Korean J. Food & Nutr. Vol. 25. No. 3, 590～598 (2012)

THE KOREAN JOURNAL OF
한국식품영양학회지
FOOD AND NUTRITION

Hypolipidemic Effects of Enzyme-Treated Tomato Cake on Sprague-Dawley Rats Fed a High Cholesterol Diet

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고 콜레스테롤을 급여한 SD-Rat에서 효소처리한 토마토케이크가 고지혈증에 미치는 영향

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국문요약

SD-rat에 대조구(Control), 고 콜레스테롤(HC), 3.5% 펙틴-가수분해 효소(Viscozyme L)로 처리된 토마토 케이크(ETC)를 각각 4주 간 급이하였다. 첫 일주일에는 HC-급이군의 체중 증가가 151.7%로 유의적 증가를 보였지만(p<0.05), ETC-급이군의 경우는 115.4%를 보였다. Control- 및 ETC-급이군의 사료 효율은 각각 0.236±0.041 및 0.447±0.030으로 HC-급이군의 경우(0.355±0.034)에 비하여 유의적인 차이를 보였다(p<0.05). ETC-급이군의 신장 및 부고환의 지방체는 각각 0.303 및 0.274 g 씩 감소하였다. HC-와 ETC-급이군 간의 혈청 콜레스테롤, 트리글리세라이드, HDL- 및 LDL-콜레스테롤 수치의 유의적인 차이는 보이지 않았다. ETC-급이군의 경우 2주 급이시 ABTS radicals로 평가한 총 항산화 활성은 약 1.1배 높았으며, 2 및 4주간 급이시 glutathione peroxidase 활성은 각각 2.5 및 1.3배 높게 나타났다.

Key words: hypolipidemic effects, tomato cake, cholesterol diet, rats

INTRODUCTION

The tomato is one of the most widely consumed vegetables in the world, and the health improving characteristics of tomatoes have been extensively investigated by numerous researchers (Anese et al. 1999; Kozukue & Friedman 2003; Hsu et al. 2008; Koh et al. 2012). Although there were many health improving components in tomatoes such as glycolalkaloids (Friedman et al. 1996), α-tomatine and dehydrotomatine (Friedman & Levin 1998), the major health improving component in red tomatoes is believed to be lycopene, one of the major carotenoid pigments (Friedman et al. 2000; Visioli et al. 2003). Gerster (1997) reported that lycopene in red tomatoes was related to the reduction of blood cholesterol levels.

Besides lycopene in tomatoes, there are other components from various sources in the reduction of blood cholesterol levels. Nishina et al. (1991) reported that gums extracted from various water soluble fibers could reduce both serum and liver cholesterol in rats. The effects of the gums on the reduction of cholesterol in human or animals were controversial by different investigators, presumably because the effects might be greatly dependant on the properties of the individual gum or the amounts of cholesterol levels in the feed (Friedman et al. 2000). However, considerable studies agreed that the hypo-lipidemic effect of water soluble fibers in fat-limited feed might decrease serum cholesterol levels to approximately 20～30% (Friedman et

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al. 2000). Friedeman et al. (2000) investigated the effects of red and green tomatoes on the serum profiles in hamsters and concluded that red tomatoes could reduce serum LDL and triglyceride levels; however the active components in reducing serum LDL level could not be identified. German et al. (1996) reported that the mechanisms of increase in blood cholesterol in male hamsters exhibited similar patterns in male humans. Silaste et al. (2007) also reported that the total cholesterol concentration and LDL concentration were reduced by 5.9% and 12.9%, respectively, with the high tomato diet compared to the low tomato diet.

Tomato cakes, one of the major by-products from tomato juice or ketchup processing, are composed of tomato pulps and seeds. The nutritional composition and biological evaluation of tomato seed cakes reported that the nutritional values of tomato seed cakes would improve the cereal-based farm animal feed quality (Rao 1991). The complexity of nutrients in tomato cakes might decrease the absorption of tomato cakes in animal feed, therefore tomato cakes were treated with a hydrolytic enzymes to increase the bioavailability of tomato cakes in this research. The overall goal of this research was to evaluate hypolipidemic activity of enzyme-treated tomato cakes (ETC) in high cholesterol fed rats, and the specific objective of this research was to evaluate the effect of ETC on weight gain, serum cholesterol levels, adipose tissue weight, and hepatic peroxides and enzymes of SD-rats fed with a high cholesterol diet for 4 weeks.

MATERIALS AND METHODS

1. Materials

Fresh tomatoes (*Lycopersicon esculentum*) used in this research were purchased from local groceries or farms. Lycopene standard (L9879) isolated from tomatoes was purchased from Sigma Company (St Louis, MO, USA). The other chemical reagents and solvents used in this research were analytical grades and HPLC grades.

2. Preparation and Analysis of Enzyme-Treated Tomato Cake

The purchased fresh tomatoes were stored in the box at room temperature for further maturation. The tomatoes were washed with tap water to remove soil and other impurities, dried at room temperature prior to use, and treated with steam for 3 to 4 min for easy peeling. The tomato fruits were ground and filtered through a pulper (AG-5500, Angel Juicer Co, Pusan, South Korea) with a sieve (0.8～1.1 ㎜ pore size) to separate tomato juice and cake containing peel and seed (Koh et al. 2010). The tomato cake was homogenized using a D-500 homogenizer (Wiggen Hauser, Berlin, Germany) for 1 min. The tomato cake was treated with 0.1% (v/v) pectin-hydrolytic enzyme (Viscozyme® L, 100 FGB/g, Novozymes, Denmark) for 3 h at 50℃, freeze-dried, and ground using a grinder (FODD, Cyclote 1093, Sweden) to possess approximately 40～80 mesh size. The enzyme-treated tomato cake was stored in a freezer prior to further analysis.

Proximate analysis of enzyme-treated tomato cakes was conducted following the standard AOAC method (AOAC 1997). The extraction and analysis of lycopene from the tomato was conducted following general procedures described by Kozukue & Friedman (2003). Lycopene was extracted from enzyme-treated tomato cakes using a mixed solvent (hexane:acetone:methanol = 50:25:25, v/v/v) in the presence of butylatedhydroxytoluene (BHT) as an antioxidant. The hexane layer containing lycopene was separated from the mixture, and recovered several times. The optical density was measured at 470 nm using a spectrophotometer (UV/VIS Lambda35, Perkin Elmer,Waltham, MA). Total lycopene content was calculated from the optical density based on a standard curve obtained from lycopene standard (Sigma, St Louis, MO, USA) (Koh et al. 2010).

3. Animals and Diets

Three-week-old male Sprague-Dawley (SD) rats (137±1g) were purchased from Orientbio Company (Gyeonggi, South Korea) and initially maintained under a controlled light/dark cycle and temperature (22±2℃) for 7 days. After acclimatization, the healthy rats were randomly divided into three groups (n=15) and fed a normal diet as a negative control (Control), a diet containing high cholesterol (D12336, Purified Diet to Match Paigen's Atherogenic Rodent Diet, Research Diets Inc., New Brunswick, NJ.) as a positive control (HC), or a HC diet containing enzyme-treated tomato cakes (ETC). The detailed formula of each diet is presented in Table 1. The compositions of experimental diets were based on the AIN-76 diet. The HC diet was prepared by supplementing 1.25% cholesterol and 0.5% cholic acid into the control diet. For the ETC diet, 3.5% enzyme-treated tomato cakes were added into the HC diet. The rats were given water sterilized by filtering and exposure to UV light *ad libitum*. The rats were maintained as a group in each cage and recognized by an identification card indicated by the group number, individual

Table 1. Formula for experimental diets

Ingredient	Control diet (g/kg diet)	HC diet[1)] (g/kg diet)	ETC diet[2)] (g/kg diet)
Casein	200.0	200.0	200.0
Corn oil	50.0	50.0	50.0
Mineral mix	35.0	35.0	35.0
Vitamin mix (AIN-76)	10.0	10.0	10.0
Choline chloride	2.0	2.0	2.0
Methionine	3.0	3.0	3.0
Cellulose	50.0	50.0	50.0
Sucrose	200.0	200.0	200.0
Corn starch	450.0	438.8	403.8
Cholesterol	-	10.0	10.0
Taurocholic acid	-	1.3	1.3
Enzyme-treated tomato cake	-	-	35.0

1) HC diet; diet containing high cholesterol,

2) ETC diet; Diet containing high cholesterol and 3.5% enzyme-treated tomato cake.

number, sex, and test date. The rats were maintained at a temperature and relative humidity of 22±2℃ and 50±10%, respectively, under a controlled light (150～300 Lux)/dark cycle (12:12 h light on 08:00 a.m.). The room was also maintained with a quiet (less than 45 db) and low ammonia (less than 20 ppm) environment, and the air was refreshed 12 times a day. The rats were treated in strict accordance with the Bio-campus of Korea Polytechnics College Guidelines for the Care and Use of Laboratory Animals.

4. Feed Consumption and Weight Gain

The health conditions of each rat were checked at least one time a day. The feed consumption and weight gain of the rats were measured weekly using a balance (GX-2000 AndEK120A, Tokyo, Japan). The feed efficiency ratio (FER) was calculated by the following equation: Feed efficiency ratio = Weight gain (g) during experimental period/Feed consumption (g) during experimental period.

5. Body Organ Weight

After 2 and 4 weeks of experimental diet feeding, the rats were fasted for 12 hr and sacrificed under isoflurane anesthesia. The heart, lung, liver, spleen, testis, epididymis, kidney, adrenal glands, thymus, and total intestines were excised and weighed using an electrical balance (AS200, Shimadzu Co., Tokyo, Japan). The adipose tissue weights were determined from the weights around the kidney or epididymis and expressed as relative adipose tissue weight.

6. Blood Sample

Each blood sample from the abdominal aorta was collected into each tube. The serum was obtained by centrifugation at 3,000 rpm for 10 min and stored at −20℃ prior to further analyses. Total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), albumin, lactate dehydrogenase (LDH), total protein (TP), aspartate transaminase (AST), and alanine transaminase (ALT) were determined using a commercial biochemical kit analyzer (Fugifilm, Tokyo, Japan).

7. Determination of Hepatic Oxidation

A standard curve was constructed using Trolox, and the antioxidant activity was compared based on trolox equivalent antioxidant capacity (TEAC) assay. Total antioxidant activity was also determined by ABTS radical method using an antioxidant assay kit (Cayman Chemical Co., Ann Arbor, MI, USA) (Miller et al. 1993). Thiobarbituric acid reactive substances (TBARS) were measured using an OxiSlect TBARS assay kit (Cell Biolabs Inc., San Diego, CA, USA). The TBARS values were expressed as malondialdehyde (MDA) equivalent (Hsu et al. 2008). Superoxide dismutase (SOD), catalase, glutathione peroxide (GPx) activities were spectrophotometrically determined using the commercial assay kits (Cayman Chemical Co., Ann Arbor, MI, USA) specially designed for SOD, catalase and GPx activity, respectively (Hsu et al. 2008).

8. Statistical Analysis

Each experiment was performed three times in duplicates. Data were analyzed using the paired *t*-test in SAS software program (Statistical Analysis System Institute Inc., Cary, N.C., USA). Multiple mean comparisons among the samples were carried out by Duncan's multiple range tests at $P<0.05$ (*), $P<0.01$ (**), and $P<0.005$ (***) significance levels.

RESULTS AND DISCUSSION

As presented in Table 2, the enzyme-treated tomato cake exhibited 24% crude fiber content, indicating that the tomato cake was a rich source of fibers. The fiber contents of tomato

Table 2. Chemical composition of enzyme-treated tomato cake

Composition	Content based on dry basis
Protein (%)	2.54
Lipid (%)	3.93
Ash (%)	10.80
Crude fiber (%)	24.04
Neutral detergent fiber (NDF) (%)	29.02
Acid detergent fiber (ADF) (%)	41.02
Lycopene (㎎/100 g)	83.61

cakes were comparable to the amount of dietary fiber contents determined in tomato pomace (Elliot et al. 1981). Rao (1991) also reported that tomato seed cakes were rich not only in protein and minerals such as phosphorus, calcium and magnesium but also in crude fibers. In addition to fiber contents, a significant amount of lycopene remained in the tomato cakes after the juice process. As compared with 11.3 ㎎/100 g lycopene previously determined in tomato juice (Koh et al. 2010), approximately 83.6 ㎎/100 g (as dry basis) remained in the enzyme-treated tomato cake. Therefore, enzyme-treated tomato cakes were considered a good source of fibers and lycopene. As also determined by Rao (1991), the results indicated that tomato cakes would be one of the good nutritional and functional additives in animal feeds.

The HC-fed group exhibited significantly higher weight gain than the Control or ETC-fed groups in one week (p<0.05) (Table 3). The mean body weight of ETC-fed group was 53.9 g, and the relative increase in body weight was 115.7%, as compared to 70.52 g and 151.4% of the HC-fed group, respectively. The results indicated that the addition of ETC to the feed was able to reduce the weight gains of SD-rats fed with high cholesterol in 1 week. However, the body weight gains of the entire groups were not significantly different after 1 week. The effects of the ETC diet on reduction of weight gain of SD-rats were not found during the 1-week feeding period. Hsu et al. (2008) reported a similar result that there was no significant difference in body weight among the experimental hamster groups fed with high cholesterol or low cholesterol diets for 8 weeks.

The feed efficiency ratios of SD-rats fed with experimental diets were presented in Table 4. The HC- and ETC-fed groups exhibited significant higher feed efficiencies than the Control-fed group during the entire feeding period. The HC-fed group exhibited significantly higher feed efficiencies than the ETC-fed group for 1 week (p<0.05); however, there was no significant difference between the two groups after one week. Therefore,

Table 3. Changes in body weight of SD-rats fed with experimental diets for 4 weeks

Experimental diet	Body weight (g)			
	1 week	2 week	3 week	4 week
Control	46.58± 5.43	97.70± 3.00	165.96± 4.86	215.94± 5.05
HC[1)]	70.52± 4.85*	106.30± 7.64	168.28±10.99	219.64±21.73
ETC[2)]	53.90±10.84	117.38±14.15	166.28± 6.58	217.92±12.21

[1)] HC diet; Diet containing high cholesterol, [2)] ETC diet; Diet containing high cholesterol and 3.5% enzyme- treated tomato cake,
Different superscripts within the column indicate significantly different in the mean±SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

Table 4. Feed efficiency ratio of SD-rats fed with experimental diets for 4 weeks

Experimental diet	Feed efficiency ratio			
	1 week	2 week	3 week	4 week
Control	0.236±0.041***	0.270±0.020*	0.301±0.020***	0.284±0.011*
HC[1)]	0.447±0.030	0.344±0.356	0.343±0.033	0.343±0.033
ETC[2)]	0.355±0.034*	0.382±0.046	0.348±0.013	0.335±0.019

[1)] HC diet; Diet containing high cholesterol, [2)] ETC diet; Diet containing high cholesterol and 3.5% enzyme-treated tomato cake,
Different superscripts within the column indicate significantly different in the mean±SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

feeding SD-rats with ETC could reduce the weight gains in the early time period, but the weight reduction effects were not continued after the 1 week-feeding period, and ETC did not affect the feeding efficiencies of SD-rats fed with high cholesterol.

The relative weights of body organs and adipose tissues of SD-rats fed with experimental diets were presented in Table 5. The liver, kidneys, and total intestines of SD-rats exhibited significant differences among the experimental groups. The weight of livers from the Control-fed group was significantly lower than those from HC- or ETC-fed groups. On the other hand, the weights of kidneys and the total intestines from the Control-fed group were significantly higher than those from the HC- or ETC-fed groups during 4 weeks. Cho et al. (2007) also reported that the high cholesterol fed group exhibited an increase in liver weight after a 5-week feeding time period, and high fiber intake reduced liver weight of rats fed with high cholesterol diets. In this research, feeding with ETC did not affect the liver weight of SD-rats. The weights of the other tested organs were not significantly different among the experimental groups.

Regarding the weight gains of adipose tissues, although the ETC-fed group exhibited lower kidney- and epididymal-fat pad weights than the HC-fed group after 2 weeks, there was no significant difference among the experimental groups during a 4-week period. The effects of ETC on high cholesterol diets on the adipose tissue weight were not clear. Cho et al. (2007) reported that feeding with high cholesterol resulted in a significant

Table 5. Relative body organ and adipose tissue weights of SD-rats fed with experimental diets for 2 and 4 weeks

Organ/tissue		Week	Weight (g)		
			Control	HC[1)]	ETC[2)]
Organ	Liver	2	3.904±0.295*	5.248±0.840	5.133±0.444
		4	3.331±0.046***	5.962±0.550	6.313±0.062
	Kidney	2	0.929±0.114	0.824±0.097	0.827±0.038
		4	0.772±0.039*	0.713±0.027	0.672±0.055
	Epididymis	2	0.152±0.012	0.158±0.011	0.135±0.009
		4	0.199±0.017	0.198±0.016	0.185±0.006
	Spleen	2	0.285±0.017	0.284±0.057	0.268±0.029
		4	0.199±0.016	0.246±0.034	0.231±0.012
	Testis	2	3.331±0.046	3.331±0.046	3.331±0.046
		4	3.094±0.295	3.094±0.295	3.094±0.295
	Heart	2	0.367±0.027	0.367±0.019	0.375±0.035
		4	0.322±0.017	0.316±0.008	0.335±0.013
	Lung	2	0.516±0.095	0.465±0.073	0.454±0.017
		4	0.394±0.016	0.368±0.032	0.539±0.057
	Adrenal glands	2	0.021±0.005	0.020±0.004	0.022±0.006
		4	0.017±0.003	0.016±0.001	0.015±0.002
	Thymus	2	0.261±0.021	0.240±0.043	0.256±0.039
		4	0.159±0.015	0.184±0.022	0.166±0.019
	Total intestines	2	7.685±0.344	8.171±1.117	7.045±0.241
		4	7.405±0.424***	5.700±0.642	5.535±0.218
Adipose tissue	Kidney fat pad	2	0.719±0.120	1.057±0.291	0.754±0.125
		4	1.668±0.308	2.103±0.296	2.316±0.425
	Epididymal fat pad	2	0.780±0.145	0.944±0.194	0.670±0.110
		4	1.243±0.261	1.093±0.211	1.378±0.226

[1)] HC diet; Diet containing high cholesterol, [2)] ETC diet; Diet containing high cholesterol and 3.5% enzyme-treated tomato cake, Different superscripts within the row indicate significantly different in the mean±SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

increase in epididymal fat pad during 5 weeks. However, Ha & Han (2005) found that there was no significant difference in epididymal fat pad weights between the normal group and high cholesterol-fed group. Our results indicated that feeding ETC to rats apparently decreased the adipose tissue weight gains in early feeding time periods; however the effects did not continue after 2 weeks. Since the weights of organs and adipose tissues were not measured in 1 week, the effects might be not observed in this experiment. Similar to the body weight gains in Tables 2 and 3, the feeding effects of ECT to SD-rats were pronounced in the early stage, and were not persisted in the later stage.

During 4 weeks, the total serum cholesterol content of the Control-fed group exhibited apparently less content than those of HC- or ETC-fed groups; however there was no significant difference among the groups. This result was somewhat different from previous reports that feeding with high cholesterol diets increased total serum cholesterol levels (Hsu et al. 2008; Cho et al. 2007). The amounts of cholesterol added into the diets might be not sufficient to alter total serum cholesterol levels in HC-fed SD-rats. The triglyceride content of the Control group exhibited significantly greater content than those of HC- or ETC-fed groups (p<0.05). The levels of HDL- and LDL-cholesterol of the Control group were significantly lower and higher, respectively, than those of HC- or ETC-fed groups (p<0.005), and there was no significant difference in HDL- and LDL-cholesterols between the HC- and ETC-fed groups.

The serum transaminase activity was often used as an indicator of the liver damages in mice (Yun et al. 2007). The damages in hepatic cells caused the changes in transport functions of plasmic membranes, resulting in the release of serum transaminases (Cho et al. 2007). The feeding with HC and ETC diets in rats induced significant increases in AST and ALT (Table 6), however there was no significant difference between the HC- and ETC-fed groups. This implied that a high cholesterol diet might affect the liver damages in rats; however, feeding with ETC did not apparently alleviate the liver cell damages during 4 weeks.

The total antioxidant activity determined by TEAC assay exhibited that the Control-fed group exhibited significantly higher antioxidant activity than those of HC-fed or ETC-fed groups during 2 weeks (Fig. 1A). The ETC-fed group exhibited approximately 1.1 fold higher total antioxidant activity than the HC-fed group. However, there was no significant difference among the groups as the experiment proceeded to 4 weeks. Although the antioxidant activity determined by TBARS did not exhibit any significant difference among the groups both in 2 and 4 weeks (Fig. 2), the MDA value of the ETC-fed group apparently reduced approximately 85%, compared to that of the HC-fed group in 4 weeks (Fig. 1B). Cho et al. (2007) reported a significant increase in TBARS in serum by feeding high cholesterol diet. In our results, TBARS values were not significantly different in the early feeding stage; however, the difference was apparently observed in the later feeding stage. It was speculated that feeding with high cholesterol and ETC might result in significant impacts on antioxidant activities only in early feeding stages, and the effects did not continued to later feeding stages.

Table 6. Serum lipid profiles and transaminase activities of SD-rats fed with experimental diets for 4 weeks

		Experimental diet		
		Control	HC[1)]	ETC[2)]
Serum lipid profile	Total cholesterol (㎎/㎗)	72.50± 0.50	97.67±20.22	118.75±26.25
	Triglyceride (㎎/㎗)	70.33± 8.44*	59.00±11.20	58.00± 4.80
	HDL-cholesterol (㎎/㎗)	18.00± 0.00***	12.60± 3.52	10.00± 1.33
	LDL-cholesterol (㎎/㎗)	9.00± 0.00***	39.00± 8.67	61.00±11.33
	Total protein (㎎/㎗)	5.87± 0.004***	7.07± 0.004	6.93± 0.111
Transaminase activity	AST (IU/ℓ)[3)]	130.50±10.50**	204.25±34.25	268.67±19.78
	ALT (IU/ℓ)[4)]	32.00± 3.00***	37.25± 8.38	54.33± 6.22

[1)] HC; Diet containing high cholesterol, [2)] ETC; Diet containing high cholesterol and 3.5% enzyme-treated tomato cake,
[3)] AST; Aspartate transaminase, [4)] ALT; Alanine transaminase,
Different superscripts within the row indicate significantly different in the mean±SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

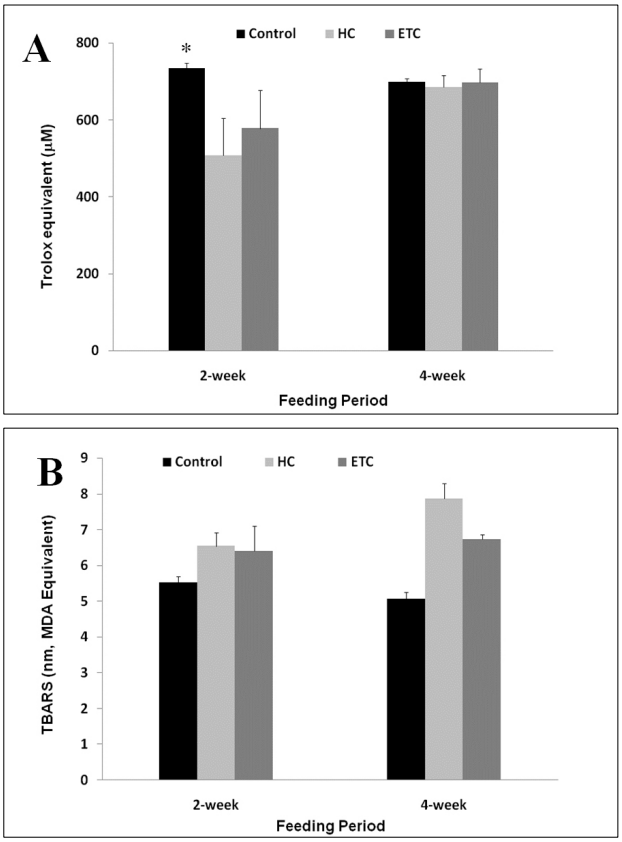

Fig. 1. Total antioxidant activities of SD-rats fed with the control (Control), high cholesterol (HC), and high cholesterol containing enzyme-treated tomato cake (ETC) diets for 2 and 4 weeks. * Indicates significantly different in the mean± SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

A; Trolox equivalent antioxidant capacity, B; Thiobarbituric acid reactive substances (TBARS).

The activities of hepatic antioxidant enzymes were presented in Fig. 2. The SOD activity of the Control group was significantly higher than that of the HC- or ETC-fed groups in 2 weeks (Fig. 2A). The SOD activity of the ETC-fed group was approximately 1.1 fold higher than that of the HC-fed group both in 2 and 4 weeks; however there was no significant difference between the two groups. Although there was no significant difference among the groups, the catalase activities of the ETC-fed group in 2 and 4 weeks exhibited 56.9% and 40.7% reduction, respectively, when compared to that of the HC-fed group (Fig. 2B). The GPx activities of the ETC-fed group in 2 and 4 weeks were 2.5-fold and 1.3-fold higher, respectively, than those of HC-fed group (Fig. 2C).

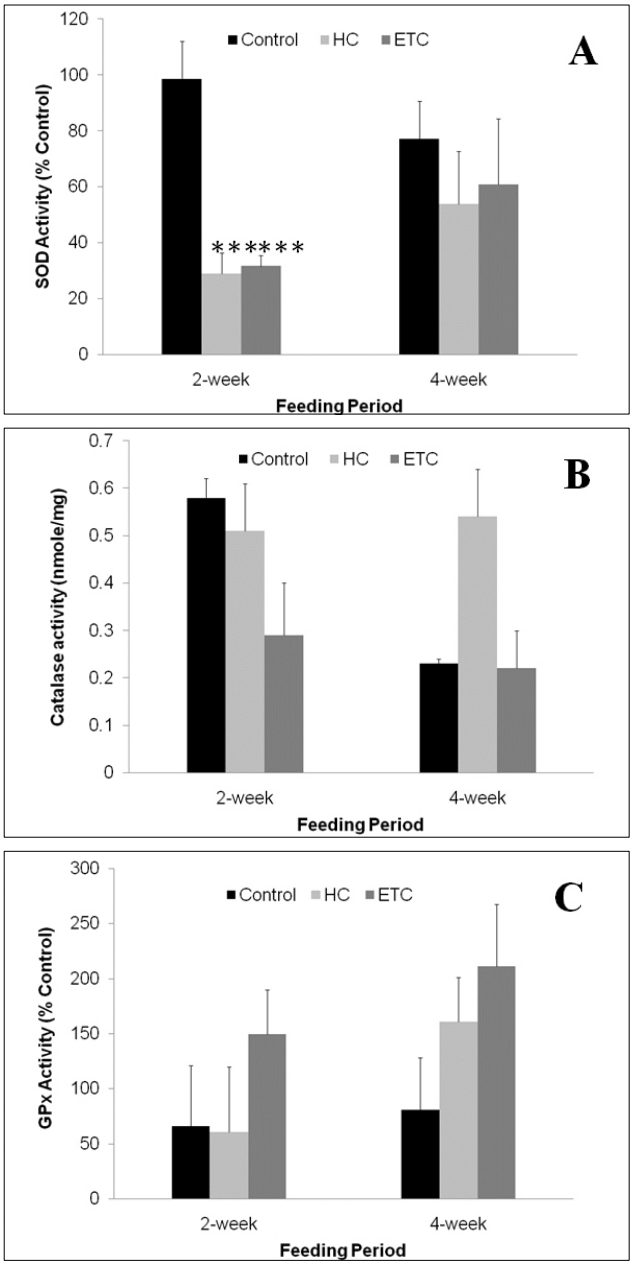

Fig. 2. Activities of hepatic antioxidant enzymes of SD-rats fed with the control (Control), high cholesterol (HC), and high cholesterol containing enzyme-treated tomato cake (ETC) diets for 2 and 4 weeks. * Indicates significantly different in the mean±SD (n=5) analyzed by Duncan's multiple range test (*p<0.05, **p<0.01, ***p<0.005).

A; SOD activity, B; Catalase activity, C; Glutathione peroxidase activity.

CONCLUSIONS

The SD-rats fed with high cholesterol diet containing enzyme-

treated tomato cake exhibited significant reduction in weight gain and feed efficiency until 1 week, and kidney- and epididymal-fat fad until 2 weeks, however did not exhibit any further reductions after 2 weeks until 4 weeks. The effects of ETC on the reduction in weight gain and adipose tissues were shown only in early feeding stages, and did not continue to later feeding stages. These results indicated that the amounts of ETC added into HC diet might be not sufficient to exhibit any significant differences. For future studies, increases in the amounts of ETC might be required to resolve the effects of ETC on adipose tissues of SD-rats.

ABSTRACT

Sprague-Dawley rats were fed with normal (Control), high cholesterol (HC), and high cholesterol containing 3.5% pectin-hydrolytic activity industrial enzyme (Viscozyme L)-treated tomato cakes (ETC) for 4 weeks. In the first week, the weight gain of the HC-fed group was significantly increased to 151.7% (p<0.05), compared to the 115.4% weight gain of the ETC-fed group. The feed efficiencies of the Control- and ETC-fed groups (0.236± 0.041 and 0.447±0.030, respectively) were significantly different to those of HC-fed group (0.355±0.034) (p<0.05). The kidney and epididymal fat pad of the rats fed with ETC were decreased to 0.303 g and 0.274 g, respectively. There were no significant differences in serum cholesterol, triglycerides, high density lipoprotein-cholesterol or low density lipoprotein-cholesterol levels between the HC- and ETC-fed groups. The ETC-fed group exhibited approximately a 1.1-fold higher total antioxidant activity determined by 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) radicals than the HC-fed group at 2 weeks. Glutathione peroxidase activity of the ETC-fed group exhibited 2.5-and 1.3-fold increases at 2 and 4 weeks, respectively.

ACKNOWLEDGEMENT

This research was carried out with the support of Region-Specific Agriculture Development Project of Rural Development Administration (RDA), Republic of Korea.

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접 수 : 2012년 7월 31일
최종수정 : 2012년 8월 31일
채 택 : 2012년 9월 3일