JOURNAL OF THE EAST ASIAN OF DIETARY LIFE
Vol. 7, No. 4(1997)

Effects of Dietary Fiber and Fat Sources on Lipid Contents of Serum and Tissues in Rats Fed Cholesterol Diet

Yaung-Ja Park and Kee-hwa Kwon*

Department of Food and Nutrition, College of Human Ecology

*College of Agriculture and Life Sciences, Seoul National University, 151-742 Korea**

식이섬유와 지방의 종류가 고콜레스테롤식을 섭취한 흰쥐의 혈청과 조직의 지질성분에 미치는 영향

박 양 자 · 권 기 화*

서울대학교 식품영양학과

서울대학교 농가정학과*

요 약

본 연구는 식이섬유의 종류와 식이지방의 종류가 혈청 콜레스테롤과 간, 소장 조직의 지질 농도에 미치는 효과를 명확히 하기 위해 시도되었다.

콜레스테롤을 1% 첨가시킨 율무기름과 라아드식에 식이 섬유인 펙틴, 리그닌, 셀룰로스를 10%씩 첨가시킨 식이를 Sprague-Dawley종 평균 체중 135g인 흰쥐 수컷에게 28일간 자유급여하였을 때 혈청, 간조직, 소장조직의 총지질, 콜레스테롤, 중성지방 수준을 측정한 결과는 다음과 같다.

1. 증체량은 율무기름식이 라아드식보다 유의적으로 컸으며($p<0.05$), 펙틴군이 리그닌군과 셀룰로스군보다 다소 낮았으나 유의성은 없었다. 총식이섭취량은 식이지방의 종류에 의한 차이는 없었으나 펙틴군이 다른 식이섬유 첨가군보다 유의적으로 낮았다($p<0.05$).
2. 혈청 콜레스테롤은 율무기름식이 라아드식보다 유의적으로 낮았으며($p<0.05$), 펙틴군이 가장 낮았고 다음이 리그닌, 셀룰로스군의 순으로 높았으며 이들은 식이섬유 무첨가군보다 유의적으로 낮은 수준이었다($p<0.05$).
3. 간조직의 무게는 식이지방이나 식이섬유에 의해 영향을 받지 않았으며 소장조직의 무게는 펙틴군과 셀룰로스군이 리그닌군과 식이섬유 무첨가군보다 유의하게 높았으나($p<0.05$) 식이지방에 의한 영향은 없었다.
4. 간의 단위 무게당 총지질과 콜레스테롤, 중성지방 함량은 펙틴군이 리그닌군과 셀룰로스군이나 식이섬유 무첨가군에 비해 유의하게 낮았으며($p<0.05$), 간의 총지질 함량은 율무기름식이 라아드식보다 유의하게 낮았다($p<0.05$).
5. 소장 조직의 단위 무게당 총지질, 콜레스테롤, 중성지방 함량은 식이섬유에 의해 영향을 받지 않았으나 총지질과 중성지질 수준은 율무기름식이 라아드식보다 유의하게 낮았으며($p<0.05$), 콜레스테롤 수준은 유의하게 높았다($p<0.05$).

이상과 같은 연구결과는 식이섬유인 펙틴, 리그닌, 셀룰로스 중 펙틴만이 혈청콜레스테롤 수준을 저하시켰으며 아울러 간과 소장조직의 총지질, 콜레스테롤 및 중성지방 수준을 저하시키는 효과가 현저했으며 식이지방인 율무기름이 라아드보다 혈청 콜레스테롤 수준을 저하시키는 효과가 큰 것으로 나타났다. 식이지방의 종류에 관계없이 식이섬유 무첨가식은 고지혈증을 초래했으며 불포화지방인 율무기름식에서는 셀룰로스 첨가군도 고지혈증을 초래하는 위험식이 임을 밝혔다. 고콜레스테롤식이에서 펙틴 첨가는 혈청 지질 수준의 저하와 함께 간과 소장조직의 지질 수준을 저하시킴으로써 펙틴식이 체내 지질 대사에 미치는 효과에 관하여는 앞으로 더욱 자세하고 분명한 연구가 요망된다.

Key words: pectin, lignin, coix oil, cholesterol diet.

Ⅰ. INTRODUCTION

Marked accumulation of cholesterol esters and other lipids in the arterial wall is a prominent feature of atherosclerosis, and high levels of serum cholesterol are associated with high risk of cardiovascular disease(CVD). CVD including atherosclerosis, myocardial infarction and stroke, is the increasing cause of death in industrialized society. Evidence has accumulated indicating that the development of CVD may be modified by dietary means[1]. The types of dietary fat have been recognized as a contributory factor of lipid changes in serum and arterial wall. Several investigators[2,3] have studied the extent of change, as seen by a predictable change in total cholesterol, to a change in dietary fat. It was demonstrated that saturated fats raise the plasma cholesterol by approximately twice as much as polyunsaturated fats lower it.

Extensive studies[4~6] on experimental animals indicated that the supplement of different types of dietary fiber have different effects on cholesterol metabolism. Dietary fiber is defined as the portion of the diet that is not digested by human digestive enzymes. It consists of non-starch polysaccharide component, cellulose, non-cellulosic polysaccharide such as pectin and a non-polysaccharide component, lignin[7]. Pectin is a mixture of galactourinan, galactan, and arabinan, and has gel texture, viscous and sticky properties, when solubilized, and is digestable a small extent by intestinal flora. Lignin is a mixture of phenolic compounds and is totally indigestible, whereas a significant amount of cellulose is digested by the bacterial flora of the large intestine. In general, viscous and soluble fibers like pectin have proven to be effective in reducing serum cholesterol, low density lipoprotein(LDL), and liver cholesterol whereas insoluble fibers like cellulose have not proven.[8]

Coix, which is classified as a close relative of maize is cultivated as an annual crop in various areas. It is generally regarded as a health food item in Korea because of its pharmacological properties. Therefore, at the present study we examined the effect of dietary fiber, namely pectin, lignin and cellulose on serum cholesterol and triglyceride in rats fed either coix oil-or lard-cholesterol diet would lead to affect total lipids content in liver and intestinal tissues.

Ⅱ. MATERIALS AND METHODS

Weanling male rats of the Sprague-Dawley strain(from animal laboratory of Seoul National University) were housed individually in stainless-steel cages, and all rats were fed a commercial diet(Je Il Feed Co., Ltd., Korea) for 1

week. Fifty six animals were randomly divided into eight groups of seven rats each. The animal room was kept at 23℃, 60% humidity, and room lighting consisted of 12-hr periods of light and dark. All animals were provided for experimental diets and tap water ad libitum for 28 days.

As shown in Table 1, each diet contained about 20% casein, 10% coix oil-or lard-supplemented 1% cholesterol, 10% dietary fiber, or fiber-free 30% sucrose, 33.7% dextrose, 4% salt mix, 1% vitamin mix and 0.3% methionine. Fatty acid of oil extracted from coix was determined by gas chromatography method(Varian Capillary Gas Chromatography Model 6000) with FFAP column(0.2mm i.d.×23m) and flame ionization detector. As shown in Table 2, six fatty acids were detected and oleic and linoleic acid were the predominant fatty acids, accounting for 45.6 and 37.2%, respectively.

At the end of the experiments, all rats were fasted for 12 to 14 hr and anesthetized under diethyl ether anesthisia. After blood sample were taken by cardiac puncture, and then serum

Table 2. Fatty acid composition of lard and coix oil

Fatty acid		Lard[1]	Coix oil[2]
		(%)	
Myristic	14:0	1.6	–
Palmitic	16:0	26.8	14.6
Palmitoleic	16:1	2.5	–
Stearic	18:0	15.6	1.6
Oleic	18:1	40.7	45.6
Linoleic	18:2	8.7	37.2
Linolenic	18:3	0.8	0.7
Eicosenoic	20:1	0.8	–
Arachidonic	20:4	–	0.3
P/M/S[3]		0.2/1/1	2.3/2.8/1
P/S[4]		0.2	2.3

[1] Paul, A.A. and Southgate, D.A.T., 1978, McCance and Widdowson's, The Composition of Foods, 4th Ed. Elsevier/North-Holland Biochemical Press

[2] Determined by gas chromatography method

[3] Polyunsaturated fatty acids/monounsaturated fatty acids/saturated fatty acids

[4] Polyunsaturated/saturated fatty acids ratio

Table 1. Composition of experimental diets (g/100g diet)

	Coix oil diet				Lard diet			
	CP[1]	CL	CC	CF	LP	LL	LC	LF
Casein	20	20	20	20	20	20	20	20
Coix oil	10	10	10	10	–	–	–	–
Lard	–	–	–	–	10	10	10	10
Cholesterol	1	1	1	1	1	1	1	1
Sucrose	30	30	30	30	30	30	30	30
Dextrose	33.7	33.7	33.7	33.7	33.7	33.7	33.7	33.7
Vit. Mix	1	1	1	1	1	1	1	1
Salt Mix	4	4	4	4	4	4	4	4
Methionine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Addition of dietary fiber								
Pectin[2]	10	–	–	–	10	–	–	–
Lignin[2]	–	10	–	–	–	10	–	–
Cellulose[2]	–	–	10	–	–	–	10	–

[1] CP: Coix oil pectin, CL: Coix oil lignin, CC: Coix oil cellulose, CF: Coix oil; fiber-free, LP: Lard pectin, LL: Lard lignin, LC: Lard cellulose, LF: Lard fiber-free diets

[2] Pectin(Wako chemical Co), Lignin(Indulin-AT) : Sigma Chemical Co. obtained Thru(pfs) Cellulose : Sigma Chemical Co. (approx 99.5%)

was prepared by centrifugation. Liver and intestinal tract were immediately removed, trimmed off fat, washed with 0.9% NaCl solution and bloted with filter paper, and weighed. Total cholesterol[9], triglyceride[10], and total lipid[11] contents in serum, liver and intestinal tissues were determined. Data were expressed as means and SD, and statistical significance was calculated by Duncans' multiple-range test among groups.

Ⅲ. RESULT AND DISCUSSION

1. Body weight gain, feed intake and FER are presented in Table 3.

Inclusion of dietary fiber at a level of 10% affected body weight gain or feed intake, but did not affect feed efficiency, FER, measured as the ratio of weight gain to feed intake(overall means±pooled SD, 0.32±0.03) ($p>0.05$). Body weight gain was the lowest in lard pectin(LP) group, and the highest in cellulose(LC) and fiber-free(LF) group of lard diet, feed intake was the lowest in lard pectin(LP) group, and the highest in lignin and cellulose groups with both of coix oil and lard diets. The difference between the lowest and the highest in body weight gain and feed intake was statistically significant($p<0.05$). Feeding of 10% pectin resulted in reduction in body weight gain and feed intake, and this result is in good agreement with other studies. Judd and Truswell explained that in 5~20% pectin fed rats reduced weight gain was more pronounced as dietary fat content increased. Rosenbergs and Jakobsen[13] explained reduction in body weight produced by pectin was mainly due to reduction in carcass fat. However, some studies[6,13,14] have shown that pectin at a level of 5, 7, or 10% did not affect body weight or feed intake.

2. Weight of liver and intestinal tissue are shown in Table 4.

In the relative liver weights, no significant differences among groups were observed indicating dietary fiber and fat sources both at 10% level did not affect the weights of livers. This finding is consistent with, the obervations of other studies[6,14]. Hexeberg et al.[6] reported that the relative liver weight were not altered by 5, 10 and 15% pectin feeding but were increased by 2% cholesterol feeding.

The relative intestinal weights differed sig-

Table 3. Influence of various fibers(10%) on body weight gain, feed intake and feed efficiency ratio(FER) in rats fed a 1% cholesterol, 10% coix oil-or lard-diet for 28 days

Experimental diets		Body weight gain(g)	Food intake (g)	FER
Coix oil	pectin(CP)	136 ± 10^{ab}	413 ± 36^{ab}	0.33 ± 0.02^{NS}
	lignin(CL)	134 ± 17^{ab}	445 ± 35^{bc}	0.30 ± 0.02
	cellulose(CC)	152 ± 20^{b}	475 ± 19^{c}	0.32 ± 0.03
	fiber-free(CF)	150 ± 14^{b}	426 ± 23^{ab}	0.35 ± 0.02
Lard	pectin(LP)	122 ± 19^{a}	398 ± 32^{a}	0.31 ± 0.04
	lignin(LL)	141 ± 20^{ab}	466 ± 29^{c}	0.30 ± 0.04
	cellulose(LC)	140 ± 22^{ab}	470 ± 18^{c}	0.30 ± 0.04
	fiber-free(LF)	142 ± 13^{ab}	428 ± 19^{ab}	0.33 ± 0.01

Values are Means±SD, NS = Not significant

Means with different superscript letters within a column are significantly different from each other at $p<0.05$ as determined by Duncan's multiple-range test

Table 4. Influence of various fibers(10%) on weight of liver and intestinal tissue in rats fed a 1% cholesterol, 10% coix oil-or lard-diet for 28 days

Experimental diets		Relative weight (g/100g B.W.)	
		Liver	Intestinal tissue
Coix oil	pectin(CP)	3.8±0.3^{NS}	3.2±0.3^{b}
	lignin(CL)	4.2±0.5	2.4±0.1^{a}
	cellulose(CC)	3.8±0.6	3.3±0.9^{b}
	fiber-free(CF)	4.2±0.5	2.5±0.3^{a}
Lard	pectin(LP)	3.6±0.4	3.2±0.5^{b}
	lignin(LL)	3.9±0.4	2.5±0.1^{a}
	cellulose(LC)	3.8±0.4	2.7±0.2^{a}
	fiber-free(LF)	3.8±0.2	2.6±0.3^{a}

Values are Means±SD, NS = Not significant
Means with different superscript letters within a column are significantly different from each other at $p<0.05$ as determined by Duncan's multiple-range test

Table 5. Influence of various fibers(10%) on contents of cholesterol and triglyceride concentration in rats fed a 1% cholesterol 10% coix oil-or lard-diet

Experimental diets		Serum (mg/dl)	
		Cholesterol	Triglyceride
Coix oil	pectin(CP)	60± 7^{a}	73± 7^{a}
	lignin(CL)	64± 4^{ab}	78±12^{a}
	cellulose(CC)	73± 5^{bc}	103± 6^{c}
	fiber-free(CF)	78±12^{c}	94±12^{bc}
Lard	pectin(LP)	62± 8^{a}	80±21^{ab}
	lignin(LL)	71± 6^{abc}	77± 8^{a}
	cellulose(LC)	73± 6^{bc}	80±23^{ab}
	fiber-free(LF)	110±22^{d}	95± 9^{bc}

Values are Means±SD
Means with different superscript letters within a column are significantly different from each other at $p<0.05$ as determined by Duncan's multiple-range test

nificantly, and were greater in pectin(CP, LP) groups of rats fed both either coix oil-or lard-cholesterol diets, and in coix oil cellulose(CC) group than in the other groups. Other study[13] suggested that the elevation of intestinal weights by pectin feeding was responsible for reduced feed intake and a barrier to energy absorption, reflecting in reduced weight gain.

3. Serum cholesterol and triglyceride levels are presented in Table 5.

Serum cholesterol was significantly lower in pectin(CP, LP) and lignin(CL, LL) groups than in their respective fiber-free(CF, LF) groups, and was highest in lard fiber-free(LF) groups ($p<0.05$). Serum triglycerides was significantly lower in coix oil pectin(CP) and lignin(CL, LL) than in fiber-free(CF, LF) groups. Pectin and lignin exhibited both hypocholesterolemic and hypotriglyceridemic effects in rat fed coix oil-cholesterol diet, but cellulose did not exhibited the same result. But in rats fed lard-cholesrerol diet, pectin exhibited the most hypocholesterolemic effect whereas lignin exhibited the most hypotriglyceridemic effect. Lard fiber-free(LF) diet and coix oil cellulose(CC) diet exhibited as a risk factor for hypercholesterolemic and hypertriglyceridemic, respectively. Results of the present study are in support of some investigators[6,12-14] that pectin exhibit hypocholesterolemic effect.

4. Lipid of liver tissue is shown in Table 6.

Liver total lipid and cholesterol contents were significantly lower in pectin than in lard fiber-free group, and liver triglycerides was lower in coix oil pectin(CP) than in fiber-free groups($p<0.05$). Pectin feedings resulted in a 3-fold decrease in liver cholesterol and a 2-fold decrease in liver triglyceride while lignin and cellulose had no effect in total lipid, cholesterol and triglyceride contents, compared with fiber-free feeding in rats fed either coix oil-or lard-cholesterol diets. Results of the present study are in support of other observations[6,7] that pectin lowered the level of cholesterol in

Table 6. Influence of various fibers(10%) on liver lipid contents of rats fed a 1% cholesterol, 10% coix oil-or lard-diet

Experimental diets		Liver(mg /g, tissue)		
		Total lipid	Cholesterol	Triglyceride
Coix oil	pectin(CP)	63±21[a]	12± 5[a]	41±15[a]
	lignin(CL)	118±30[bc]	26± 5[b]	76±26[ab]
	cellulose(CC)	145±17[bc]	26± 3[b]	59±11[ab]
	fiber-free(CF)	138±41[bc]	30±10[bc]	82±38[b]
Lard	pectin(LP)	107±14[b]	15± 4[a]	65±21[ab]
	lignin(LL)	122±30[bc]	30± 5[bc]	83±10[b]
	cellulose(LC)	140±26[bc]	28± 4[bc]	85±12[b]
	fiber-free(LF)	150±27[c]	34± 6[c]	83±21[b]

Values are Means±SD

Means with different superscript letters within a column are significantly different from each other at $p<0.05$ as determined by Duncan's multiple-range test

liver of rats fed cholesterol diet.

5. Lipid of intestinal tissue is shown in Table 7.

Total lipid, cholesterol and triglyceride contents of intestinal tissue were not altered by dietary fiber sources, but were affected significantly by dietary fat sources. But total lipid and triglyceride content of intestinal tissues was significantly lower, and cholesterol content was higher in coix oil group than in lard group($p<0.05$). Coix oil feeding resulted in a 2-fold decrease in triglyceride content of intestinal tissue.

Ⅳ. CONCLUSION

These results indicate that pectin and lignin reduced serum cholesterol. Pectin also decreased total lipid, cholesterol and triglyceride contents of liver in rats fed either coix oil-or lard-cholesterol diets whereas lignin did not affect liver lipid content. Lipid content of intestinal tissue was not affected by dietary fiber sources,

Table 7. Influence of various fibers(10%) on lipid content in intestinal tissue in rats fed a 1% cholesterol, coix oil-or lard-diet

Experimental diets		Intestinal tissue(mg /g, tissue)		
		Total lipid	Cholesterol	Triglyceride
Coix oil	pectin(CP)	37± 9[a]	9.3±1.5[c]	15± 9[a]
	lignin(CL)	45±10[abcd]	9.9±1.5[c]	16±3[a]
	cellulose(CC)	42±12[abc]	9.9±3.2[c]	21±8[a]
	fiber-free(CF)	38± 4[ab]	9.1±1.8[bc]	14±2[a]
Lard	pectin(LP)	45±15[abcd]	6.3±0.7[a]	36±9[b]
	lignin(LL)	50± 9[bcd]	6.7±0.5[a]	41±18[b]
	cellulose(LC)	54± 4[d]	6.7±0.4[a]	47±15[b]
	fiber-free(LF)	52±13[cd]	7.7±1.4[abc]	36±13[b]

Values are Means±SD

Means with different superscript letters within a column are significantly different from each other at $p<0.05$ as determined by Duncan's multiple-range test

but coix oil feeding resulted in 2-fold decrease in intestinal triglyceride content.

V. ABSTRACT

The purpose of this research was to investigate the effects of 10%(w/w) of various dietary fiber, pectin(P), lignin(L), cellulose(C) and fiber-free(F) on lipid content of serum, liver and intestinal tissues in rats fed 10% coix oil(C)-or lard(L)-1% cholesterol diets for four weeks. The lard pectin(LP) group was the lowest in body weight gain and feed intake. Liver weight was not affected by dietary fiber and fat sources, and intestinal weight was higher in pectin(CP, LP) groups than in the other groups. Serum cholesterol was significantly lower in pectin(CP, LP) groups than in fiber-free(CF, LF) groups, and was higher in lard fiber- free (LF) than in the other groups($p<0.05$). Serum triglycerides was significantly lower in coix oil pectin(CP) and lignin(CL, LL) than in fiber-free(CF, LF) groups. Liver total lipid and cholesterol content was significantly lower in pectin than in lard fiber-free group, and liver triglycerides was lower in coix oil pectin(CP) than in fiber-free groups($p<0.05$). Lipid content of intestinal tissue was not affected by dietary fiber source. But total lipid and triglyceride content of intestinal tissues was significantly lower, and cholesterol content was higher in coix oil than in lard group($p<0.05$). These results indicate that pectin and lignin reduced serum cholesterol. Pectin also decreased total lipid, cholesterol and triglyceride contents of liver in rats fed either coix oil-or lard-cholesterol diets whereas lignin did not affect liver lipid content.

VI. REFERENCES

1. NRC. : Atherosclerotic cardiovascular diseases. In: Diet and Health, Implications for Reducing Chronic Disease Risk. National Academy Press, Washington, D. C., 529-547, 1989.
2. Keys, A., Amderson, J. T., Grande, F. : Prediction of serum cholesterol responses of man to changes in fats in the diet. Lancet ii 959-966, 1957.
3. Hegsted, D. M., McGandy, R. B., Myer, M. L., Stare F. J. : Quantitative effects of dietary fat on serum cholesterol in man, Am. J. Clin. Nutr. 17: 281-295, 1965.
4. Anderson, J. W., Chen, W. J. L. : Plant fiber : carbohydrate and lipid metabolism. Am. J. Clin. Nutr. 32: 346-363, 1979.
5. Hexeberg, S., Hexeberg, E., Willumsen, N. and Berge, R. K. : A study on lipid metabolism in heart and liver of cholesterol and pectinfed rats. Br. J. Nutr. 71: 181-192, 1994.
6. Tsai, A. C., Elias, J., Kelley, J. J., Lin R-S and Robson, J. : Influence of certain dietary fibers on serum and tissue cholesterol levels in rats. J. Nutr. 106: 118-123, 1976.
7. Bhagavan, N. V. : Medical Biochemistry, Jones and Bartlett Publishers, 1992.
8. Kritchevsky, D. : Dietary fiber, Annual Review of Nutrition 8: 301-328, 1988.
9. Zlatkis, A. and Zak, B. : Study of a new cholesterol reagent. Anal. Biochem., 29: 143, 1969.
10. Biggs, H. G., Erikson, M. J. and Wells, R. M. A. : Manual colorimetric assay of triglycerides in serum. Clin. Chem., 21: 437, 1975.
11. Folch, J., Less, M. and Sloaestanley, G. H. : A simple method for the isolation and purification of total lipids from animal tissues. J. Bio. Chem. 226: 4497, 1957.
12. Judd, P. A. and Truswell, A. S. : The

hypocholesterolaemic effects of pectins in rats. Br. J. Nutr., 53: 409-425, 1985.

13. Rotenberg, S. and Jakobsen, P. E. : The effect of dietary pectin on lipid composition of blood, skeletal muscle and internal organs of rats. J. Nutr., 108: 1384-1392, 1978.

14. Mueller, M. A., Cleary, M. P. and Kritchevsky, D. : Influence of dietary fiber on lipid metabolism in meal-fed rats. J. Nutr., 113: 2229-2238, 1983.

(1997년 11월 28일 접수)