, creatinine, calcium, and phosphate level

The levels of urea nitrogen and creatinine in the blood serum and urine samples were determined by Urease-Indophenol method [19] and Jaffe method [20], respectively. The levels of calcium and phosphate in the blood serum and urine samples were determined by o-cresolphthalein complexone method [21] and Goldenberg method [22] using Hitachi automatic analyzer.

Statistical analysis

All values are expressed as a mean \pm SD error of mean. Data analysis was determined significant at the level of $p < 0.05$ using Student's *t*-test.

RESULTS

To evaluate the effect of SG in adenine-induced renal failure rats, we treated with adenine diet to rats and measured body weight change (Fig. 1.). The body weight of normal group was gradually increased during the experiment period. However, the body weight of control group

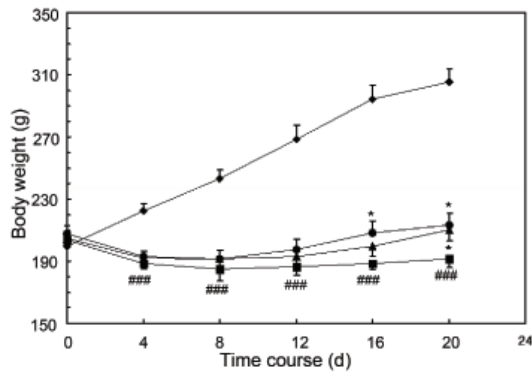


Fig. 1. Effect of sun ginseng (SG) on body weight in adenine-induced renal failure rats. SG (low dose-SG [LSG], high dose-SG [HSG]) were fed to the rats with 0.75% adenine diet once a day for 20 d. Values are expressed as mean±standard error of 7 rats. #Significantly different from the normal value (###*p*<0.001), *Significantly different from the control value (**p*<0.05). ♦, normal diet group (normal); ■, 0.75% adenine diet group (control); ▲, 0.75% adenine diet plus LSG group (0.5 g/kg); ●, 0.75% adenine diet plus HSG group (1.0 g/kg).

Table 1. Effect of sun ginseng on blood urea nitrogen level in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Time course of blood urea nitrogen levels (mg/dL)	
		10 d	20 d
Normal ¹⁾	-	12.3±1.1	16.9±0.6
Control ²⁾	-	82.9±2.9(-575.7)###	113.5±9.3(-570.2)###
LSG ³⁾	0.5	78.4±4.4 (6.4)	91.6±4.5 (22.7)*
HSG ⁴⁾	1.0	66.6±4.7 (23.1)*	88.9±6.8 (25.5)**

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

#Significantly different from the normal value (###*p*<0.001); *Significantly different from the control value (**p*<0.05 and ***p*<0.01).

fed on adenine diet was significantly reduced, compared with that of normal group. LSG and HSG dose-dependently suppressed the body weight loss caused by adenine (*p*<0.05).

Next we investigated the effect of SG on blood urea nitrogen and serum creatinine levels in adenine-induced renal failure rats. Blood urea nitrogen level of control group was increased to 82.9±2.9 mg/dL and 113.5±9.3 mg/dL on the 10th and 20th days after the administration of adenine, respectively (Table 1). It was significantly increased as compared with that of normal group (*p*<0.001). LSG or HSG significantly inhibited blood urea nitrogen level increased by adenine. HSG

Table 2. Effect of heat sun ginseng on serum creatinine level in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Time course of serum creatinine levels (mg/dL)	
		10 d	20 d
Normal ¹⁾	-	0.54±0.02	0.72±0.01
Control ²⁾	-	1.47±0.15(-173.9)###	2.10±0.18(-192.8)###
LSG ³⁾	0.5	1.13±0.05 (36.0)*	1.57±0.14 (38.2)*
HSG ⁴⁾	1.0	1.10±0.07 (39.4)*	1.51±0.07 (42.4)*

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

#Significantly different from the normal value (###*p*<0.001); *Significantly different from the control value (**p*<0.05).

reduced blood urea nitrogen level to 66.6±4.7 mg/dL and 88.9±6.8 mg/dL on the 10th and 20th days, respectively (*p*<0.01, *p*<0.05).

Treatment with adenine also increased serum creatinine level to 1.47±0.15 mg/dL and 2.10±0.18 mg/dL on the 10th and 20th days after the administration of adenine, respectively (Table 2). Creatinine level of control group was significantly increased as compared with that of normal group (0.54±0.02 mg/dL and 0.72±0.01 mg/dL on the 10th and 20th days). LSG and HSG dose-dependently reduced creatinine levels increased by adenine (*p*<0.05). HSG significantly reduced creatinine level to 1.10±0.07 mg/dL and 1.51±0.07 mg/dL on the 10th and 20th days after the administration of adenine, respectively. Then we investigated the effect of SG on serum levels of calcium and phosphate in adenine-induced renal failure rats. Treatment with adenine significantly reduced serum calcium level to 9.8±0.2 mg/dL and 11.0±0.3 mg/dL on the 10th and 20th days after the administration of adenine, respectively (Table 3). LSG and HSG significantly reversed calcium level to 12.2±0.4 mg/dL and 12.3±0.3 mg/dL on the 20th day (*p*<0.05, *p*<0.01). Treatment with adenine significantly increased serum phosphate level to 15.6±1.2 mg/dL and 21.4±1.1 mg/dL on the 10th and 20th days after the administration of adenine, respectively (Table 4). LSG and HSG significantly reduced phosphate level to 18.8±0.6 mg/dL and 18.4±0.7 mg/dL on the 20th day after the administration of adenine, respectively (*p*<0.05).

The effect of SG on urine volume in adenine-induced renal failure rats was investigated (Table 5). Treatment with adenine reduced urine volume to 61.0±1.9 mL/

Table 3. Effect of sun ginseng on serum calcium content in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Time course of serum Ca contents (mg/dL)	
		10 d	20 d
Normal ¹⁾	-	11.3±0.3	13.0±0.7
Control ²⁾	-	9.8±0.2 (-14.2) [#]	11.0±0.3 (-15.1) ^{###}
LSG ³⁾	0.5	10.2±0.1 (28.3)	12.2±0.4 (59.2) [*]
HSG ⁴⁾	1.0	10.3±0.2 (36.3)	12.3±0.3 (63.5) ^{**}

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

[#]Significantly different from the normal value ([#] $p<0.05$, ^{###} $p<0.01$);

^{*}Significantly different from the control value (^{*} $p<0.05$, ^{**} $p<0.01$).

Table 4. Effect of sun ginseng on serum phosphate content in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Time course of serum P contents (mg/dL)	
		10 d	20 d
Normal ¹⁾	-	11.7±1.3	16.5±0.7
Control ²⁾	-	15.6±1.2 (-33.8) ^{##}	21.4±1.1 (-29.4) [#]
LSG ³⁾	0.5	10.9±0.8 (118.1) ^{**}	18.8±0.6 (53.2) [*]
HSG ⁴⁾	1.0	9.2±0.5 (162.0) ^{***}	18.4±0.7 (62.1) [*]

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

[#]Significantly different from the normal value ([#] $p<0.05$, ^{##} $p<0.01$);

^{*}Significantly different from the control value (^{*} $p<0.05$, ^{**} $p<0.01$, ^{***} $p<0.001$).

Table 5. Effect of sun ginseng on urine volume in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Urine volume	
		Urine volume (mL/d)	Inhibition (%)
Normal ¹⁾	-	74.3±1.7	-
Control ²⁾	-	61.0±1.9 ^{###}	-17.9
LSG ³⁾	0.5	65.0±2.9	30.2
HSG ⁴⁾	1.0	69.0±2.7 [*]	60.4

Values are expressed as mean±standard error of 7 rats.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

^{###}Significantly different from the normal value (^{###} $p<0.001$); ^{*}Significantly different from the control value (^{*} $p<0.05$).

Table 6. Effect of sun ginseng on urine urea nitrogen and creatinine levels in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Urine levels (mg/dL)	
		Urea nitrogen	Creatinine
Normal ¹⁾	-	586.8±66.5	40.7±2.1
Control ²⁾	-	408.7±25.1 (-30.4) [#]	19.1±0.9 (-53.2) ^{###}
LSG ³⁾	0.5	543.1±37.9 (75.5) [*]	23.7±0.8 (21.2) ^{**}
HSG ⁴⁾	1.0	568.2±30.3 (89.6) ^{**}	26.8±1.3 (35.8) ^{**}

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

[#]Significantly different from the normal value ([#] $p<0.05$, ^{###} $p<0.001$);

^{*}Significantly different from the control value (^{*} $p<0.05$, ^{**} $p<0.01$).

Table 7. Effect of sun ginseng on urine calcium and phosphate contents in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Urine levels (mg/dL)	
		Ca	P
Normal ¹⁾	-	0.93±0.21	32.3±2.7
Control ²⁾	-	1.62±0.08 (-74.4) ^{##}	15.6±1.9 (-51.6) [#]
LSG ³⁾	0.5	1.37±0.16 (44.4)	18.8±4.2 (19.2)
HSG ⁴⁾	1.0	1.19±0.14 (62.6) [*]	22.8±2.3 (43.3) [*]

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

[#]Significantly different from the normal value ([#] $p<0.05$, ^{##} $p<0.01$);

^{*}Significantly different from the control value (^{*} $p<0.05$).

d, compared with that of normal group (74.3±1.7 mL/d, $p<0.001$). LSG and HSG reversed the urine volume reduced by the administration of adenine.

The effect of SG on the urea nitrogen and creatinine levels in the urine was measured (Table 6). Treatment with adenine significantly reduced urine urea nitrogen level to 408.7±25.1 mg/dL, compared with that of normal group (586.8±66.5 mg/dL, $p<0.05$). LSG and HSG significantly reversed urea nitrogen level to 543.1±37.9 mg/dL ($p<0.05$) and 568.2±30.3 mg/dL ($p<0.01$), respectively. Adenine also reduced urine creatinine level to 19.1±0.9 mg/dL, compared with that of normal group (40.7±2.1 mg/dL) ($p<0.001$). LSG and HSG reversed creatinine level to 23.7±0.8 mg/dL and 26.8±1.3 mg/dL, respectively ($p<0.01$). The effect of SG on the cal-

Table 8. Effect of sun ginseng on relative kidney weight in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Relative kidney weight (g/100 g)	
		Weight (g)	Inhibition (%)
Normal ¹⁾	-	0.99±0.01	-
Control ²⁾	-	3.00±0.19 ^{###}	-203.2
LSG ³⁾	0.5	2.44±0.12*	27.7
HSG ⁴⁾	1.0	2.30±0.22*	34.7

Values are expressed as mean±standard error of 7 rats. Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

^{###}Significantly different from the normal value (^{###}*p*<0.001); *Significantly different from the control value (*p*<0.05).

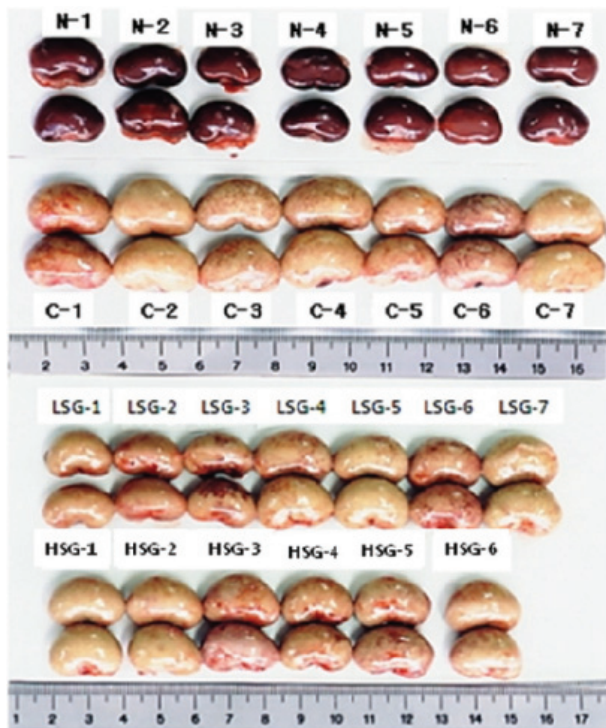


Fig. 2. Macroscopic findings of rat kidneys treated with adenine in the presence or absence of sung ginseng (SG). N1-N8, normal diet group (normal); C1-C7, 0.75% adenine diet group (control); LSG1-LSG7, 0.75% adenine diet plus low dose (0.5 g/kg) of the SG group; HSG1-HSG6, 0.75% adenine diet plus high dose (1.0 g/kg) of the SG group.

cium and phosphate levels in the urine was measured (Table 7). Treatment with adenine significantly increased urine calcium level to 1.62±0.08 mg/dL, compared with that of normal group (0.93±0.21 mg/dL, *p*<0.01). LSG and HSG reversed urine calcium level. Treatment with adenine significantly reduced urine phosphate level to

Table 9. Effect of sun ginseng on blood pressure and heart rate in adenine-induced renal failure rats

Groups	Sample dose (g/kg, p.o.)	Blood pressure (mmHg)	Heart rate
			(beats/min)
Normal ¹⁾	-	111.6±3.5	398.6±27.9
Control ²⁾	-	127.3±3.7 (-14.1) ^{###}	394.3±53.8
LSG ³⁾	0.5	117.7±4.0 (60.9)*	380.0±21.3
HSG ⁴⁾	1.0	116.9±2.9 (66.4)*	370.0±13.7

Values are expressed as mean±standard error of 7 rats. The values in parenthesis are % of protection.

Sun ginseng (SG; low dose-SG [LSG], high dose-SG [HSG]) were fed to the renal failure rats which was induced 0.75% adenine diet once a day for 20 d.

p.o., per os.

¹⁾ Normal diet group; ²⁾ 0.75% adenine diet group; ³⁾ 0.75% adenine diet plus LSG group (0.5 g/kg); ⁴⁾ 0.75% adenine diet plus HSG group (1.0 g/kg).

^{###}Significantly different from the normal value (^{###}*p*<0.01); *Significantly different from the control value (*p*<0.05).

15.6±1.9 mg/dL, compared with that of normal group (32.3±2.7 mg/dL, *p*<0.05). LSG and HSG reversed urine phosphate level.

Next we measured relative kidney weight per 100 g of body weight (Table 8) and macroscopically observed the occurrence of hypertrophy and edema on 20th day after the administration of adenine (Fig. 2). Adenine caused hypertrophy or edema, but LSG and HSG inhibited adenine-induced hypertrophy and edema. Treatment with adenine significantly increased the relative kidney weight to 3.00±0.19 g/100 g, compared with that of normal group (0.99±0.01 g/100 g, *p*<0.001). LSG and HSG significantly reduced it to 2.44±0.12 g/100 g and 2.30±0.22 g/100 g, respectively (*p*<0.05). Next we also measured blood pressure and heart pulse rate (Table 9). Treatment with adenine significantly increased blood pressure to 127.3±3.7 mmHg, compared with that of normal group (111.6±3.5 mmHg, *p*<0.01). LSG and HSG significantly reduced 117.7±4.0 mmHg and 116.9±2.9 mmHg (*p*<0.05). However, treatment with LSG and HSG did not affect heart pulse rate compared with the control group.

DISCUSSION

Ginseng, which is widely used in Asian countries as a traditional medicine for enhancing body strength, recovering physical balance and stimulating metabolic function [23,24]. When it is steamed at a higher temperature, it is called SG. SG exhibits anti-tumor, anti-stress, anti-diabetic, and anti-hypertension effects. However, the inhibitory effect of SG against chronic renal failure has been thoroughly not studied.

CRD is a progressive loss in renal function over a period of months or years. In the majority of cases, CRD is the result of chronic diseases, such as diabetes, hypertension, pyelonephritis, glomerulonephritis, etc. [1,25]. There is no specific treatment unequivocally shown to cure or slow the worsening of chronic kidney disease. Simply, an underlying cause to CRD, such as vasculitis, may be treated to slow the damage. In more progressed stages, treatments may be required for anemia and bone disease. Severe CRD requires dialysis or renal replacement therapy, which is expensive. Therefore, herbal medicines have received increasing attention [2,3].

In the present study, we investigated the inhibitory effect of SG in adenine-induced renal failure rats. It has been reported that long-term feeding of adenine in rats suppressed the excretion of nitrogenous compounds by means of renal tubular occlusion, and produced metabolic abnormalities resembling chronic renal failure in humans. The intake of adenine produced extraordinary increases of creatinine, urea nitrogen, and urea in the serum as well as a reduction in their urinary excretion. Dietary adenine also caused a nephrotoxic condition as reflected in the morphological changes of the kidney [26,27]. As a result, SG significantly decreased the levels of both urea nitrogen and creatinine in the serum, indicating an improvement of renal function. And, it significantly increased the urinary excretion of both urea and creatinine. Moreover the administration of SG increased serum calcium level, indicating an improvement of hypocalcemia. Improvement of the hyperphosphatemia was also observed. Furthermore, treatment with SG inhibited adenine-induced kidney hypertrophy and edema. These experimental results indicate that SG improves the renal clearance in the uremic state induced by adenine feeding, and suggest that the progression of renal failure may be stopped. SG contains ginsenosides Rg3, Rg5, Rk1 as main constituents. The ginsenoside Rg5, which is a representative constituent in SG, is produced from protopanaxadiol ginsenosides by steaming of raw ginseng [13-16]. These constituents exhibit anti-inflammatory, anti-tumor, platelet aggregation-inhibitory, anti-diabetes, anti-hypertensive and antioxidant effects [28-33]. These results suggest that the inhibitory effect of SG against chronic renal failure may be dependent on its main constituent, ginsenoside Rg5. Based on these findings, SG may improve chronic renal disease.

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