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Effects of *Coriandrum Sativum L.* on Lipid Metabolism in Rats with Hypertriglyceridemic Diet*

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ABSTRACT

This study was designed to investigate the effects of *Coriandrum Sativum L.* on lipid metabolism in rats with hypertriglyceridemia. Also, we compared the effects of the leaf, seed and root of *Coriandrum Sativum L.* on lipid metabolism in rats with hypertriglyceridemia. Hypertriglyceridemia was induced in 32 male Sprague-Dawley rats weighting 108 ± 13 g through the feeding of high-fat diets containing 20% fat and 5% cellulose for ten days. The rats were divided into four groups as follows: control (C), leaf (L), seed (S) and root (R) groups. For the five-week experimental period, the C group was fed the above diet and the L, S and R groups were fed *Coriandrum Sativum L.* diets containing 5% dry leaf, seed and root of *Coriandrum Sativum L.*, respectively. Intake of diet and weight gain were significantly lower in the C group than in the L, S and R groups. But there was no significant difference among the L, S and R groups. Because of weight differences among the groups, all obtained data was adjusted to weight. The level of plasma total cholesterol was not significantly different among the four groups. But after adjusting to weight differences, the level of plasma total cholesterol was significantly higher in the C group than in the other three groups. The level of plasma triglyceride was highest in the C group and lowest in the R group. But after adjusting to weight differences, the level of plasma triglyceride was significantly higher in the C group than in the other three groups. Photomicrographs of liver tissue showed higher fat accumulation in the C and R groups than in the L and S groups. These results suggest that dietary *Coriandrum Sativum L.* may increase appetite and have an inhibitory effect on the lipid metabolism of rats with hypertriglyceridemia. Also, those effects may be partly different (leaf, root and seed) from those of *Coriandrum Sativum L.*

KEY WORDS: coriander (*Coriandrum Sativum L.*), hypertriglyceridemia, plasma total cholesterol, morphology of liver.

INTRODUCTION

Coronary heart disease (CHD) is currently the leading cause of death among Koreans and was responsible for 26% of all Korean deaths in 1996.[1] High plasma lipids levels have been recognized as a risk factor in the development of CHD and the premature development of atherosclerosis. Recently there has been increased interest in the consumption of edible wild vegetables[2-7] because of increased awareness of the need to lower elevated plasma lipids in order to decrease the risk of developing coronary heart disease (CHD).

Coriander (*Coriandrum Sativum L.*) is one of the first spices used by humankind. The coriander plant yields two primary products that are used for flavoring purposes: fresh green herb and spice. The latter is the dried form of the whole mature seed capsule (fruit) but is frequently termed coriander seed in commerce. The herb is used for culinary flavoring purposes in Asia, the Middle East, and Central and South America. The fruit is important ingredients in curry powder. It is used as a pickling spice, seasoning and in the making of sausages, pastries, buns, cakes and other confections.[8-10]

As a medicinal plant, coriander has been used as an antispasmodic, carminative, stimulant, and stomachic. Coriander has also exhibited hypoglycemic activity. Chinese herbal medicine includes the use of coriander for measles, stomachache, nausea, hernia and is also used as a tonic. Seeds are sometimes used as a flavoring agent to improve the taste of other medicinal preparations.[11-13] Also, it stimulates the heart, improves circulation and helps eliminate toxins from the blood. It can encourage the production of estrogen, thus helping regulate the menstrual cycle and alleviate the symptoms of PMS.[14] Herbs containing coriander have properties to regulate the physiological function and there has been increased attention

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to the components of herbs.[8]

Koreans have long used coriander to tone down bitterness in certain foods and more recently they have used it in various vegetable dishes prepared in Buddhist temples[15] and in some restaurants.

Cultivation of coriander,[16] its flavor[17,18] and components[19] have been widely studied in Korea but research on the physiological effects of coriander has not been carried out here.

This study was meant to investigate the effects of *Coriandrum Sativum L.* on lipid metabolism in rats with hypertriglyceridemia. Also, we compared the effects of the leaf, seed and root of *Coriandrum Sativum L.* on lipid metabolism in rats with hypertriglyceridemia.

MATERIALS AND METHODS

1. Animals and diet

Coriandrum Sativum L. (coriander) was obtained from Sunchun, Chollanam-do, Korea, divided into leaf, seed and root, dried in the shade and powdered through 60 – 80 mesh. Hypertriglyceridemic was induced in 32 male Sprague-Dawley rats weighting 108 ± 13 g through the feeding of high-fat diets containing 20% lard (w/w) for 10 days. The condition was confirmed by determination of plasma triglyceride level before the rats were randomly divided into four groups: hypertriglyceridemic control group for control (C) and three experimental coriander treated groups. Each group consisted of eight rats. For the five-week experimental period, the C group was fed the above diet and the L, S, and R groups were fed coriander diets containing 5% dry leaf, seed and root of *Coriandrum Sativum L.*, respectively (Table 1). During the experimental period, the rats were housed in a laboratory maintained at a constant temperature (22 ± 2℃) with a controlled 12-hr light/dark cycle. The animals were given free access to food and water during the entire experimental period.

Table 1. Composition of control diet and experimental diet for hypertriglyceridemic rat

Ingredient	Control[1]	Experimental[2]		
		Leaf	Seed	Root
Casein	20.0	20.0	20.0	20.0
D,L-methionine	0.3	0.3	0.3	0.3
Corn starch	15.0	15.0	15.0	15.0
Sucrose	32.5	32.5	32.5	32.5
Corn oil	5.0	5.0	5.0	5.0
Lard	20.0	20.0	20.0	20.0
Mineral mix.[3]	1.0	1.0	1.0	1.0
Vitamin mix.[4]	1.0	1.0	1.0	1.0
Cholin bitratrate	0.2	0.2	0.2	0.2
Cellulose powder	5.0	–	–	–
Coriandrum S. L. Leaf powder	–	5.0	–	–
Coriandrum S. L. Seed powder	–	–	5.0	–
Coriandrum S. L. Root powder	–	–	–	5.0

1) *Control diet: high cholesterol diet*
2) *Coriandrum S.* L diet: high cholesterol diet + *Coriandrum S.* L powder (leaf, seed and root)
3) AIN mineral mixture 76 (American Institute of Nutrition. Report of the AIN Ad Hoc Committee on standards for nutritional studies. J Nutr 107: 1340-1348, 1977)
4) AIN vitamin mixture 76-A contained (in g/kg mixture): thiamin HCL, 0.6: riboflavin, 0.6: pyridoxine HCl, 0.7: nicotinic acid, 0.003: D-calcium pantothenate, 0.0016: folate, 0.2: D-biotin, 0.02: cyanocobalamin, 0.001: retinyl palmitate premix, 0.8: DL-alpha tocopheryl acetate premix, 20: cholecalciferol, 0.0025: menaquinone, 0.05: antioxidant, 0.01: sucrose fineyl powedered, 972.8

2. Biochemical analysis

After the experimental period, the animals were anesthetized following a 15-hr fast. Blood samples were collected from the cardic, which was punctured by heparinized syringe, centrifuged at 4℃, 3000 rpm for 30 min and serum was separated and stored at −40℃ until assayed. Liver, heart, kidney, spleen, testicles and pancreas were removed and rinsed with saline solution, wiped with paper towel and stored at −40℃ until assayed. Small portions of liver were separately fixed in 10% formalin solution in preparation for light microscope observation.

Plasma total cholesterol, HDL-cholesterol and triglyceride were measured using enzymatic kit (Eiken Co., Japan). Hepatic lipids were extracted using method of Folch *et al.*[20] Cholesterol was measured colorimetrically and triglyceride was measured using enzymatic kit (Eiken Co., Japan) with the aid of detergent, triton X-100. The thiobarbituric acid reactive substances (TBARS) level of plasma and liver were measured using Buege *et al.*[21] method.

For microscope viewing of the liver tissue, liver sections were stored in 10% formalin solution and exchanged with fresh solution daily until staining. Specimens (4 μm thickeness) stained with Catalano-Lillie's oil red O were observed under 200 times magnification through a light microscope.

3. Statistical analysis

All values are expressed as group means ± SD. Significance of difference was determined by students t-test or analysis of variance (ANOVA) with Duncan's multiple range test using SAS version 6 (SAS Institute, Cary, NC, USA). $p < 0.05$ was considered significant.

RESULTS

1. Food consumption, weight gain and feeding efficiency ratios

As shown in Table 2, there was a significant difference in daily food intake among the four experimental groups. Daily food intake was lowest in the control group and highest in the root group. Weight gain of the control group was significantly lower than that of the coriander groups. It was highest in the seed group but there was no statistical difference among the L, S and R groups. Feeding efficiency of coriander diets was significantly higher than that of the control group and there were statistical differences among the L, S and R groups.

2. Organ weights

Table 3 shows organ weights of the four experimental groups. Excluding the weight of the testicles, the organ weights of the control group were significantly lower than those of the other groups. But there were no significant differences among the L, S and R groups. The weight gain of the organs in the control group was significantly lower than those of the other groups, as shown in Table 2. There was no significant difference among the L, S and R groups in terms of organ weight.

3. Effects of dietary coriander on plasma and liver lipids

Table 4 shows plasma lipid levels of the experimental groups. Levels of total cholesterol slightly decreased among those fed the L, S and R diets compared to the control (5% cellulose) diet. But there were no significant differences in levels of plasma total cholesterol among the control and experimental groups. But after adjusting to weight differences, the level of plasma total cholesterol was significantly higher in the C group than in the other three groups. Plasma levels of HDL-cholesterol significantly decreased in R diet compared with the control, L and S diets. The control, L and S coriander groups did

Table 2. Food consumption, weight gain, feeding efficiency ratios in hypertriglyceridemic rat fed the experimental diets for 4 weeks

Variables	Control	Leaf	Seed	Root
Daily food intake (g/day)	12.30 ± 1.30^{c}	13.85 ± 0.49^{b}	14.23 ± 0.85^{ab}	15.10 ± 0.27^{a}
Weight gain (g/day)	3.18 ± 0.43^{b}	4.42 ± 0.81^{a}	4.88 ± 0.42^{a}	4.42 ± 0.21^{a}
Food efficiency (%)	25.88 ± 3.26^{b}	32.02 ± 6.14^{b}	34.34 ± 2.20^{ab}	29.57 ± 1.58^{a}

Values are mean ± standard deviation
Values with different superscript (s) in the same row (s) are significantly different by Duncan's multiple range test at $p < 0.05$

Table 3. Organ weights in hypertriglyceridemic rat fed the experimental diets for 4 weeks

Variables	Control	Leaf	Seed	Root
Liver (g)	6.54 ± 0.74^{b}	8.27 ± 0.72^{a}	8.75 ± 0.89^{a}	8.28 ± 0.56^{a}
Heart (g)	0.85 ± 0.10^{b}	1.06 ± 0.08^{a}	1.06 ± 0.08^{a}	1.07 ± 0.02^{a}
Kidney (g)	1.90 ± 0.17^{b}	2.04 ± 0.10^{ab}	2.09 ± 0.13^{ab}	2.12 ± 0.13^{a}
Spleen (g)	0.48 ± 0.09^{b}	0.61 ± 0.09^{a}	0.57 ± 0.06^{ab}	0.59 ± 0.03^{a}
Testicles (g)	3.14 ± 0.25^{ns}	3.27 ± 0.19	3.31 ± 0.25	3.18 ± 0.16
Pancreas (g)	0.68 ± 0.18^{b}	1.02 ± 0.21^{a}	0.94 ± 0.13^{a}	1.05 ± 0.14^{a}
Liver (g/wt)	2.73 ± 0.18	2.90 ± 0.35	2.83 ± 0.40	2.85 ± 0.22
Heart (g/wt)	0.35 ± 0.01	0.37 ± 0.05	0.34 ± 0.04	0.37 ± 0.01
Kidney (g/wt)	0.80 ± 0.05	0.71 ± 0.07	0.68 ± 0.06	0.73 ± 0.04
Spleen (g/wt)	0.20 ± 0.02	0.22 ± 0.04	0.18 ± 0.03	0.20 ± 0.01
Testicles (g/wt)	1.30 ± 0.08	1.15 ± 0.12	1.07 ± 0.10	1.10 ± 0.04
Pancreas (g/wt)	0.28 ± 0.05	0.36 ± 0.06	0.30 ± 0.04	0.36 ± 0.04

Values are mean ± standard deviation
Values with different superscript (s) in the same row (s) are significantly different by Duncan's multiple range test at $p < 0.05$

Table 4. Plasma lipid levels in hypertriglyceridemic rat fed the experimental diets for 4 weeks

Variables	Control	Leaf	Seed	Root
Triglyceride (mg/dl)	57.2 ± 23.1^{a}	36.5 ± 11.5^{b}	33.7 ± 10.5^{b}	32.3 ± 14.4^{b}
Total cholesterol (mg/dl)	118.6 ± 9.4^{ns}	115.6 ± 14.0	102.1 ± 12.3	116.4 ± 24.0
Total chol/wt.gain(mg/dl)	37.56 ± 5.11^{a}	26.74 ± 4.41^{b}	21.09 ± 3.53^{b}	26.16 ± 5.98^{b}
HDL-cholesterol (mg/dl)	69.0 ± 7.9^{a}	66.3 ± 10.0^{a}	64.1 ± 6.9^{ab}	55.1 ± 5.8^{b}
LDL-cholesterol (mg/dl)	38.15 ± 10.11^{b}	41.95 ± 13.92^{ab}	31.33 ± 7.96^{b}	54.80 ± 26.81^{a}
VLDL-cholesterol (mg/dl)	11.44 ± 4.61^{a}	7.29 ± 2.29^{b}	6.75 ± 2.09^{b}	6.46 ± 2.88^{b}
HDL-C/Total-C	0.59 ± 0.08^{ab}	0.58 ± 0.09^{ab}	0.63 ± 0.04^{a}	0.49 ± 0.15^{b}
AI†	0.74 ± 0.25^{b}	0.77 ± 0.29^{b}	0.60 ± 0.11^{b}	1.14 ± 0.54^{a}

Values are mean ± standard deviation
Values with different superscript (s) in the same row (s) are significantly different by Duncan's multiple range test at $p < 0.05$
† [(Total-C)-(HDL-C)]/HDL-C

not significantly differ in this area. HDL-cholesterol levels relative to total-cholesterol (HDL/TChol) were 0.59 ± 0.08 in control group, and 0.58 ± 0.09, 0.63 ± 0.04 and 0.49 ± 0.15 in L, S and R groups, respectively. The figure was highest in those fed the S diet. Plasma triglyceride levels, which tended to be higher in the control group compared to those fed the coriander diet, were significantly (36 – 43%) lower in the three coriander groups than in the control group.

Hepatic cholesterol concentrations dropped about 12 – 55% by using the coriander diets, as shown in Table 5. Cholesterol levels in the liver were significantly reduced in all coriander groups compared with the control group. Liver triglyceride levels were significantly (20% and 27%) lower in groups fed the 5% seed and root of coriander powder diets, respectively. There were no significant differences in levels of hepatic total lipids among those fed the C and S diets. The corresponding figures for those fed the L and R diet significantly increased.

4. Levels of plasma and liver TBARS

Lipid peroxide contents in plasma and the liver were estimated by measuring thiobarbituric acid reactive substances (TBARS). Table 6 shows levels of plasma and liver TBARS of four experimental groups.

Levels of TBARS were 2.64 ± 1.02 nmol/mg protein in control group, and 2.19 ± 0.4, 2.01 ± 0.58 and 2.30 ± 0.89 nmol/mg protein in L, S and R groups, respectively. Plasma TBARS levels were slightly higher among those fed the L, R and S diets compared with those given the control diet. But there were no significant differences in levels of plasma TBARS among the control and experimental groups.

Hepatic TBARS levels were 1.76 ± 0.52 nmole/mg protein in control group, 1.90 ± 0.52 nmole/mg protein in L group, 1.99 ± 0.43 nmole/mg protein in S group and 2.15 ± 0.35 nmole/mg protein in R group. In contrast to the figures recorded for plasma TBARS levels, liver TBARS levels significantly increased in all coriander groups compared with the control group.

5. Morphological observations

The morphological lesions found in the rat livers are illustrated in Fig. 1. Photomicrographs of liver tissue in the four experimental groups did not show differences in the content of fat and size of fat globular. In the control, L and S groups, fat was scattered in the central vein in the liver, but in the R group it was distributed in the porta hepatis. These results suggest that dietary *Coriandrum Sativum L.* may have an inhibitory effect on the lipid metabolism of rats with hypertriglyceridemia. Also, those effects were different between those fed the leaf, seed and root diets and those given *Coriandrum Sativum L.*

DISCUSSION

In this study, feed efficiency significantly increased in the coriander groups compared to the control groups, with the L and S groups showing higher levels than the R group. Coriander stimulates the production of gastric juices, tones the stomach, improves digestion, relaxes the muscles of the digestive tract and stimulates the appetite.[14] Also, when fed a diet with powder of green tea,[3] food intake, weight gain and feed efficiency increased compared with the results found among those in the control group. And the green tea stimulated HCl secretion and increased appetite. Moreover, coriander was used as an herb in high-fat diets, especially Chinese food dishes.[12] The apparent effectiveness of coriander in inducing increased food intake and boosting weight was more likely the result of strong flavor.

From these results, we anticipate that coriander may in-

Table 5. *Hepatic lipid levels in hypertriglyceridemic rat fed the experimental diets for 4 weeks*

Variables	Control	Leaf	Seed	Root
Total lipid (mg/g)	66.11 ± 53.04^{c}	88.36 ± 101.66^{a}	59.03 ± 34.36^{c}	73.74 ± 17.38^{b}
Triglyceride (mg/g)	11.78 ± 2.02^{a}	9.97 ± 2.15^{ab}	8.16 ± 1.71^{b}	7.46 ± 2.29^{b}
Cholesterol (mg/g)	15.06 ± 2.53^{a}	13.13 ± 2.99^{ab}	9.79 ± 3.19^{bc}	6.69 ± 1.63^{c}

Values are mean ± standard deviation
Values with different superscript (s) in the same row (s) are significantly different by Duncan's multiple range test at $p < 0.05$

Table 6. TBARS levels in hypertriglyceridemic rat fed the experimental diets for 4 weeks

Variables	Control	Leaf	Seed	Root
Plasma TBARS (nmole/mL)	2.64 ± 1.02^{ns}	2.19 ± 0.4	2.01 ± 0.58	2.30 ± 0.89
Hepatic TBARS (nmole/mg protein)	1.76 ± 0.52^{ns}	1.90 ± 0.52	1.99 ± 0.43	2.15 ± 0.35

Values are mean ± standard deviation
Values with different superscript (s) in the same row (s) are significantly different by Duncan's multiple range test at $p < 0.05$

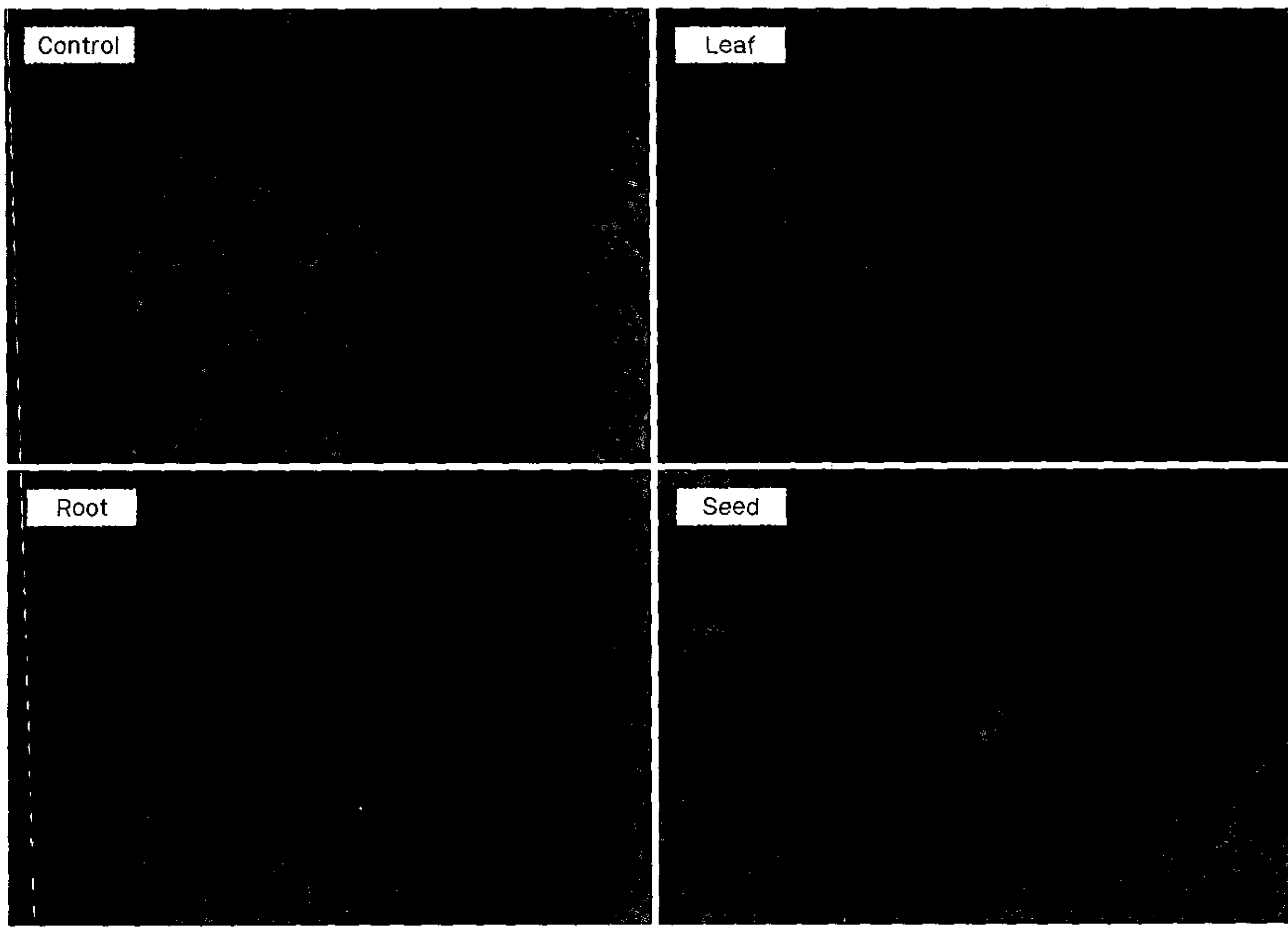

Fig. 1. The liver morphology of experimental groups.

crease the appetite.

With the exception of testicles, organ weights in the coriander group were significantly higher than those of the control group. This result indicates that the increased organ weight affected on the weight gain because it was fed with high triglyceride diet.

In this study, hypotriglyceridemic and hypocholesterolemic effects were clearly shown among those in the L, S and R groups given coriander powder. Coriander can exert a lipid-lowering effect above a certain level of plasma and hepatic triglyceride and cholesterol. This result is consistent with those in other reports that dealt with diets that included gamyip, nokchayip and solyip[3] powder from pine pollen,[4] powder of mugwort[2,5,6] and leaf and root of Godulbaegui.[7] These studies showed that the level of HDL-cholesterol increased, but those given the 5% coriander powder diet did not experience a higher HDL-cholesterol. The hypocholesteroelmic effects of powder parts from various plants and they concluded that active materials were soluble fiber[2-7,23,24] chlorophyll[25] and vegetable sterol.[22,26-29] By reducing the enterohepatic circulation of bile acids, blood cholesterol concentrations were decreased.[23,24] Therefore, in this study the hypolipidemic effect of coriander (L and S) is speculated fibers and it was may be due to reduced LDL or VLDL-cholesterol and fecal excretion of bile acid and cholesterol were increased. Epidemiologic studies have demonstrated that a high cholesterol diet is atherogenic and plasma HDL-cholesterol concentrations are inversely correlated with CHD. Recently, high plasma triglyceride and low plasma HDL-cholesterol level have been cited as risk factors in atherosclerosis. Therefore, Americans and Europeans established new clinical guidelines to prevent CHD. Although plasma HDL-cholesterol levels did not increase, the effectiveness of coriander at lowering triglyceride and total cholesterol levels among the L and S groups is good evidence of its effectiveness in the treatment and prevention of CHD.

Lipid peroxidation has received much attention in food science, nutrition and clinical medicine because its products are related to food deterioration, cytotoxicity and a number of pathological reactions involved in the etiology of degenerative disease.[30]

It is well known that the TBARS levels were lower in those fed a diet with antioxidant-containing materials. In the present results, the effect of lowering the TBARS levels in plasma was clearly shown among the L, S and R groups fed coriander powder. But the effect of lowering the TBARS levels in the liver was not shown. Cha Jae Young *et al.*[31] reported that extract from Morus alba did not decrease the TBARS level. To fed diet with powder from gamyip and nokchayip,[3] the levels of plasma were decreased and also hepatic TBARS were decreased. It was due to vitamin E in gamyip and it is directly affected in lipid peroxidation in liver. In nokchayip, they have an anti- oxidants as like flavonoids, phenolic acid, β-carotene and vitamin C and they increased the enzyme activity in related antioxidation. Also, herbs and coriander contain antioxidative materials in the leaf, seed and root.[12] This means that coriander can exert an antioxidative effect on a certain level of plasma. Coriander leaf, in particular, may have an effect on the lipid peroxide contents in plasma.

The morphological lesions in the rat liver were not shown clearly among those fed the coriander diet. But dietary coriander had an effect on the content and size of fat droplets. This is consistent with Lee Young-Ju *et al.*,[4] which dealt with a diet of powder from pine pollen, where it was found that fat slightly inhibited accumulation in the liver. This may be due to a decrease in the level of triglyceride and cholesterol in plasma and the liver.

In conclusion, the use of coriander increased the food efficiency. It reduced the level of total cholesterol and triglyceride in plasma and the liver, but did not increase the plasma HDL-cholesterol level. It was more helpful in reducing triglyceride than cholesterol. It reduced the levels of TBARS in plasma and arrested somewhat the accumulation of fat in the liver.

These results show that dietary *Coriandrum Sativum L.* may increase the appetite and have an inhibitory effect on the lipid metabolism of rats with hypertriglyceridemia. These effects are partly different (leaf, seed and root) from those of *Coriandrum Sativum L.* Coriander leaf and seed are helpful in the prevention and treatment of CHD.

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