

Effect of Red Pepper Seeds Powder on Lipid Composition in Rats Fed High-Fat · High-Cholesterol Diets

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Abstract

The purpose of the present study was to evaluate the effects of red pepper seeds powder on lipid metabolism in rats fed high fat · high cholesterol diet. Rats were divided into five experimental groups: normal diet group, high fat · high cholesterol diet group, high fat · high cholesterol diet with 5% red pepper seeds powder supplemented group (SA group), high fat · high cholesterol diet with 10% red pepper seeds powder supplemented group (SB group) and high fat · high cholesterol diet with 15% red pepper seeds powder supplemented group (SC group). The serum triglyceride (TG) and cholesterol contents, and LDL-cholesterol and atherogenic index (AI) of the red pepper seed powder supplemented groups were significantly decreased compared to the HF group. The serum HDL-cholesterol contents of the red pepper seed powder supplemented groups were increased compared to the HF group. However, there was no significant difference in the serum HDL-cholesterol among all experimental groups. The hepatic TG and cholesterol contents of the red pepper seed powder supplemented groups were significantly decreased compared to the HF group. The fecal total cholesterol and triglyceride contents of the red pepper seeds powder supplemented groups were significantly increased compared to the HF group. These results suggest that supplementation of red pepper seed powder may have a pronounced impact on markers of lipid metabolism in serum and liver of rats fed high fat · high cholesterol diets.

Key words: red pepper seeds powder, high cholesterol, triglyceride, lipid, atherogenic index

INTRODUCTION

With the recent westernization of Korean dietary habits, calorie and fat intakes have increased and that of dietary fiber and phytochemicals has decreased. Accordingly the risk factors of developing diseases such as obesity, cardiovascular disease, diabetes mellitus, hypertension and cancer have abruptly increased, raising complex social issues (1). Consequently, studies are being conducted to identify the treatment protocols and functional foods that can prevent and treat the above diseases (2-5). In association with triglycerides and cholesterol, both of which are major causative factors of these diseases, new studies have recently been conducted to determine the efficacy of seeds from food plants (6-11). Of these, safflower seed powder and extracts have been reported (8,12) to have excellent effectiveness for improving lipid metabolism in the plasma and liver of high cholesterol-fed and ovariectomized rats. Grape seed has been reported to have various physiologic functions such as the lowering of serum cholesterol, anti-hypertensive effects and anti-inflammatory effects (13,14). Additionally, green

tea seeds have excellent anti-oxidative (15) effects as well as an excellent profile of health promoting activities. Red pepper has been used as a raw material in many Korean traditional preparations since ancient times. Capsicum spices such as hot pepper are important culinary plants and are used worldwide in food and medicines. Specifically, red pepper has been shown to increase plasma catecholamine levels, induce lypolysis (16) and reverse the effects of a high fat diet on body weight and blood and tissue lipid levels (17). Evidence from several studies indicates that garlic can normalize plasma lipid levels (18-20), enhance fibrinolytic activity (21), inhibit, platelet aggregation (22) and reduce blood pressure (23) and blood glucose (24). Dried pepper seeds are less than 10% water, 15~17% of protein 25~30% lipid and 35~40% fiber and they are often used in oil. Pepper seed oil is 68~72% of linoleic acid, 13~15% palmitic acid and 9~11% oleic acid. In recent years, studies (25) have examined the anti-mutagenic effects and anti-cancer effects of red pepper. However, the number of studies on red pepper seeds is negligible, particularly regarding the mechanisms by which red pepper

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seeds affect cholesterol and lipid metabolism.

This study examined the improvement of lipid metabolism by feeding rats a high fat · high cholesterol diet containing red pepper seed powder and then observing the changes in lipid metabolism in the serum and livers.

MATERIALS AND METHODS

Preparation of red pepper seeds powder

Red pepper seeds used in this experiment were cultivated at Andong and harvested in 2007, after harvest red pepper seeds were sent to Namandong agricultural cooperative, where they were dried immediately using hot-air at the temperatures of 85~90°C. The dried pepper sample was shattered in a grinder (Desung power mixer/grinder DA-280G, Seoul, Korea) and separated, after which the shattered pepper seeds were placed in cold storage for future use.

Experimental animals and diet

Sprague-Dawley male rats weighing 100 ± 10 g were purchased from KRITC (Daejeon, Korea). Rats were individually housed in stainless steel cages in a room with controlled temperature (20~23°C) and lighting (alternating 12 hr periods of light and dark). Rats were divided into five experimental groups: normal diet group, high fat · high cholesterol diet group, high fat · high cholesterol diet with 5% red pepper seed powder supplemented group (SA group), high fat · high cholesterol diet with 10% red pepper seed powder supplemented group (SB group) and high fat · high cholesterol diet with 15% red pepper seed powder supplemented group (SC group) (Table 1). The rats were fed the experimental diets for a period of 4 weeks. The experimental design was approved by the committee of Korea International University for the care and use of laboratory animals.

Measurement of triglyceride, cholesterol concentrations in serum, liver and fecal

A colometric kit (Asan Co., Korea) was used to measure serum levels of triglyceride (TG), total cholesterol, and HDL-cholesterol. Serum LDL-cholesterol was calculated by the Friedewald formula (26) {total cholesterol - (HDL-cholesterol + TG/5)} and the atherogenic index (AI) was calculated as {9 total cholesterol - HDL-cholesterol} / HDL-cholesterol (27). Liver and fecal lipids were extracted by the Folch method (28) and the triglyceride and cholesterol concentrations were analyzed by the same methods as for serum. Absorbance was measured at 550 nm and 500 nm, respectively after removing the turbidity that may occur at the time of the color reaction in the course of combining 0.5% triton X-100 and

Table 1. Compositions of experimental diets (g/kg diet)

Ingredients	Groups ¹⁾				
	N	HF	SA	SB	SC
Corn starch	539	429	379	329	279
Casein	200	200	200	200	200
Sucrose	100	100	100	100	100
Corn oil	60	60	60	60	60
Mineral mixture ²⁾	35	35	35	35	35
Vitamin mixture ³⁾	10	10	10	10	10
Cellulose	50	50	50	50	50
DL-methionine	3	3	3	3	3
Choline chloride	3	3	3	3	3
Lard	—	100	100	100	100
Cholesterol	—	10	10	10	10
Red pepper seeds ⁴⁾	—	—	50	100	150
Total	1000	1000	1000	1000	1000

¹⁾N: normal diet, HF: high fat diet, SA: high fat diet + 50 g red pepper seeds powder (5%), SB: high fat diet + 100 g red pepper seeds powder (10%), SC: high fat diet + 150 g red pepper seeds powder (15%)

²⁾AIN-76 mineral mixture (g/kg mixture).

³⁾AIN-76 vitamin mixture (g/kg mixture).

⁴⁾Red pepper seeds: Andong.

3 mM sodium cholate in the fixed quantity of lipid in liver tissue, as the emulsifier for the sample enzyme liquid for measuring triglyceride and cholesterol by the modified methods of Sale et al. (29).

Statistical analysis

Results were analyzed by ANOVA and Tukey's honestly significant difference test (30). Statistical significance is defined as $p < 0.05$.

RESULTS AND DISCUSSION

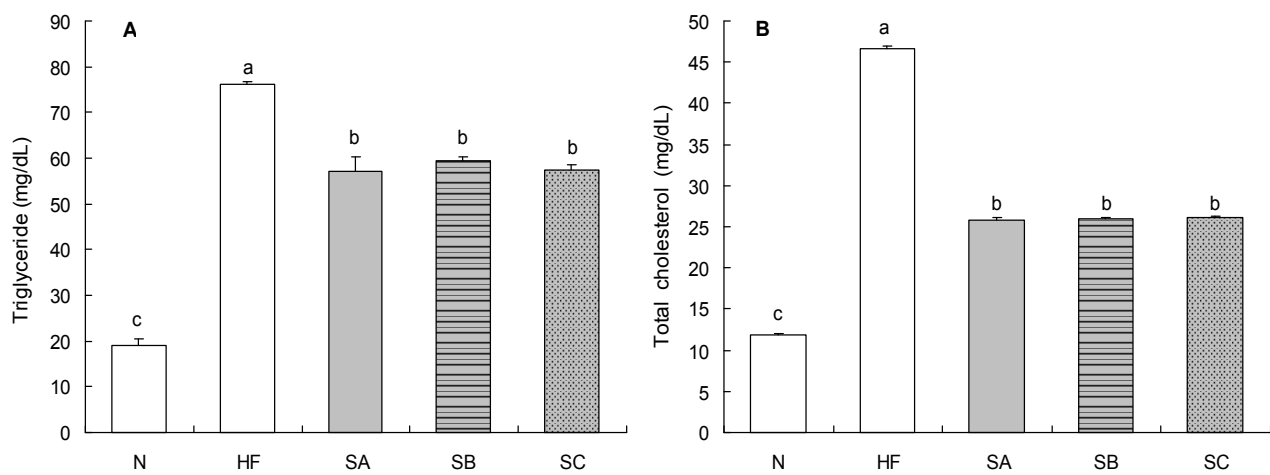
Serum triglyceride, total cholesterol, HDL-cholesterol, LDL-cholesterol and atherogenic index

Serum lipids and AI are shown in Table 2. The serum TG contents of the red pepper seed powder supplemented groups were significantly decreased compared to the HF group. Especially, the SC group was similar to that of the normal group. The serum total cholesterol contents of the SA, SB and SC groups were lower, respectively by 27%, 38% and 39%, than that in the HF groups, the SC group was not significantly different from the N group. No significant difference was found in the HDL-cholesterol between the experimental groups. The LDL-cholesterol in the HF group was 21.5% greater than that of the N group, but was lower in the SB and SC groups than in the SA group. The AI in the HF group was 25.4% greater than that in the N group, whereas there were no differences between the SA, SB and SC groups and the N group. The concentration of serum LDL-cholesterol could be a major indicator of arterio-

Table 2. Effects of red pepper seeds on serum triglyceride, total-cholesterol, HDL-cholesterol, LDL-cholesterol and atherogenic index levels of rats fed high fat · high cholesterol diets

Group	Triglyceride	Total-cholesterol	HDL-cholesterol	LDL-cholesterol	AI
	(mg/dL)				
N	48.30 ± 4.27 ^d	64.39 ± 4.14 ^c	33.23 ± 5.91 ^{NS}	28.52 ± 3.13 ^c	1.14 ± 0.40 ^b
HF	85.70 ± 6.01 ^a	111.8 ± 12.86 ^a	29.25 ± 6.31	61.53 ± 7.21 ^a	2.89 ± 0.42 ^a
SA	66.91 ± 1.33 ^b	81.44 ± 4.70 ^b	33.61 ± 8.46	35.85 ± 4.05 ^b	1.43 ± 0.39 ^b
SB	63.45 ± 3.03 ^{bc}	69.58 ± 4.66 ^{bc}	35.20 ± 4.57	24.42 ± 4.71 ^c	1.06 ± 0.37 ^b
SC	58.15 ± 4.16 ^{cd}	68.17 ± 3.76 ^c	35.33 ± 6.19	26.56 ± 3.54 ^c	1.11 ± 0.39 ^b

Values are the means ± SE (n=10). Means with different superscript letters within the same column are significantly different at $p < 0.05$ by Tukey's test. The experimental groups are the same as in Table 1. NS: not significant.

**Fig. 1.** Effects of red pepper seeds on liver triglyceride (A) and total cholesterol (B) levels of rats fed high fat · high cholesterol diet. Values are the means ± SE (n=10). Means with different superscript letters are significantly different at $p < 0.05$ by Tukey's test. The experimental groups are the same as in Table 1.

sclerosis, which is closely associated with AI. This might be due to the actions of dietary fibers present in the seeds of red pepper, which lower the concentrations of serum triglyceride and cholesterol. These results are in agreement with a previous report by Kaewprasert (31) et al., who found that undigested water-soluble dietary fibers lower the concentration of serum cholesterol.

Hepatic triglyceride and total-cholesterol concentrations

Hepatic triglyceride and total-cholesterol were measured, as shown in Fig. 1. The TG and total cholesterol of livers in the red pepper seed groups were significantly lower than that of the HF group. However, there were no significant differences among the red pepper seed groups. Since lipid metabolism mainly occurs in the liver, fat is being persistently introduced. Unless the triglycerides that are synthesized in the liver are removed, fat will be accumulated in the liver, leading to the occurrence of fatty liver. These phenomena can also be seen following the intake of a high-lipid diet (32,33). Accordingly, it is considered that red pepper seeds are effective not only for decreasing obesity, high blood sugar and fatty liver caused by a high-fat · high-cholesterol diet,

but also for reducing the risk of cardiovascular disease by controlling cholesterol content in the tissues and serum.

Fecal total lipid, triglyceride and total-cholesterol concentrations

Fecal total lipid, triglyceride and total-cholesterol were measured, as shown in Table 3. The fecal total lipid and cholesterol contents of the HF, SA, SB and SC groups were significantly greater than that of the N group. However, there were no significant differences among the

Table 3. Effects of red pepper seeds on fecal total lipid, triglyceride and total cholesterol contents in rats fed high fat · high cholesterol diets (mg/dL)

Group	Total lipid	Triglyceride	Total cholesterol
N	40.00 ± 15.97 ^b	9.50 ± 2.34 ^c	7.80 ± 0.26 ^c
HF	149.0 ± 29.23 ^a	18.67 ± 1.23 ^b	30.45 ± 1.69 ^b
SA	138.5 ± 28.86 ^a	19.93 ± 4.34 ^b	34.12 ± 2.68 ^b
SB	163.0 ± 21.04 ^a	43.78 ± 11.85 ^a	39.42 ± 8.18 ^b
SC	162.0 ± 10.60 ^a	42.22 ± 8.97 ^a	46.72 ± 6.03 ^a

Values are the means ± SE (n=10). Means with different superscript letters within the same column are significantly different at $p < 0.05$ by Tukey's test. The experimental groups are the same as in Table 1.

HF groups. The fecal TG was 23.5% and 22.6% greater in the SB and SC groups, respectively than in the HF group. The fecal TG contents of SB and SC groups were significantly greater than in the SA group, which may have been due to the abundant amount (40~60%) of dietary fiber present in the seeds of red peppers. According to Vahouny et al. (34), various types of dietary fiber impair the reabsorption of cholesterol and bile acid in the small intestine of white rats, resulting in their excretion. These results indicate that the powder of red pepper seeds promoted the excretion of TG and cholesterol into the stool, thereby suppressing the absorption of dietary fat. As a result, the significant decrease in lipid metabolism might have occurred due to the introduction of red pepper seed powder in serum and liver tissue.

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