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Studies on the Anti-aging Action of Korean Ginseng

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高麗人蔘의 老化抑制作用에 関한 研究

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Abstract

The inhibitory effects of red-ginseng saponin hydrolyzates (prosapogenin, panaxadiol and panaxatriol) on lipoperoxide formation *in vitro* and *in vivo* were investigated and correlated with anti-aging.

Saponin hydrolyzates showed the electron-donating ability (EDA) of 13.88 – 19.76% to DPPH *in vitro*, and the ability was distinctively decreased in order of prosapogenin, panaxatriol and panaxadiol. The induction period of saponin hydrolyzates, which was measured by the method of peroxide value (POV), was much longer than red–ginseng saponin and decreased in order of prosapogenin, panaxatriol and panaxadiol. The inhibitory effect of saponin hydrolyzates *in vivo* was remarkably greater than control. In contrast to red-ginseng saponin, almost similar inhibitory effect in rat liver and kidney was observed, whereas they were much more effective than red-ginseng saponin in blood. The superoxide dismutase (SOD) activity of saponin hydrolyzates *in vitro* was also measured, and the inhibitory effect of saponin hydrolyzates was found to be 24.2–36.4% and 2–3 times greater than that of red–ginseng saponin (12.1%). Saponin hydrolyzates showed the inhibitory effects of 11.2–21.6% and 12.9–22.2% in oral and intraperitoneal administrations, respectively. It was also found from the measurement of peroxidase activity that the inhibitory effects of saponin hydrolyzates were 111.4–139.6% in oral administration and 129.0–188.6% in intraperitoneal administration.

Introduction

Recently, ginseng saponin has been paid a great attention to many researchers because of its biochemical and pharmacological importance. In our previous reports,[1,2] we have demonstrated the inhibitory effect of Korean ginseng (*Panax ginseng* C.A. Meyer) on the lipoperoxide formation *in vitro* and *in vivo* and correlated the effect with anti-aging.

There are a number of theories in the causes and biological changes of aging.[3-8] According to the free radical theory of Harman,[8] aging starts with functional and structural damages in cells and tissues which were resulted from the side effects of free radical formed normally in the course of biochemical reactions. The free radical formed under various conditions can cause the changes in deoxyribonucleic acid through chromosomal oberrations and/or can

initiate lipid peroxidation in subcellular and cellular membrane systems; the accumulation of lipoperoxides in cells and tissues accelerates not only aging action but also causes adult diseases. Ginseng saponin is classified into diol and triol saponins of which sapogenins are 20(S)-protopanaxadiol and 20(S)-protopanaxatriol, respectively. Diol saponin is composed of ginsenoside-Rb_1, $-Rb_2$, $-Rb_3$, $-Rc$ and $-Rd$. In contrast, however, triol is composed of ginsenoside-Re, $-Rf$, $-Rg_1$, $-Rg_2$, $-Rh_1$ and 20-gluco-Rf. The isolation of saponins is indispensable and of great importance in studies on the bio-chemical and pharmacological effects of saponins. The application of HPLC technique to the rapid isolation of major and minor components of saponins was reported in a number of paper.[9-14]

The objective of this paper was not only to demonstrate the inhibitory effects of ginseng saponin hydrolyzates on lipoperoxide formation *in vitro* and *in vivo* but also to correlate with anti-aging. To this end, the inhibitory effects on lipoperoxide formation were measured by the methods of thiobarbituric acid (TBA), peroxide vaue (POV) and electron donating ability (EDA). And also the superoxide dismutase (SOD) and peroxidase activities were measured by the methods of pyrogallol autoxidation and initial velocity, respectively.

Materials and Methods

Materials and chemicals

Six-year-old fresh ginseng (*Panax ginseng* C.A. Meyer) used was cultivated in 1982 and purchased from Kwanghwa in Korea. Red ginseng was prepared by steaming and drying the fresh ginseng, and it was powdered (80 mesh).

Superoxide dismutase (E.C. 1.15.1.1, from horse-radish, Sigma Co., U.S.A.) and peroxidase (E.C 1.11.1.6, from bovine liver, Sigma Co., U.S.A.) were used for the measurement of enzyme activities. Commercial Kiesel gel 60 (No. 7734, Merk Co., Germany) and Kiesel gel 60 plate (0.25mm, Merck Co., Germany) were used for the fractionation and identification of diol and triol saponins. All other reagents used were analytical and/or reagent grade without further purification.

Animals

Male Sprague-Dawley rats (SD, 150–200g) were maintained in an airconditioned room by lighting from 6 a.m. to 6 p.m. Prior to the experiments, rats were locally obtained before one week and then fed with commercial diet. The diet and water were prepared late in the afternoon and given freely. The rats were weighed evey morning (10:00 a.m.) for the observation of body conditions.

Fractionation and identification of saponin hydrolyzates

1) Prosapogenin

Crude saponin (50g) prepared from red ginseng was subjected to column chromatography (6.0 i.d. x 75cm column; Kieselgel 60, 70-230 mesh) using a mixed solvent of $CHCl_3$–MtOH–H_2O (65:35:10, lower phase), in oreder to fractionate diol saponin. To 50% acetic acid was added diol saponin. Diol saponin was hydrolyzed with 50% acetic acid on a water bath at 70°C to obtain prosapogenin. The homogeneity of isolated prosapogenin (Rf; 0.48) was examined with authentic sample by TLC with a mixed solvent of $CHCl_3$–MtOH–H_2O (7:3:1, lower phase). The ir spectrum of isolated prosapogenin showed characteristic absorption frequencies at 3360cm^{-1} ($\nu_{o\text{-}H}$) and 1620cm^{-1} ($\nu_{c=o}$) (KBr).[15]

2) Panaxadiol and panaxatriol

Acid hydrolysis of ginseng saponin did not give genuine aglycone–20(S)–protopanaxadiol

and 20(S)-protopanaxatriol–but decomposition products–panaxadiol and panaxatriol. The crude saponin of red-ginseng was hydrolyzed with 4N HCl–50% dioxane (v/v, 1:1), and panaxadiol and panaxatriol were separated from the hydrolyzates by column chromatography. And the homogeneity was examined with the authentic samples by TLC; the Rf values of panaxadiol and panaxatriol were 0.52 and 0.34 (benzene–acetone, 3:1, v/v), and 0.68 and 0.43 (ethyl ether), respectively.

Measurement of anti-aging effects

1) Electron donating ability (EDA)

Antioxidant activity by the EDA of diol, triol and total saponins to DPPH (α, α-diphenyl-β-picrylhydrazyl) were measured by the method described in the previous paper[16].

2) Inhibitory effects on lipoperoxide formation

(a) Lipoperoxide assay by TBA value

In Vitro Experiments: The inhibitory effects of diol, triol and total saponins on liperoxide *in vitro* were measured by TBA value (OD at 532 *nm*) according to the method described in the previous paper[16]. Diol, triol and total saponins were added to substrate to give the final concentration of 0.02%. The lipoperoxide contents formed were measured in the course of time, and TBA values were calculated from absorbance (OD at 532 *nm*) x 100.

In Vivo Experiments: 1.0% saline solution (1.0 *ml*) of diol, triol and total saponins were intraperitoneally administered (50 *mg/kg* body weight) to rats (200 *g*, 8 rats/group), and 0.5% saline solution (1.0 *ml*) of these saponins were orally administered (33.4 *mg/kg* body weight) to rats (150 *g*, 10 rats/group) at 10:00 a.m. every day for two weeks.

The TBA values of blood, liver and kidney were measured according to the method described in the previous papers.[16,17].

(b) Estimation of induction period by peroxide value

In order to estimate an induction period in the initial stage of lipoperoxide formation, diol, triol and total saponins were added to substrate to give the final concentration of 0.02%, and the peroxide values were measured by the method described in the previous paper[16].

Induction period was calculated from the time required to reach the peroxide value (OD at 500 *nm*) of 0.4.

3) Enzyme activity on the inhibition of lipoperoxide formation

(a) Determination of superoxide dismutase (SOD) activity

In Vitro Experiments: The SOD activities of diol and total saponins were measured by the modified pyrogallol autoxidation method of Marklund[18].

In Vivo Experiments: To examine the effects of these saponins on SOD activity, saponins were intraperitoneally (50 *mg/kg* body weight) and/or orally (33.4 *mg/kg* body weight) administered to rats by the same method as the measurement of TBA value *in vitro*. The SOD activity in rat liver on pyrogallol autoxidation was converted into the value for 50 μl of rat-liver homogenate, and the percent inhibition of SOD against pyrogallol autoxidation was expressed as the ratio of administered group to control group by the same method as *in vitro*.

(b) Determination of peroxidase activity

In Vitro Experiments: The perioxidase activities of diol, triol and total saponins were measured by the modified method of Bergmeyer[19] as described in the previous paper[16]. The peroxidase activity was calculated from initial velocity (△A 436 *nm*/min) by absorbance changes at 436 *nm* with respect to H_2O as a reference and expressed in terms of unit per *mg* sample as the following equation. The percent activity was expressed as the ratio of experiment

groups to control group.

$$\text{unit}/mg \text{ sample} = \frac{\triangle A\ 436nm/20 \text{ sec} \times 3}{12^* \times mg \text{ sample in Rx. mix.}}$$

* 12: extinction coefficient

In Vivo Experiments: To examine the effects of these saponins on peroxidase activity, saponins were intraperitoneally and/or orally administered to rats by the same method as the measurement of SOD activity *in vivo*. Peroxidase activity was measured and calculated by the same method as *in vitro* experiment.

Results and Discussion

Comparison of saponin hydrolyzates

Red-ginseng saponin was hydrolyzed with 50% acetic acid.

The uv spectra of prosapogenin, which was isolated and purified from the hydrolyzates of red-ginseng saponin with 50% acetic acid, and panaxadiol and panaxatriol which was isolated and purified from the complete hydrolyzates of red-ginseng saponin with 4N HCl–50% dioxane (1:1, v/v) are shown in Fig. 1. In contrast to the uv spectra of prosapogenin (λ_{max} 262 *nm*), panaxadiol (λ_{max} 260 *nm*) and panaxatriol (λ_{max} 250, 269 and 285 *nm*) showed distinctive differences. The ir and nmr data of panaxadiol and panaxatriol isolated from the acid hydrolyzates of red-ginseng saponin are shown in Table 1, and the results were found to be very consistant with previous reports[1,3], except the broad peak of triol at 3380cm^{-1} indicating that the diol[20,21,23] and triol[22] were sufficiently purified.

Effect of the hydrolyzates of red-ginseng saponin on electron-donating abilities.

Electron-donating abilities to DPPH have been used for the comparison of water-soluble antioxidants in antioxidative activities. However, saponin hydrolyzates–prosapogenin, panaxadiol and panaxatriol–were found to have low water solubility and dissolved in small amount of DMSO for experiment. The elctron-donating abilities of saponin hydrolyzates to DPPH were

Table 1. IR and NMR data of panaxadiol and panaxatriol isolated from red-ginseng saponin by acid hydrolysis

Artifacts	IR, cm^{-1} (KBr)	Ref.	NMR, δ ($CDCl_3$)	Ref.
Panaxadiol	1120 (C-O-C)	Fujita, M. et al[20]	0.78 (1Me)	Shibata, S. et al[21]
	3240 (OH)		0.88 (2Me)	
	3420 (OH)		0.97 (2Me)	
			1.18 (1Me)	
			1.21 (1Me)	
			1.26 (1Me)	
Panaxatriol	1120 (C-O-C)	Shibata, S. et al[22]	0.80 (1Me)	Shibata, S. et al[23]
	3380 (OH)		0.92 (2Me)	
	*broad peak		1.00 (2Me)	
			1.19 (1Me)	
			1.24 (1Me)	
			1.28 (1Me)	

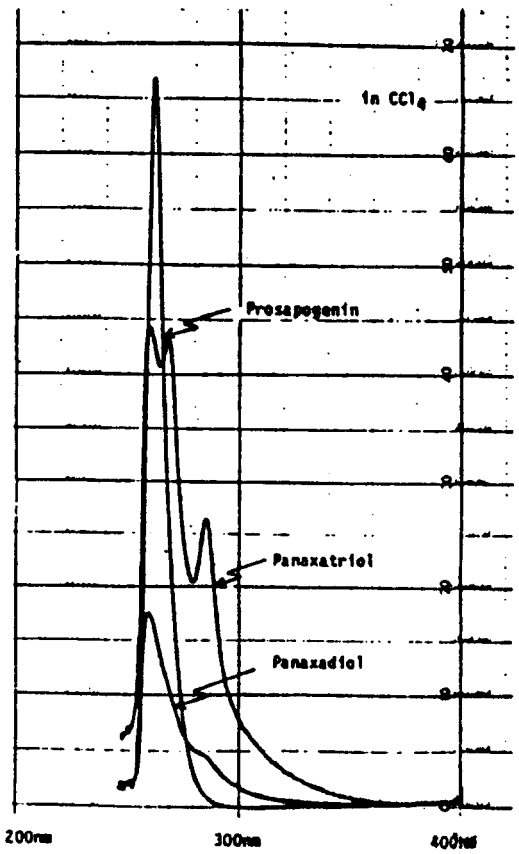

Fig. 1. UV spectra of prosapogenin, panaxadiol and panaxatriol isolated from red ginseng by acid hydrolysis (in CCl_4)

decreased in order of prosapogenin (19.76%), panaxatriol (15.29%) and panaxadiol (13.88%) as shown in Table 2. The total saponin of red-ginseng reported in our previous paper[1,2]

Table 2. Electorn donating abilities (EDA) of prosapogenin, panaxadiol and ponaxatriol hydrolyzed from red-ginseng saponin to DPPH.

Ginseng components (0.02% addition)	Decrease in OD at 525 nm during ten minutes	EDA (%)
Control	0.850	–
Prosapogenin	0.682	19.76
Panaxadiol	0.732	13.88
Panaxatriol	0.720	15.29

Sample was dissolved in small amount of DMSO.

showed the EDA of 17.41% in which the value was lower than prosapogenin but higher than panaxadiol and panaxatriol. Electron-donating ability of saponin hydrolyzates to DPPH is of great importance in the study on anti-aging effect by the antioxidation of ginseng, because the glycoside linkage of saponin has a great possbility to the hydrolyzed by various enzymes and gastric juice in the body to give rise prosapogenin, panaxadiol and panaxatriol, when administered ginseng. Among the hydrolyzates, prosapogenin showed the highest electron-donating ability, and this may be due to highly reactive tertiary hydroxyl group at C-20 position.

The hydroxyl group at C-12 position is not so reactive. In contrast, however, the hydroxyl group at C-20 position of triterpenoid, a damarane type which has the β-configuration of hydroxyl group at C-12 position, is easily epimerized[24,25] by acid or heat and thus expected to show strong reducing power-electron-donating ability to DPPH.

And also the stronger electron-donating ability of panaxatriol than that of panaxadiol can be possibly explained by the synergistic action of C-6 hydroxyl group to C-3 hydroxyl group.[26-28]

Thus, it is interesting to find strong electron-donating ability in ginseng hydrolyzates, which is likely to be hydrolyzed during the thermal extraction and digestion of red-ginseng. This is compatible with early report that ginseng extracts and sapogenin showed continuous stimulative action and high activity.[29]

Inhibitory effect on lipoperoxide formation

1) *In vitro* experiment – The TBA value of red-ginseng saponin hydrolyzates (0.02 %) – prosapogenin, panaxadiol and panaxatriol – were measured against time, and the results obtained are shown in Fig. 2. Inhibitory effect on lipoperoxide formation was increased in order of panaxadiol, panaxatriol and prosapogenin, and

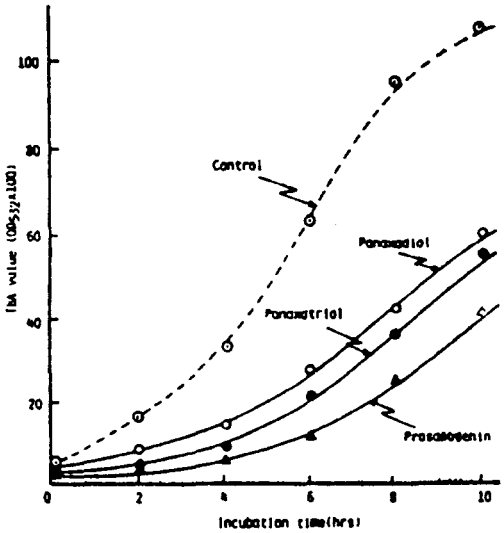

Fig. 2. Antioxidative activities of prosapogenin, panaxadiol and panaxatriol hydrolyzed from red-ginseng saponin at 60°C (0.02% addition)

this trend was very similar to electron-donating ability to DPPH. Perhaps anti-aging effect by the anti-oxidation of red-ginseng is deeply related to saponin and its hydrolyzate, for ginseng saponin will actually produce a large amount of prosapogenin as a partial acid hydrolyzate during digestion.

The induction period of the initial lipoperoxide formation of saponin hydrolyzates was measured by the method of peroxide value (Table 3), and it was increased in order of panaxadiol (142.6 min), panaxatriol (186.2 min) and prosapogenin (202.4 min). Thus, prosapogenin was found to inhibit lipoperoxide formation effectively in the initial stage. Such a trend was very consistent with that of TBA value and electron-donating ability in an inhibitory effect on lipoperoxide formation. As described above, a remarkable inhibitory effect of prosapogenin on lipoperoxide formation is resulted in the synergistic action of C-20 tertiary hydroxyl group[24,25] and electron-donating ability of C-3 hydroxyl group[26-28] as well as the action of sugar as a cofactor.

The induction period of total red-ginseng saponin was 135.2 min as reported in our previous papers[1,2] and this value was found to be lower than that of saponin hydrolyzates.

2) *In vivo* experiment.

Saponin hydrolyzates (50 *mg/kg* body weight) – prosapogenin, panaxadiol and panaxatriol – were intraperitoneally administered to animal groups (8 Sprague-Dawley rats/group, 200g body weight/rat), and the TBA values of blood, liver and kidney were measured (Fig. 3). In contrast to blood and kidney, liver showed a remarkable inhibitory effect of saponin hydrolyzates on the lipoperoxide formation, and the effect was increased in order of panaxadiol, panaxatriol and prosapogenin. Such a trend was also obtained from blood and very close to the results obtained from *in vitro* experiment. On the contrary, however, kidney increased the inhibitory effect in order of prosapogenin, panaxadiol and panaxatriol. This may be attributed to the different reaction site of saponin hydrolyzates in organs. As reported in our previous papers,[1,2] the inhibitory effects of saponin hydrolyzates and total saponin were almost similar in liver and kidney, but saponin hydrolyzates were more effective than total saponin in blood.

On the other hand, saponin hydrolyzates (33.4 *mg/kg* body weight) were orally administered to animal groups (10 SD rats/group, 150 g body weight/rat) for 7 days, and liver, blood and

Table 3. Induction period of prosapogenin, panaxadiol and panaxatriol of red-ginseng saponin measured with peroxide value

Ginseng components (0.02% addition)	Induction period* (minutes)
Control	30.0
Prosapogenin	202.4
Panaxadiol	142.6
Panaxatriol	186.2

* Time required to reach the peroxide value of 0.4 (OD 500)

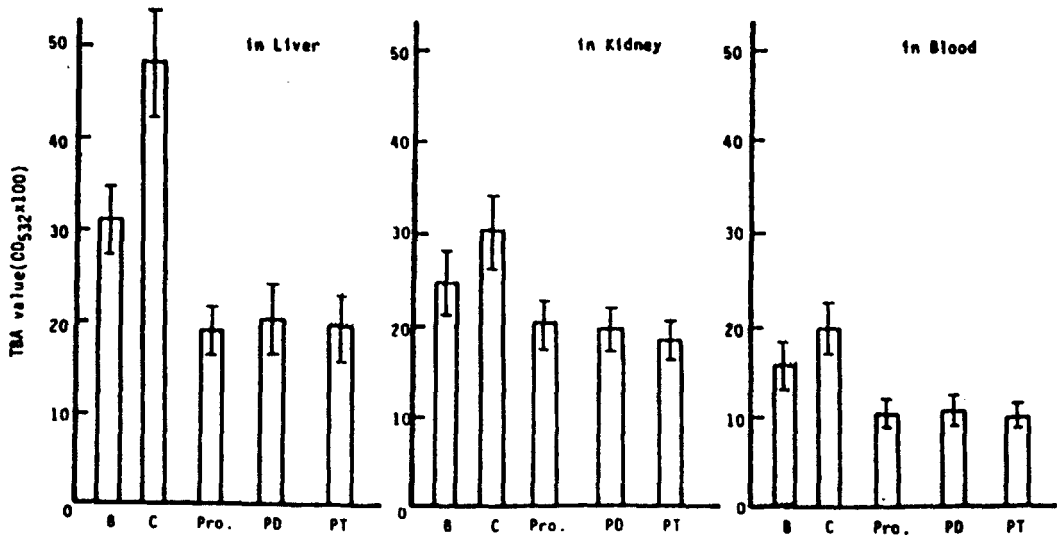

Fig. 3. Inhibitory effect of prosapogenin, panaxadiol and panaxatriol of red ginseng administered intraperitoneally to rats on the formation of lipoperoxide ($P < 0.02$): B, blank; C, control; Pro., prosapogenin; PD, panaxadiol: PT, panaxatirol.

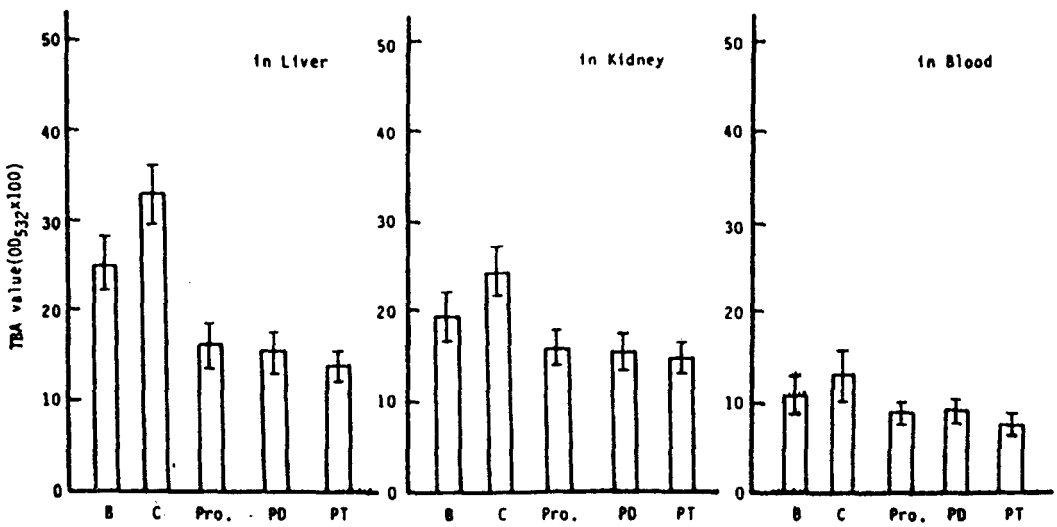

Fig. 4. Inhibitory effect of prosapogenin, panaxadiol and panaxatriol of red ginseng administered orally to rats on the formation of lipopetoxide ($P < 0.03$): B, blank: C, control; Pro., prosapogenin; PD, panaxadiol; PT, panaxatiol.

kidney were examined the inhibitory effect on lipoperoxide formation by the method of TBA value (Fig. 4). The results showed a slightly different trend from *in vivo* and intraperitoneal experiments; the inhibitory effect was decreased in order of panaxatriol, panaxadiol and prosapogenin. Such a similar trend was observed from liver, blood and kidney, and particularly liver showed the strongest inhibitory effect, suggesting that a final reaction site and reactants when administered ginseng would be possibly liver and saponin hydrolyzates, respectively. It was also found that the inhibitory effect of saponin hydrolyzates on lipoperoxide formation showed a very similar trend to that of the total saponin of red-ginseng[1,2] in either orally or intraperitoneal administration.

Effect on enzyme activity:

1) Superoxide dismutase – The effect of red-ginseng saponin hydrolyzates (0.02% level) on superoxide dismutase activity *in vitro* was examined by pyrogallol autoxidation method. As shown in Table 4, the superoxide decomposition of saponin hydrolyzates expressed as percentage inhibition against control was decreased in order of panaxatriol (36.4%), panaxadiol (31.8%), and prosapogenin (24.2%). Thus, the inhibitory effects of saponin hydrolyzates were found to be 2–3 times greater than that of the total saponin of red-ginseng[1,2].

Also, the inhibitory effect was examined on liver homogenates which were obtained from rats administered saponin hydrolyzates orally and/or intraperitoneally. As shown in Table 5, prosapogenin showed the greatest inhibitory effect in case of intraperitoneal administration, whereas panaxatriol showed the greatest inhibitory effect in case of oral administration. As reported in our previous paper[1], the total, diol and triol saponins of red-ginseng showed the 17.3, 14.9 and 20.9% inhibitions of superoxide dismutase, respectively, in case of oral administration. In contrast, panaxatriol showed 21.6% inhibition, indicating that saponin hydrolyzates were more effective and also that among saponin hydrolyzates, panaxatriol was much more effective than the total saponin of red-ginseng. Taking the digestion process of ginseng into consideration, oral administration seems to be more effective than intraperitoneal administration. Accordingly, the anti-aging effect of red-ginseng is likely to be closely related to fat-soluble components (prosapogenin, panaxadiol, and panaxatriol), for saponin hydrolyzates increase the activity of superoxide dismutase. Compared with foreign ginseng, in particular, Korean ginseng not only contains a large amount of triol saponin but also shows the high activity of superoxide dismutase from panaxatriol, a saponin hydrolyzate. Thus, the superiority of Korean ginseng can be well recognized by the anti-aging effect.

Table 4. Effect of prosapogenin, panaxadiol and panaxatriol hydrolyzed from red–ginseng saponin on pyrogallol autoxidation *in vitro*

Ginseng components (0.02% addition)	Rate of autoxidation ($\triangle$A 420/min) x 10^3	Inhibition/ Control (%)
Control	33.0	–
Prosapogenin	25.0	24.2
Panaxadiol	22.5	31.8
Panaxatriol	21.0	36.4

2) Peroxidase – The effect of red-ginseng hydrolyzates on peroxidase *in vitro* was shown in Table 6. Prosapogenin was found to have some effects by showing the peroxidase activity of 111.7%. In contrast, however, panaxadiol and panaxatriol showed an inhibitory effect. Perhaps

Table 5. Effect of prosapogenin, panaxadiol and panaxatriol isolated from red–ginseng saponin on superoxide dismutase (SOD) *in vivo*

Ginseng components (0.02% addition)	SOD activity (x 10^3) (50μl of 10% liver homogenate)		inhibition/Control (%)	
	ip	oral	ip	oral
Control	29.25 ± 0.4	29.75 ± 1.8	–	–
Prosapogenin	22.75 ± 0.6	26.40 ± 1.5	22.2	11.2
Panaxadiol	25.46 ± 0.5	24.85 ± 2.0	12.9	16.5
Panaxatriol	23.42 ± 0.4	23.32 ± 1.5	19.3	21.6

Table 6. Effect of prosapongenin, panaxadiol and panaxatriol hydrolyzed from red-ginseng saponin on peroxidase *in vitro*

Ginseng components (0.02 % addition)	Peroxidase activity (unit/mg)	Activity/ Control (%)
Control	$5{,}000 \times 10^{-2}$	100
Prosapogenin	5.584×10^{-2}	111.7
Panaxadiol*	4.472×10^{-2}	89.4
Panaxatriol*	4.889×10^{-2}	97.8

* Sample dissolved in small amount of DMSO

this is attributed to the inactivation of authentic peroxidase by DMSO, and thus the solubility of panaxadiol and panaxatriol is a trouble to *in vitro* experiment.

On the other hand, the peroxidase activity in rat liver, which was administered red-ginseng hydrolyzates orally and/or intraperitoneally, was measured. As shown in Table 7, prosapogenin showed the highest peroxidase activity and was 1.9 times greater than control in intraperitoneal administration. The activity was decreased in order of prosapogenin (188.6%), panaxatriol (163.4%) and panaxadiol (129.0%), and the results were very similar trend to the TBA value obtained from intraperitoneal administration. It was noteworthy to find that prosapogenin and panaxatriol showed much higher activity than the total saponin (133.4%) of red-ginseng as reported in our early papers.[1,2]

In oral administration, panaxatriol showed the peroxidase activity of 139.6% and was 1.4 times higher than control. The activity was decreased in order of panaxadiol (120.2%) and prosapogenin (111.4%). Compared with the rat group administered total saponin as described in our early papers, the peroxidase activity of saponin hydrolyzates, except panaxatriol, was interestingly lower. There were some differences in the peroxidase activity of saponin hydrolyzates unlike the activity of superoxide dismutase.

要 約

紅蔘사포닌 加水分解物의 抗酸化作用에 의한 老化抑制作用을 究明하기 위하여 紅蔘사포닌을 加水分解하여 얻은 prosapogenin, panaxadiol 및 panaxatriol 을 試料로 하여 *in vitro* 및 *in vivo* 実験을 통하여 이들 加水分解物들의 生体 過酸化脂質生成에 미치는 抑制効果를 比較하였다.

DPPH에 대한 電子供與能(EDA)은 13.88～19.76 %를 나타내고 있었으며 *in vitro*에서 過酸化脂質生成 抑制効果는 현저하였으며 그 순서는 prosapogenin＞panaxatriol＞panaxadiol이었다. POV에 의한 誘導期間은 이들 加水分解物이 紅蔘사포닌보다 훨씬 높았으며 prosaposenin＞panaxatriol＞panaxadiol의 순이었다. *in vivo*에서 復腔(i. p.) 및 経口(p. o.) 投與에 의한 生体内 過酸化脂質生成 抑制効果는 対照群에 比해 훨씬 効果的이었으며, 紅蔘사포닌과 比較했을때 肝臟과 腎臟에는 거의 비슷한 効果를 나타냈지만 血液에서는 이들 加水分解物이 紅蔘사포닌보다 훨씬 効果的이었다.

酵素活性으로서 superoxide dismutase 活性을 *in vitro*에서 비교해 보면 이들 加水分解物이 24.2～36.4%

Table 7. Effect of prosapogenin, panaxadiol and panaxatriol hydrolyzed from red ginseng saponin on peroxidase *in vivo*

Ginseng component (0.02% addition)	Peroxidase activity (unit/mg wet liver)		Activity/Control (%)	
	ip	oral	ip	oral
Control	4.20×10^{-5}	6.04×10^{-5}	100	100
Prosapogenin	7.92×10^{-5}	6.73×10^{-5}	188.6	111.4
Panaxadiol	5.42×10^{-5}	7.26×10^{-5}	129.0	120.2
Panaxatriol	6.83×10^{-5}	8.43×10^{-5}	163.4	139.6

의 過酸化脂質生成 抑制効果를 나타내고 있어, 紅蔘사포닌의 12.1%보다 2～3倍의 効果를 나타내고 있었고, *in vivo*에서는 腹腔(i.p.)投與에서는 12.9～22.2%, 経口(p.o.)投與에서는 11.2～21.6%의 높은 活性을 나타내고 있었다. 단 peroxidase 活性은 腹腔(i.p.)投與에서는 129.0～188.6%, 経口(p.o.)投與에서는 111.4～139.6%의 活性을 나타내고 있었다.

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