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Effects of *Portulaca oleracea* Powder on the Lipid Levels of Rats Fed a Hypercholesterolemia Inducing Diet

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Abstract

This study was initiated to investigate the effects of lyophilized purslane (*Portulaca oleracea*) powder (5% and 10%) on lipid levels in rats fed a hypercholesterolemia-inducing diet (1% cholesterol). During the four week study, there were no significant differences in either weight change or the food efficiency ratio between the group fed the hypercholesterol diet alone (HC) and the groups fed the purslane powder (HCPO-I and HCPO-II, 5% and 10% purslane, respectively). In serum, the levels of total lipid, total cholesterol and LDL-C decreased significantly for the group fed the 10% purslane powder (HCPO-II) in comparison with the group fed the 5% purslane powder (HCPO-I). The atherogenic index (AI) was reduced by about 51% for the group fed the 10% purslane powder (1.47) in comparison with the HC group (3.03). The activities of GOT, GPT, ALP and LDH decreased significantly for the groups fed the purslane powder in comparison with the HC group. Regarding liver tissue, the levels of total lipid, total cholesterol and triglyceride decreased significantly for the purslane powder-fed rats compared to the HC group. The fecal lipid profiles increased significantly as the amount of purslane powder was increased. Compared to the HC group, the fecal total cholesterol and triglyceride levels were higher in the group fed the 10% purslane powder by about 2.8 times and 2.3 times, respectively. For the serum and liver tissue, the content of lipid peroxide decreased significantly in the groups fed purslane powder compared to the HC group. The data from this experiment show an increase in the lipid levels discharged in feces, suggesting that the supplementation of purslane powder to a hypercholesterolemia-inducing diet reduces lipid levels.

Key words: *Portulaca oleracea*, hypercholesterolemic rats, triglyceride, fiber

INTRODUCTION

In recent years, the average consumer's diet has changed so that the intake level of carbohydrates has decreased, while the intake levels of meat and meat products have increased. As a result, lipid levels in the body have also increased, greatly raising the occurrence rate of cardiovascular diseases such as hyperlipidemia, arteriosclerosis and hypertension. In fact, these diseases rank at the second position among the major factors causing death (1). Notably, cholesterol level is considered to be a representative factor of danger of cardiovascular diseases (2), and reducing the level of cholesterol in serum is believed to change that level of danger. To aid in cholesterol reduction, there have recently been many attempts to use certain common plants that are already well-known in traditional medicine for having biological components that can be used to reduce the lipid levels in body (3-5). Since it is more beneficial to prevent dietary diseases than to cure them, and to change one's diet rather than take medicine, the diet of choice in modern societies should include food with functionality.

Purslane (*Portulaca oleracea*) is a kind of annual plant which belongs to Portulacaceae and is commonly called "Shebirum" in Korea. It can be frequently seen in such places as vegetable gardens and empty spaces as well as any roadside. It is sometimes called by common name as "Ohaengcho", "Jangmyeongchae" and "Machihyeon". In the Western style, it can be mainly used with lettuce for salads (6). Also, it can be dried and used as a material for various dishes (7) as well as tea or soup (8). In Korea, people used to blanch a tender shoot of the plant in summer to preserve them for eating throughout the winter.

Purslane shows higher amounts than many other plants of certain biological components, including oleic acid, linoleic acid and γ-linolenic acid, and has been reported to suppress cancer or be effective in decreasing the occurrence rate of heart diseases (9,10). Also, purslane contains great amounts of nutrients such as tocopherol and ascorbic acid (11). Moreover, purslane extract shows an antioxidant activity based on phenolic compounds,

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including flavonoids (8,12,13), which are known to lower cholesterol or triglyceride levels in hyperlipidemic rats (14,15). However, there are few studies related to the prevention of hyperlipidemia *in vivo* by purslane (16-18). To verify the biological effect of purslane on hyperlipidemia, this study focuses on the effects of lyophilized purslane powder on the change of the lipid components in serum and liver tissue of hypercholesterolemic rats.

MATERIALS AND METHODS

Materials

Lyophilized purslane (*Portulaca oleracea* L., Portulacaceae) powder, which was made by gathering and lyophilizing the wild sprouts of the plant in Yeongdeok-gun, Gyeongsangbuk-do, Korea, was purchased at Hanbeat Farm (80～100 mesh). It was used for the physicochemical composition analysis and added to the diet of rats.

Analysis of physicochemical composition

The contents of moisture, ash, crude lipids, crude protein and crude fiber in purslane powder were determined as described in AOAC methods (19). Carbohydrate content was calculated by subtracting the contents of moisture, ash, crude lipids, crude protein and crude fiber from 100.

Animals and diet compositions

Five-week-old male Sprague-Dawley rats with an average weight of 150±10 g were received from Samtako Co. Ltd. (Osan, Korea). In the animal-breeding chamber (DJ1-252-2, Daejong Instrument Industry Co. Ltd., Seoul, Korea) with automatically adjusted conditions for temperature (22±2°C), relative humidity (50±5%) and the period of brightness (12 hr, 07:00～19:00), the rats were preliminarily fed with the normal diet containing the 7% soybean oil for the first week. Then, four groups were created based on the randomized block design, each group containing seven rats whose combined weight was similar to those of the others. There was a normal group (Normal), a hypercholesterol fed group (HC), an HC plus 5% purslane powder group (HCPO-I) and an HC plus 10% purslane powder group (HCPO-II). These groups were maintained for four weeks for the experiment. The composition of the experimental diet is shown in Table 1.

Table 1. Diet compositions for the experimental groups (g/100 g diet)

	Normal	HC	HCPO-I	HCPO-II
Corn starch	39.80	38.55	33.55	28.55
Casein	20	20	20	20
Dextrin	13.2	13.2	13.2	13.2
Cellulose	5	5	5	5
Sucrose	10	10	10	10
Vitamin Mix.[1)]	1	1	1	1
Mineral Mix.[2)]	3.5	3.5	3.5	3.5
L-Cysteine	0.3	0.3	0.3	0.3
Choline bitartrate	0.2	0.2	0.2	0.2
Soybean oil	7	7	7	7
Cholesterol	-	1	1	1
Sodium cholate	-	0.25	0.25	0.25
Portulaca oleracea[3)]	-	-	5	10

Normal: group fed the normal diet by AIN-93G, HC: group fed the hypercholesterol diet, HCPO-I: group fed the hypercholesterol diet+5% of *Portulaca oleracea* powder, HCPO-II: group fed the hypercholesterol diet+10% of *Portulaca oleracea* powder.
[1,2)]Vitamin and mineral mixture by AIN-93G.
[3)]Lyophilized powder (80～100 mesh).

Measurement of food intake, body weight and food efficiency ratio

To calculate the daily food intake amounts during the experimental period, food was provided at 5 PM and any remaining amounts were measured at 10 AM the next day. Fresh tap water was supplied every day at the same time. Body weight was measured once a week at a fixed time. The food efficiency ratio (FER) was calculated as total body weight gain (g)/ total food intake amount (g) for 4 weeks.

Animal treatments

On the last day of the experiment, after fasting for 16 hr, all rats were anesthetized with diethyl ether and the blood was collected via the heart. Then, the collected blood was kept in cold water for about 30 min. and the serum was separated by centrifuge (Mega 17R, Hanil Science Industrial Co., Ltd., Incheon, Korea) at 3000 rpm for 15 min. Liver tissues of rat were excised rapidly, after the weight of the tissues was measured, and stored under -70°C. Feces were collected during the last three days of the experimental periods and dried at 50°C for 2 hr. in a drying oven before being blended for the analysis.

Determination of lipid levels in serum

Total lipid level was determined according to the method of Frings et al. (20). The serum was mixed with 200 μL concentrated H_2SO_4 in a boiling water bath for 10 min, then 10 mL of phospho-vanillin solution was added, and the mixture was incubated 37°C for 15 min, then measured at 540 nm, and olive oil (0～500 mg) was used as standard for calibration curve. The total cholesterol, triglyceride and high density lipoprotein cholesterol (HDL-C) were quantified by enzymatic assay using a commercial AM kit reagents (Asan Pharm., Seoul, Korea). The low density lipoprotein cholesterol (LDL-C) level was calculated by the Friedewald formula (21); total cholesterol−(HDL-C+triglyceride/5). The athero-

genic index (AI) was calculated according to the equation of total cholesterol − HDL-C)/HDL-C (22). The cardiac risk factor (CRF) was calculated according to the equation of total cholesterol/HDL-C (23).

Analysis of GOT, GPT, ALP and LDH activities

The activities of glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) in serum were individually measured with the commercial AM kit reagents (Asan Pharm.), respectively.

Determination of lipid levels in liver and feces

For the determination of lipid components in the liver tissue and feces, 0.5 g of liver tissue or 1 g of feces was homogenized with the Poter-Elvehjem tissue grinder (WOS01010, Daihan, Wonju, Korea) under the chloroform and methanol solution (C:M, 2:1, v/v), then stayed at 4°C for 24 hr (24). The C:M solution from the filtrate were dried by a rotary vacuum evaporator at 30～40°C for determination of total lipid, total cholesterol and triglyceride levels. Determination of the lipid profiles were evaluated using the commercial AM kit reagent (Asan Pharm.).

Determination of lipid peroxide in serum and liver tissue

1/12 N H_2SO_4 solution and 10% phosphotungstic acid were added to 100 μL serum, in order, then centrifuged at 4000 rpm for 10 min. The distilled water and thiobarbituric acid (TBA) reagent were mixed with the residue. The mixture was incubated in a 95°C water bath for 60 min and then rapidly cooled in the ice bath. The mixture was added to exactly *n*-butanol of 4 mL, and then centrifuged at 3000 rpm for 10 min. The absorbance of the butanol layer was spectrophotometrically measured at 532 nm (25). For determination of lipid peroxide content from liver tissue, the 10% homogenate was made by adding a 1.5% KCl solution to 1 g of liver tissue. 0.5 mL of the homogenate was added to 3 mL of 1% phosphoric acid and 1 mL of 0.6% TBA solution. The mixture was incubated in the water bath for 45 min at 95°C, and then cooled in the ice bath. Four mL of butanol was added, and color substances were transferred into the butanol layer before the optical density at 535 and 520 nm (26) was measured. The content was calculated from the calibration curve established by using 1,1,3,3-tetraethoxypropane (TEP, Sigma Co., St. Louis, MO, USA).

Statistical analysis

The results obtained were analyzed using SPSS program (version 12.0), and expressed as mean and standard deviations (SD). Statistical significance ($p<0.05$) among the groups were determined by one-way ANOVA followed by Duncan's multiple range test.

Table 2. Proximate compositions of lyophilized *Portulaca oleracea* powder (%)

	Portulaca oleracea
Moisture	5.14±0.05[2)]
Ash	18.97±0.05
Crude lipids	4.91±0.52
Crude protein	12.96±0.25
Crude fiber	31.35±3.96
Carbohydrate[1)]	26.67±4.83

[1)]100 − (sum of moisture, ash, crude lipids, crude protein and crude fiber).
[2)]Values are mean±SD (*n*=3).

RESULTS AND DISCUSSION

Nutritional components of purslane

The contents of moisture, ash, crude lipids, crude protein and crude fiber of the lyophilized purslane powder are shown in Table 2. The moisture content was 5.14%, while the content of crude lipids was the lowest at 4.91%, and the content of crude fiber was the highest at 31.35%. It was reported that the ash and crude lipids contents for dried purslane were 20.6% and 2.3%, respectively, while the crude protein and fiber contents were 15.0% and 15.8%, respectively (27). Except crude fiber, those results were similar to those of this study. The purslane tea made by roasting process showed about 7% moisture, 3.47% crude lipids, 20.82% crude protein and 54.78% crude fiber (28). Also, because the purslane shows differences for the nutrient components depending on its maturity, it is known that the intake of sprouts is effective in terms of minerals and the ω-3 fatty acids (29).

Since the dietary fiber could be prompt the elimination of bile, the lack of bile in body could be reproduced from dietary cholesterol and then the level of serum cholesterol could be decrease (30). Thus, we assume that the fiber of plants is the important substance for the lowering the lipid levels in body.

Body weight change, food intake and FER

The body weight change, food intake and FER for 4 weeks are shown in Table 3. The experimental groups were rearranged by the initial body weight between 220.00 g and 227.50 g before the feeding of the hypercholesterolemia-inducing diet. After 4 weeks on their diets, the final weight of all experimental groups showed no significant difference. However, the groups fed the purslane powder showed a slight loss compared to the HC group fed the hypercholesterol diet. In comparison with the HC group, the daily food intake showed a significant decrease only in the group fed the 10% purslane

Table 3. Changes of body weight, food intake and FER in the hypercholesterolemic rats administered with *Portulaca oleracea* powder

	Normal	HC	HCPO-I	HCPO-II
Initial body weight (g)	220.00±0.00[NS1)]	227.50±5.00	222.50±9.57	222.50±9.57
Final body weight (g)	358.75±14.36[NS]	375.00±40.41	360.00±29.44	347.50±44.25
Food intake (g/day)	18.28±0.91[ab]	19.12±0.46[b]	18.45±1.32[ab]	17.14±1.60[a]
Total body weight gain (g/4 weeks)	138.75±14.36[NS]	147.50±37.75	137.50±29.86	125.00±35.12
FER (food efficiency ratio)	29.04±2.39[NS]	29.16±6.77	28.58±5.22	25.70±4.93

[1)]Values are mean±SD (n=7).
[a,b]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.
NS: not significant.

(HCPO-II). The FER was not significantly different among the experimental groups. Therefore, we guess that the supplementation of 5～10% purslane powder in a hypercholesterol diet has no significant influence on the body weight loss of experimental rats.

Kim et al. (31) reported that when 10% mulberry leaf powder was added to hypercholesterolemic rats, the increased body weight and the reduction of the FER were dependent on the dietary fiber. In this study, the groups fed the purslane powder showed a significant reduction in terms of the daily food intake. The dietary fiber reduces the gastric emptying rate and makes it possible for people to feel full, while delaying the absorption and digestion of nutrients (32). Therefore, the reduction of food intake shown in the group fed the 10% purslane powder is thought to be the result of the higher content of fiber in the diet.

Serum lipid levels

The changes of serum lipid components, AI and CRF are shown in Table 4. The total lipid, total cholesterol, triglyceride and LDL-C levels increased significantly in the HC group in comparison with the normal group. Regarding the groups fed the purslane powder, as the amount of purslane powder increased, the lipid levels in serum significantly decreased. In the HCPO-II, the total lipid was reduced by 12.2%, total cholesterol by 26.2%, triglyceride by 41.1% and LDL-C by 41.6% as compared to the HC group. In particular, the total cholesterol and triglyceride levels showed a reduction to a level similar to that of the normal group. HDL-C levels for the HC group was significantly lower, by about 29.7%, than that for the Normal group. Even if HDL-C level is increased due to the feeding of purslane powder, it was significant only in the group fed the 10% purslane powder. The AI decreased significantly according to the amount of purslane powder added in comparison with the HC group, while the CRF showed a significant decrease only in the group fed the 10% purslane powder compared to the HC group.

Kwon and Song (18) showed the total cholesterol level decreased significantly when supplying 3% purslane powder in the hypercholesterol diet in comparison with the HC group, however there was no change regarding the triglyceride level. And they reported that the reduction of the total cholesterol level of serum is highly associated with the ω-3 fatty acid of purslane. In addition to having high levels of ω-3 fatty acid, purslane also has high levels of γ-linolenic acid, fiber and polyphenols (12), all of which have been shown to have a reducing effect on serum lipid levels (31,33). In particular, the ethanol extract of purslane also demonstrated a lowering effect of total lipid, total cholesterol and triglyceride levels in the serum of hypercholesterolemic rats (33).

Additionally, the reduction of LDL-C by the supplementation of 10% purslane powder within the hypercholesterol diet is expected to be effective for the prevention of arteriosclerosis and cardiovascular diseases, since an increase of serum LDL-C level is considered to be a stronger risk factor for the occurrence of cardiovascular diseases than the increase of the total choles-

Table 4. Effect of *Portulaca oleracea* powder on the lipid profiles, AI and CRF in serum of hypercholesterolemic rats

	Normal	HC	HCPO-I	HCPO-II
Total lipid (mg/dL)	205.98±6.59[a1)]	253.69±7.50[d]	241.85±10.56[c]	222.76±7.57[b]
Total cholesterol (mg/dL)	62.27±3.83[a]	92.50±3.98[c]	82.69±5.42[b]	68.29±6.72[a]
Triglyceride (mg/dL)	36.95±1.39[a]	68.44±3.37[c]	41.70±3.61[b]	40.29±2.36[ab]
HDL-C (mg/dL)	32.72±1.62[c]	22.99±1.13[a]	24.31±1.36[a]	27.64±2.05[b]
LDL-C (mg/dL)	22.16±3.66[a]	55.82±3.71[c]	50.04±4.71[c]	32.60±5.67[b]
AI (atherogenic index)	0.91±0.13[a]	3.03±0.24[d]	2.40±0.16[c]	1.47±0.16[b]
CRF (cardiac risk factor)	2.12±0.09[a]	3.26±0.65[c]	2.99±0.55[bc]	2.44±0.58[ab]

[1)]Values are mean±SD (n=7).
[a-d]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.

Table 5. Activities of GOT, GPT, ALP and LDH in serum of hypercholesterolemic rats administered with *Portulaca oleracea* powder (U/mL)

	Normal	HC	HCPO-I	HCPO-II
GOT	46.80±1.10[a1)]	56.00±1.41[b]	47.20±1.79[a]	47.20±1.10[a]
GPT	22.60±2.41[a]	33.20±3.63[c]	29.00±1.00[b]	23.60±2.61[a]
ALP	24.57±1.38[ab]	26.98±1.09[c]	25.98±0.99[bc]	23.89±1.51[a]
LDH	211.30±7.63[a]	311.88±11.41[d]	275.09±13.23[c]	245.02±5.73[b]

[1)]Values are mean±SD (n=7).
[a-d]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.

terol level. In fact, the reduction of LDL-C is emphasized more for the therapy of hyperlipidemia (34).

GOT, GPT, ALP and LDH activities in serum

The enzymatic activities for the hepatic function evaluation in hypercholesterolemic rats fed the purslane powder are shown in Table 5. The activities of GOT, GPT, ALP and LDH increased significantly in the HC group in comparison with the normal group. However, the groups fed the purslane powder showed a significant decrease in comparison with the HC group. GOT activity showed no significant difference according to the feeding amount of purslane powder. However, the activities of GPT, ALP and LDH decreased by 12.7%, 3.7% and 11.8%, respectively, regarding the feeding of 5% purslane powder in comparison with the HC group. Also, the group fed the 10% purslane powder showed the reductions of 28.9%, 11.5% and 21.4% to the HC group. In particular, the activities of GOT, GPT and ALP were recovered up to a similar level in the group fed the 10% purslane powder compared to the normal group.

The activities of GOT and GPT tend to increase according to the exogenous cholesterol contents from diet (35). Since these enzymatic activities in serum decreased significantly due to the supplementation of purslane powder in this experiment, it is expected that the adding of purslane powder to the hypercholesterolemic diet will be effective for the recovery of the hepatic function by the improvement of lipid metabolism or delaying the hepatic disorder. Also, the activity of LDH tends to increase due to the occurrence of hyperlipidemia with a high lipid diet and biliary blocking caused by the accumulation of lipid in liver tissue (36). In this experiment, the 5~10% supplementation of purslane powder in the hypercholesterolemic rats has shown the significant decrease of LDH activity, therefore, we suppose that it will be effective showing a closer relevance between the reducing of serum lipid levels and the excrete of bile.

Lipid levels of liver tissue

After 4 weeks of the purslane powder supplementation, the lipid levels of the liver tissue in the hypercholesterolemic rats are shown in Table 6. The total lipid level was 25.72 mg/g in the normal group, but it increased by about 5.4 times for the HC group. The groups fed the 5% and 10% of purslane powder showed a reduction of about 24.2% and 21.4%, respectively, for the total lipid level in comparison with the HC group. However, there was no significant difference caused by the amount of purslane powder added. The total cholesterol level in the HC group was significantly greater than that in the normal group, while the group fed the 5% of purslane powder showed no significant difference with the HC group. Only the group fed the 10% of purslane powder showed a significant decrease in total cholesterol. For the triglyceride level for liver tissue, the HC group showed a figure which was about 2.9 times higher than that of the normal group. However, when purslane powder was added, the difference was significantly decreased by 22~28%.

The polyphenol compounds of plants decrease the cholesterol level for liver tissue (37), showing a higher connection with the reduction of triglyceride level (38). In particular, when purslane powder is given, liver tissue tends to show a significant reduction compared to the HC group. It is also reported that purslane blocks the re-absorption of the bile acid and restrains the creation of endogenous cholesterol (23). The decline of cholesterol for liver tissue shown in this study is considered to be similar to that of Lee et al. (39), showing the reduc-

Table 6. Levels of total lipid, total cholesterol and triglyceride in liver tissue of hypercholesterolemic rats administered with *Portulaca oleracea* powder (mg/g, wet liver)

	Normal	HC	HCPO-I	HCPO-II
Total lipid	25.72±4.72[a1)]	139.56±1.26[c]	105.82±4.81[b]	109.69±2.49[b]
Total cholesterol	2.18±0.41[a]	2.87±0.13[b]	2.62±0.21[b]	2.28±0.31[a]
Triglyceride	12.25±3.46[a]	35.65±1.56[c]	27.81±2.41[b]	25.68±2.40[b]

[1)]Values are mean±SD (n=7).
[a-c]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.

Table 7. The fecal total lipid, total cholesterol and triglyceride levels of hypercholesterolemic rats administered with *Portulaca oleracea* powder (mg/g dried feces)

	Normal	HC	HCPO-I	HCPO-II
Total lipid	18.70±2.49[a1)]	49.80±4.30[b]	69.35±3.04[c]	73.88±3.13[d]
Total cholesterol	1.50±0.27[a]	8.36±1.12[b]	20.11±2.28[c]	23.15±2.29[d]
Triglyceride	1.44±0.12[a]	3.50±0.28[b]	7.85±0.91[c]	8.21±0.63[c]

[1)]Values are mean±SD (*n*=7).
[a-c]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.

Table 8. Lipid peroxide content in serum and liver tissue of hypercholesterolemic rats administered with *Portulaca oleracea* powder

	Normal	HC	HCPO-I	HCPO-II
In serum (mmol/mL)	28.35±4.36[ab1)]	30.21±2.82[b]	27.75±2.89[ab]	26.16±1.61[a]
In liver (mmol/g)	111.49±5.25[a]	195.05±8.23[c]	174.43±3.29[b]	169.89±2.59[b]

[1)]Values are mean±SD (*n*=7).
[a-c]Values in a row sharing the same superscript letter are not significantly different at $p<0.05$.

tion of the serum cholesterol level.

Fecal lipid levels

Fecal lipid levels were determined in the 4 groups of rats (Table 7). The total lipid, total cholesterol and triglyceride levels in feces were significantly higher in the HC group than the normal group. The fecal total lipid level in the groups supplemented with purslane powder was significantly increased compared to the HC group. These results show that the discharging level significantly increased as the amount of purslane powder increased. The fecal total cholesterol level increased significantly in the HC group compared to the normal group, while in the groups fed the purslane powder, the discharge level increased by 2.4～2.8 times more than the HC group. Triglyceride levels showed a result similar to that of total cholesterol.

In supplementation of 5% or 10% radish leaf powder in the hypercholesterolemic rat, the fecal total cholesterol increased by 86～107%, while the triglyceride level elevated by 119～126%. Such increases were caused by dietary fiber and flavonoids in the plants (40). Notably, quercetin, which is a kind of flavonoid, decreases the serum cholesterol and LDL-C level by suppressing the activity of the HMG-Co A reductase within liver tissue and controlling the formation of cholesterol in body (41). Quercetin increases the discharge level of sterol through feces (42). According to these results, the groups fed the purslane tend to discharge the total cholesterol and triglyceride through feces more than twice those of the HC group. Therefore, it seems that the reducing activity of lipid levels in the serum and liver tissue has a stronger relevance with the increase of fecal lipid levels.

Lipid peroxide in serum and liver tissue

The content of lipid peroxide in a serum and liver tissue for rats fed the purslane powder in a hypercholesterol diet is shown in Table 8. The lipid peroxide content of serum showed significant decline was only seen in the group fed the 10% purslane powder in comparison with in the HC group. The lipid peroxide content of liver tissue increased significantly in the HC group in comparison with the normal group. When purslane powder was given, the figure decreased significantly compared to the HC group.

Radicals, as a result of the oxidative stress by the feeding of hypercholesterol or hyperlipids, tend to cause the reaction of lipid peroxide within a human body. At this point, since polyphenolic compounds, flavonoids, vitamin C and E of ubiquitous plants play a strong role in antioxidant activities, it is known that such substances increase the activities of antioxidant enzymes in human body and suppression the reaction of lipid peroxide based on radicals (43). Groups fed persimmon leaf powder failed to increase the activities of antioxidant enzymes for red blood cells and liver tissue compared to the high cholesterol feeding group, however, the persimmon leaf powder-group showed positive results regarding the inhibitory activity of lipid peroxide for serum and liver tissue, because antioxidant substances such as flavonoids and vitamin E were directly used as eliminating agents of radicals (44). Among various purslane extracts from the different solvents, the fractions of ethyl acetate and butanol are considered to be capable of protecting liver tissue from being damaged, showing an excellent inhibitory activity of lipid peroxide for liver tissue (45). Furthermore, since purslane shows high contents of such antioxidants as ω-3 fatty acids, α-tocopherol, ascorbic acid, β-carotene, glutathione (46), polyphenolic compounds (8,12,13), and dietary fiber, purslane is believed to have an internal inhibitory activ-

ity of lipid peroxide and be effective for the decrease of lipid levels.

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