Nutraceuticals & Food
Vol. 7, p.162~167 (2002)

Nutraceuticals and Food

Red Pepper Powder and *Kimchi* Reduce Body Weight and Blood and Tissue Lipids in Rats Fed a High Fat Diet

Sun-Mi Choi, Young-Soo Jeon, Sook-Hee Rhee and Kun-Young Park†

Department of Food Science and Nutrition, and Kimchi Research Institute, Pusan National University, Busan 609-735, Korea

Abstract

The effect of red pepper powder (RPP) or *kimchi* on body weight and blood and tissue lipids was evaluated in male Sprague-Dawley rats fed a high fat diet (HFD). RPP (0.006% capsaicin) diet contained 5% RPP in HFD; the *kimchi* diet was 10% *kimchi* (50% RPP by dry weight) in HFD. Food consumption of the RPP and *kimchi* diet groups was not different than the normal or HFD groups, but final body weights were significantly lower than the HFD group ($p<0.05$) after 4 weeks on the RPP or *kimchi* diets. The weights of liver, epididymal fat pad and perirenal fat pad in RPP and *kimchi* diet groups were lower than those of the HFD group, but the rats on the *kimchi* diet had even lower weights than those on the RPP diet. Plasma concentrations of triglyceride and cholesterol were lowest in the *kimchi* diet group ($p<0.05$). The RPP and *kimchi* diet groups had lower total lipids, triglycerides and cholesterol in liver; as well as in tissue fat pads than the HFD group, with the greatest effect being in the *kimchi* diet group. These results suggested that RPP and *kimchi* consumption can reverse the effects of HFD on weight gain and blood and tissue lipids, and that *kimchi* does so more effectively than RPP alone.

Key words: red pepper powder, *kimchi*, high fat diet, body weight, lipid contents

INTRODUCTION

High fat diets can cause body weight gain and increase the lipid and cholesterol content of organ tissues (1,2). Oriental diets are typically low in fat and high in vegetable content, which may contribute to the low incidence of obesity in oriental countries. Dietary interventions aimed at regulating lipid metabolism, and reducing body weight and serum concentrations of triglycerides and cholesterol, include the use dietary components including: chitin-chitosan (3), dietary fiber (4,5) green tea (6), oolong tea (7), carnitine (8), red pepper (9,10), *kochujang* (11) and *kimchi* (12) and others. Red pepper (*Capsicum annum L.*) is an important ingredient in many traditional Korean foods such as *kimchi* (Korean fermented vegetables) and *kochujang* (Korean red pepper soybean paste) (13). Lim et al. (10) reported that hot red pepper meal increased plasma catecholamine levels and induced lipolysis in rats. The effects of red pepper powder on energy and lipid metabolism appear to be a consequence of capsaicin (9,10,12,14) and dietary fiber (4). Red pepper and capsaicin modulate total body fat and lipogenic enzyme activities in the liver, and increases lipid oxidation in rats (9). Capsaicin is an active, hot, and characteristic compound found in red pepper powder that has established lipolytic activity (14). However, red pepper powder (0.02% capsaicin) has been shown to be more effective than equal amounts of capsaicin alone in reducing obesity in rats, suggesting that other compounds in addition to capsaicin in RPP may have antiobesity activity (15).

Kimchi is a traditional Korean fermented vegetable food used as a side dish at every meal. *Kimchi* is a source of vitamins, minerals, dietary fiber, lactic acid bacteria, and fermented phytochemicals (16). *Kimchi* is known to inhibit mutagenicity (17), carcinogenicity (18), and oxidation processes (19). Recently, *kimchi* was also reported to function as a regulator of lipid metabolism (12). *Kimchi* (*baechu kimchi*) is made with *baechu* (cabbage) and secondary-ingredients such as red pepper powder, garlic, ginger, etc. *Kimchi* has about 24% fiber, on a dry weight basis (20). Dietary fiber decreases lipid concentrations in blood and liver by binding bile acids, thereby increasing their fecal excretion, and by enhancing fecal energy loss (4). Increased bile excretion may cause increased hepatic synthesis of bile acids from cholesterol resulting in a depletion of liver cholesterol, and reduced serum cholesterol (5). Garlic, an important secondary-ingredient in *kimchi*, contains allyl sulfide which exerts a regulatory influence on lipid metabolism. It was reported that the administration of garlic decreased

†Corresponding author. E-mail: kunypark@pusan.ac.kr
Phone: 82-51-510-2839. Fax: 82-51-514-3138

blood cholesterol and triglyceride levels in both human and rats (21). Thus, it can be postulated that *kimchi* might reduce weight gain and lipid parameters by inducing lipolysis. *Kimchi* also contains fermented phytochemicals (16), red pepper powder, and dietary fiber in addition to garlic; all of which have potential for weight reduction activity. Kim and Lee (12) reported that ripened *kimchi* reduced the body weight of rats more effectively than fresh *kimchi*, indicating that the additional fermentation products may contribute to weight reduction.

In this study, we investigated the effect of red pepper powder and ripened *kimchi* on body weight, and organ lipids in male Sprague-Dawley rats fed a 20% corn oil diet for 4 weeks. Body, organ, and fat pad weights; and total lipid, triglyceride and cholesterol concentrations in blood and tissues, were compared and used to evaluate the relative antiobesity effect of RPP and *kimchi*.

MATERIALS AND METHODS

Animals

Twenty four 4 week old male Sprague-Dawley rats, weighting approx 120 g, were purchased from the Korean Experimental Animal Center (Daegu, Korea). Rats were acclimated to the experimental facility for 1 week, during which time average weights increased to 171±7.2 g. The rats were divided into 4 groups of 6 and individually housed in polycarbonate cages in a room maintained at 23±1°C with 50±10% relative humidity. The room was exposed to alternating 12-hr periods of light and dark. All rats were allowed free access to their respective diets and drinking water for 4 weeks. Food intake was measured daily and body weight weekly.

Red pepper powder (RPP)

Sun dried red pepper (Taeyangcho; 41.7 mg% capsaicinoid and 19.1% free sugar contents, Youngyang, Kyungbuk, Korea) was purchased from the Agriculture Cooperative Association in Youngyang, ground and sifted through a 50 mesh sieve.

Preparation of *kimchi*

Baechu, cabbage, was cut into 4 pieces and soaked in 10% saltwater brine for 10 hours and then rinsed three times with tap water and drained for 3 hours. The ratio of ingredients was as follows: 13 parts radish, 2.0 green onion, 5.0 red pepper powder (Youngyang, Kyungbuk, Korea), 2.8 garlic, 0.6 ginger, 2.2 anchovy juice, 1.0 sugar, 5.0 mustard leaf, 0.1 Chinese pepper powder, and a final salt concentration of 2.5 in 100 parts salted *baechu* cabbage. The ingredients for the *kimchi* were purchased from a local vegetable market. *Kimchi* was prepared by the standardized recipe of the *Kimchi* Research Institute (12). The *kimchi* was fermented at 15°C for 1 day and then at 5°C for 4 weeks. The optimally ripened *kimchi* (pH 4.3) was freeze-dried and powdered. The final product was approximately 50% red pepper powder.

Experimental diets

The experimental diets consisted of a normal diet based on the AIN-76*TM* diet (22); high fat diet (HFD), 20% corn oil in the normal diet (23); RPP diet (RPP+HFD), 5% RPP in the HFD; and *kimchi* diet (*kimchi*+HFD), 10% *kimchi* (the freeze dried *kimchi* with 50% red pepper powder) in the HFD. Since the dry weight of the *kimchi* was 50% RPP, both the RPP and *kimchi* diets had approximately equal amounts of RPP. Casein was purchased from Junsei Chemical Co., Japan. Vitamins, minerals and cellulose were purchased from ICN Biochmical Co., USA. The HFD without RPP and *kimchi* was used as the control. The composition of the experimental diets is shown in Table 1. FER (food efficiency ratio) was calculated as daily weight gain in grams divided by daily dietary intake in grams.

Measurement of body weight and feed consumption

Body weight was measured every week and rounded to the second decimal place. Feed consumption was measured every day.

Preparation of organ tissues for lipid analysis

After 4 weeks on the experimental diets, the rats were anesthetized with dry ice. Blood samples were taken from the inferior vena cava, and the plasma separated by centrifugation (3000 rpm, for 15 min) and stored at -20°C until

Table 1. Compositions of normal diet, high fat diet (HFD) and red pepper powder (RPP) diet (HFD+RPP) and *kimchi* diet (HFD+*kimchi*) (g/100 g diet)

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD + RPP[3)]	HFD + *kimchi*[4)]
Casein	20.0	20.0	19.1*	18.0**
Methionin	0.3	0.3	0.3	0.3
Corn starch	30.0	30.0	27.7*	25.8**
Sucrose	35.0	20.0	20.0	20.0
Fiber	5.0	5.0	4.0*	2.6**
Corn oil	5.0	20.0	19.3*	18.9**
AIN-mineral mixture	3.5	3.5	3.5	3.5
AIN-vitamin mixture	1.0	1.0	1.0	1.0
Cholin bitartrate	0.2	0.2	0.2	0.2
Red pepper powder	-	-	5.0	-
Kimchi	-	-	-	10.0
Total	100.0	100.0	100.1	100.3

1)Normal diet is based on AIN-76*TM* diet (22).
2)Contains 20% corn oil in normal diet (23).
3)High fat diet+5% RPP.
4)High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
*Adjusted quantities from the proximate analysis of 5% RPP.
**Adjusted quantities from the proximate analysis of 10% *kimchi*.

assayed. The liver, spleen, kidney, epididymal fat pad and perirenal fat pad were excised, weighed and stored at -20°C until assayed.

Quantitation of total lipid, triglyceride and cholesterol in tissues

The concentrations of plasma triglyceride and cholesterol were assayed enzymatically using commercial kits (Asan pharm. Co., Korea). Total lipid in liver and adipose tissues were extracted by the method of Folch et al. (24) and weighed. Triglyceride and cholesterol concentrations in liver and adipose tissues were enzymatically assayed by a commercial kit (Asan pharm. Co., Korea) with the aid of a detergent, triton X-100.

Statistical analysis

Comparisons among groups were evaluated by analysis of variance (ANOVA). Significant differences among the treatment means were determined using Duncan's multiple range test at $p<0.05$ (25).

RESULTS AND DISCUSSION

Body weight of the rats

Final body weights are shown in Table 2. Rats fed the HFD, containing 20% corn oil, had a significantly higher final body weight (338.7±12.4 g) than rats fed the normal diet (302.5±10.7 g, $p<0.05$). However, rats fed the RPP diet and *kimchi* diet had comparable final body weights to the rats fed the normal diet. The *kimchi* diet group gained the least body weight among the treated groups. The final body weight of the *kimchi* diet group was almost the same as that of the normal diet group. *Kimchi* contains additional ingredients and fermented components besides RPP, which may be responsible for the lower weight gain in the *kimchi* group than the RPP group. Garlic (21) and dietary fiber (4,5) in *kimchi* seem to play a role in reducing weight gain by stimulating lipolysis in adipose tissues, and/or decreasing intestinal absorption of lipids. β-Sitosterol is also an active functional compound in *kimchi* (26) which may contribute to reduced body weight gain (27).

Kim and Lee (12) reported that ripened *kimchi* was more effective than fresh *kimchi* at reducing weight gain. They also suggested that fermentation products other than the raw RPP, garlic, dietary fiber, etc, in fresh kimchi were responsible for the greater effects. The food efficiency ratio of the HFD group was the highest among the groups, while those of RPP and *kimchi* groups were the same as the normal diet group ($p<0.05$). The high food efficiency ratio of the HFD group was due to an increase in body weight, and not to decreased feed consumption.

Weight of organs and fat pads

Liver weights (g/100 g body weight) were significantly higher in HFD group rats than in the normal diet group. The addition of *kimchi* to the HFD negated the effect of HFD on liver weight (normal 3.61 g: *kimchi* + HFD 3.69 g), but RPP addition had an intermediate effect, and liver weights in that group were not significantly different from any of the other groups.

RPP and *kimchi* supplementation in the HFD significantly reduced epididymal and perirenal fat pad weights to an intermediate value between normal and HFD. *Kimchi* appeared to have a greater effect than RPP in reducing fat pad weights, although the differences the two were not significant. *Kimchi* diet exhibited the same effect in the reduction of tissue weight as in the reduction of body weight gain.

Lipid contents in blood

Rats fed HFD had significantly higher triglyceride concentrations than those on a normal diet, addition of *kimchi* or RPP to the HFD resulted in lowered triglycerides, but the effect was only significant in the *kimchi* group. Plasma cholesterol was also higher in HFD diets, but the effect of HFD was significantly reduced in both the RPP and *kimchi* groups, but the greatest reduction was in the *kimchi* group (Table 4). The lipid lowering properties of the *kimchi* diet may again be due to the presence of secondary-ingredients

Table 2. Changes in body weight, food intake and food efficiency ratio (FER) of rats fed experimental diets for 4 weeks

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD+RPP[3)]	HFD+*kimchi*[4)]
Body weight				
Initial weight (g)	171.5± 9.1[ns6)]	170.3±7.0	171.8±8.5	171.2±4.1
Final weight (g)	302.5±10.7[b7)]	338.7±12.4[a]	311.0±10.3[b]	305.7±9.7[b]
Weight gain (g/day)	4.78±0.47[b]	6.24±0.51[a]	5.16±0.49[b]	4.80±0.42[b]
Food intake & FER				
Food intake (g/day)	19.13±0.85[ns]	19.93±0.81	19.50±1.06	19.42±0.94
FER[5)]	0.25±0.02[b]	0.31±0.02[a]	0.26±0.02[b]	0.25±0.02[b]

[1)]Normal diet is based on AIN-76^{TM} diet (22). [2)]Contains 20% corn oil in normal diet (23).
[3)]High fat diet+5% RPP. [4)]High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
[5)]Calculated as daily weight gain/daily dietary intake. [6)]ns: not significant.
[7)]Means with the different letters in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.

Table 3. Weights (g/100 g body weight) of liver, spleen, kidney and adipose tissues in rats fed experimental diets for 4 weeks

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD+RPP[3)]	HFD+*kimchi*[4)]
Liver	$3.61 \pm 0.25^{bc5)}$	4.39 ± 0.22^{a}	4.01 ± 0.19^{ab}	3.69 ± 0.13^{bc}
Spleen	$0.20 \pm 0.03^{ns6)}$	0.21 ± 0.04	0.21 ± 0.05	0.22 ± 0.05
Kidney	0.91 ± 0.07^{ns}	0.93 ± 0.11	0.90 ± 0.06	0.90 ± 0.06
Epididymal fat pad	0.96 ± 0.07^{d}	1.59 ± 0.12^{a}	1.35 ± 0.09^{b}	1.26 ± 0.07^{bc}
Perirenal fat pad	0.89 ± 0.02^{d}	1.35 ± 0.11^{a}	1.21 ± 0.03^{b}	1.14 ± 0.06^{bc}

1)Normal diet is based on AIN-76^{TM} diet (22). 2)Contains 20% corn oil in normal diet (23).
3)High fat diet+5% RPP. 4)High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
5)Means with the different letters in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.
6)ns: not significant.

Table 4. Triglyceride and cholesterol concentrations in plasma (mg/dL) of the rats fed with experimental diets for 4 weeks

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD + RPP[3)]	HFD + *kimchi*[4)]
Triglyceride	$79.5 \pm 7.9^{b5)}$	100.8 ± 11.1^{a}	88.3 ± 7.2^{ab}	81.5 ± 7.0^{b}
Cholesterol	72.3 ± 5.8^{c}	119.5 ± 7.2^{a}	89.5 ± 7.9^{b}	75.3 ± 4.4^{c}

1)Normal diet is based on AIN-76^{TM} diet (22).
2)Contains 20% corn oil in normal diet (23).
3)High fat diet+5% RPP.
4)High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
5)Means with the different letters in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.

and fermented products in *kimchi*. Dietary fiber decreases the lipid contents of blood and liver by binding bile acids and enhancing fecal energy loss (28). Allicin in garlic decreases blood lipids by inhibiting lipid synthesis, increasing HDL-cholesterol in blood and secretion of bile acids (21). β-Sitosterol can also decrease triglyceride and cholesterol concentrations in the blood of rats (27,29,30). Lactic acid bacteria in *kimchi* may also decrease cholesterol levels in blood (31). Sambaiah and Satyanarayana (9) found that rats fed a diet containing 10% fructose and 0.015% capsaicin for 6 weeks had lower serum triglyceride concentrations than the control group. Capsaicin decreased total serum cholesterol and lipid contents in turkeys fed a high cholesterol diet (32). The combined results of our data and those of others illustrate that *kimchi* has various compounds/components with blood lipid lowering properties.

Lipid contents in liver

Lipid contents of the rat livers are shown in Table 5. RPP and *kimchi* diets significantly decreased total lipid, triglyceride and cholesterol in the livers as compared to the HFD ($p<0.05$). However, the *kimchi* diet decreased total lipid and cholesterol more than the RPP diet. Liver triglyceride, cholesterol, and total lipids were almost identical in the *kimchi* and normal diet groups, suggesting that *kimchi* completely reversed the effect of HFD. Capsaicin in RPP can increase lipid metabolism. Lim et al. (10) reported that capsaicinoid in RPP has a liver glycogen sparing effect, increases the breakdown of fat in adipose tissues, and increases the release of free fatty acid by increasing insulin and catecholamine concentrations in serum. However, *kimchi* has other compounds that lower lipids in liver even more effectively than red pepper or capsaicin alone. Further study is needed to identify the active compounds in *kimchi* and to elucidate their roles in the reduction of liver lipids.

Lipid contents of fat pads

The lipid profiles of fat pads are shown in Table 6. Total lipid and triglyceride contents (mg/g, wet wt) of epididymal fat pad were significantly reduced in the *kimchi* diet group (653.3 ± 21.5) and were not significantly different than the normal diet group (637.3 ± 23.7, $p<0.05$). Total lipids and triglycerides in the perirenal fat pad were also lower in the *kimchi* diet group, and not significantly different than the normal diet group.

Kimchi decreased the lipid contents in the fat pads more effectively than RPP alone. This is probably due to the additive effects of RPP, dietary fiber, garlic, and fermented phytochemicals in *kimchi*. These results indicate that RPP and *kimchi* stimulate lipid metabolism in adipose tissues

Table 5. Total lipid, triglyceride and cholesterol concentrations in liver (mg/g, wet wt) of rats fed experimental diet for 4 weeks

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD+RPP[3)]	HFD+*kimchi*[4)]
Total lipid	$168.5 \pm 6.3^{b5)}$	190.8 ± 11.0^{a}	178.6 ± 8.8^{ab}	169.8 ± 7.9^{b}
Triglyceride	20.0 ± 2.2^{b}	28.5 ± 2.1^{a}	23.5 ± 1.9^{b}	20.5 ± 1.7^{b}
Cholesterol	18.3 ± 1.7^{b}	23.5 ± 2.1^{a}	21.3 ± 2.5^{ab}	18.5 ± 1.3^{b}

1)Normal diet is based on AIN-76^{TM} diet (22). 2)Contains 20% corn oil in normal diet (23).
3)High fat diet+5% RPP. 4)High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
5)Means with the different letters in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.

Table 6. Total lipid, triglyceride and cholesterol contents in epididymal fat pad and perirenal fat pad of rats fed experimental diet for 4 weeks

	Normal diet[1)]	High fat diet (HFD)[2)]	HFD+RPP[3)]	HFD+*kimchi*[4)]
Epididymal fat pad (mg/g, wet wt)				
Total lipid	637.3±23.7[c5)]	731.0±11.9[a]	690.5±17.8[b]	653.3±21.5[c]
Triglyceride	187.8±17.9[c]	273.8±21.4[a]	231.5±15.4[b]	186.3±16.9[c]
Cholesterol	23.8± 2.2[b]	30.5± 2.4[a]	27.5± 1.3[ab]	25.0± 0.8[b]
Perirenal fat pad (mg/g, wet wt)				
Total lipid	584.8±12.3[c]	747.8±29.2[a]	656.0±25.1[b]	616.3±24.7[bc]
Triglyceride	181.3±15.1[c]	272.8±15.7[a]	239.3±11.6[b]	181.5±17.0[c]
Cholesterol	23.8± 1.3[b]	31.0± 2.3[a]	26.3± 1.7[b]	24.3± 1.0[b]

[1)]Normal diet is based on AIN-76[TM] diet (22). [2)]Contains 20% corn oil in normal diet (23).
[3)]High fat diet+5% RPP. [4)]High fat diet+10% freeze dried *kimchi* that contained 50% RPP.
[5)]Means with the different letters in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.

and effectively inhibit adipose lipid accumulation caused by HFD.

In this study, we compared the antiobesity effects of RPP and *kimchi* in HFD. RPP and capsaicin are known to decrease body fatness and lipid content in the tissues of rats (15). However, *kimchi* has even greater antiobesity activity than RPP alone. This is probably due to the presence of the RPP and other components found in *kimchi* such as dietary fiber (4,5), garlic (21), β-sitosterol (27,29,30), and probably some unidentified fermented phytochemicals, since fermented *kimchi* is known to have higher antiobesity activity rather than fresh *kimchi* (12). *Kimchi* decreases total lipids, triglyceride and cholesterol concentrations in serum, liver and fat pad by increasing lipid metabolism and lipid excretion via feces (12).

Further studies are needed to identify the antiobesity components, especially the fermented compounds, in *kimchi* and to elucidate detailed mechanisms of the antiobesity activity of *kimchi*.

ACKNOWLEDGEMENTS

This research was funded by the MAF-SGRP (Ministry of Agriculture and Forestry Special Grants Research Program) in Korea.

REFERENCES

1. Sim KW, Lee SH, Lee HS. 2001. The relationship between body mass index and mobility in Korea. *J Korean Soc Study Obes* 10: 147-155.
2. Kang SY, Hong CH, Hong YJ. 1997. The prevalence of childhood and adolescent obesity over the last 18 years in Seoul area. *Korean J Nutr* 30: 832-839.
3. Han LK, Kimura Y. 1999. Reduction in fat storage during chitin-chitosan treatment in mice fed a high fat diet. *Int J Obes* 23: 174-179.
4. Jang JY, Lee MK. 1998. Effect of fiber on serum lipid metabolism in rats with diet induced cholesterolemia. *J Korean Soc Food Sci Nutr* 27: 1211-1216.
5. Fructuoso GD, Victoria GM, Enrique B, Javier GG. 1996. Pectin feeding influences fecal bile acid excretion hepatic bile acid and cholesterol synthesis and serum cholesterol in rats. *J Nutr* 126: 1766-1771.
6. Pullo AG, Seydoux J. 2000. Green tea and thermogenesis. *Int J Obes* 24: 252-258.
7. Han LK, Takaku T, Kimura Y, Okuda H. 1999. Antiobesity action of oolong tea. *Int J Obes* 23: 98-105.
8. Cha YS, Sohn HS, Daily JW, Oh SH. 1999. Effect of exercise training and/or high fat diet on lipid metabolism and carnitine concentrations in rats. *Nutr Res* 19: 937-945.
9. Sambaiah K, Satyanrayana MN. 1982. Influence of red pepper and capsaicin on body composition and lipogenesis in rats. *J Biosci* 4: 425-430.
10. Lim K, Yoshioka M, Kikuzato S, Kiyonaga A, Tanaka H, Shido M, Suzuki M. 1997. Dietary red pepper ingestion increases carbohydrate oxidation at rest and during exercise in runners. *Med Sci Sports Exerc* 29: 355-361.
11. Choo JJ. 2000. Anti-obesity effects of *kochujang* in rats fed on a high fat diet. *Korean J Nutr* 33: 787-793.
12. Kim JY, Lee YS. 1997. The effects of *kimchi* intake on lipid contents of body and mitogen response of spleen lympocytes in rats. *J Korean Soc Food Sci Nutr* 26: 1200-1207.
13. Kang IH. 1983. *Hankook Shiksenghwalsa*. Samyongsa, Seoul. p 190.
14. Kawada T, Hagihara KI, Iwai K. 1986. Effect of capsaicin on lipid metabolism in rats fed a high fat diet. *J Nutr* 116: 1272-1278.
15. Choi SM. 2001. Antiobesity and anticancer effects of red pepper powder and *kimchi*. *PhD Thesis*. Pusan National University, Busan, Korea.
16. Park KY. 1995. The nutritional evaluation and antimutagenic and anticancer effects of *kimchi*. *J Korean Soc Food Nutr* 24: 169-182.
17. Park KY, Cho EJ, Rhee SH. 1998. Increased antimutagenic and anticancer activities of chinese cabbage *kimchi* by changing kinds and levels of sub-ingredient. *J Korean Soc Food Sci Nutr* 27: 625-632.
18. Kim JY, Rhee SH, Park KY. 2000. Enhancement of anticancer activities of *kimchi* by manipulating ingredients. *J Korean Soc Food Sci Nutr* 5: 126-130.
19. Lee YO, Cheigh HS. 1996. Antioxidant activity of various solvent extracts from freeze dried *kimchi*. *Korean J Life Sci* 6: 66-71.
20. Park KY, Ha JO, Rhee SH. 1996. A study on the contents of dietary fibers and crude fiber in *kimchi* ingredients and *kimchi*. *J Korean Soc Food Sci Nutr* 25: 69-75.
21. Sheo HJ. 1999. Effects of garlic on the blood lipid and other

serum components in rats. *J Korean Soc Food Sci Nutr* 28: 1139-1148.
22. American institute of nutrition. 1977. Report of the American institute of nutrition, Ad Hoc committee on standards for nutritional studies. *J Nutr* 107: 1340-1343.
23. Shaw MA, Rasmussen KM, Myers TR. 1996. Consumption of high fat impairs reproductive performance in Sprague-Dawley rats. *J Nutr* 127: 64-69.
24. Folch J, Less M, Sbanestanley GH. 1957. A sample method for the isolation and purification of total lipids from animal tissue. *J Biol Chem* 226: 497-499.
25. Steel RG, Torrie JH. 1980. *Principles and procedure of statistics*. McGraw-Hill Kogakusha Ltd., Tokyo. p 96.
26. Cho EJ. 2001. Standardization and cancer chemopreventive activities of Chinese cabbage *kimchi*. *PhD Thesis*. Pusan National University, Busan, Korea.
27. Katz M, Bartove I, Budowski P, Bondi A. 1970. Inhibition of cholesterol deposition in livers of mice fed phytosterols in short term experiments. *J Nutr* 100: 1141 -1147.
28. Hwang EH. 1996. The relationship to dietary fiber intake and fecal bile acid profiles. *Korean J Nutr* 29: 41-49.
29. Ikeda I, Tanaka K, Sugano M, Vahouny GV, Gallo LL. 1988. Inhibition of cholesterol absorption in rats by plant sterols. *J Lipid Res* 29: 1573-1582.
30. Choi JS, Lee JH, Young HS. 1995. Anti-hyperlipidemic effect of *Phragmites communis* and its active principles. *J Korean Soc Food Nutr* 24: 523-529.
31. Kim JH, Oh MK, Rhee YH, Choi KC, Lee YK, Shin SY. 1999. Selection and physico-chemical characteristics of lactic acid bacteria which had cholesterol lowering activities. *J Korean Agric Chem Biotech* 42: 83-90.
32. Negulesco NA, Noel SA, Newman HA, Naber EC, Bhat HB, Witiak DT. 1987. Effect of pure capsaicinoids (capsaicin and dihydrocapsaicin) on plasma lipid and lipoprotein concentrations of turkey poultry. *Atherosclerosis* 64: 85-98.

(Received March 5, 2002; Accepted May 30, 2002)