High monounsaturated fatty acids in beef lowered serum triglyceride, total cholesterol and low-density lipoprotein in young male

Hana Kwon[1], Gwang Ho Lee[2], Kyung Hoon Baik[1], Seong Il Kim[3], Yong Woon Kim[4] and Changbon Choi[1*]

[1]School of Biotechnology, Yeungnam University, Gyeongsan, Korea

[2]Department of Statistics, Yeungnam University, Gyeongsan, Korea

[3]Gyeongbuk Provincial College, Yecheon, Korea

[4]Department of Physiology, College of Medicine, Yeungnam University, Korea

[*]cbchoi@yu.ac.kr

Abstract - Recent researches provide evidences that monounsaturated fatty acids (MUFA) increase HDL cholesterol and reduce LDL cholesterol. Objective of the current study was to determine the effects of MUFA in beef on the health related indices of human. Beef taken from three (3) individual beef cattle based on six (6) different intramuscular fat (IMF) levels, IMF-1, IMF-2, IMF-3, IMF-4, IMF-5 and IMF-6 (total 18 samples) were fed to 54 (3 subjects x 18 samples) male college students. Three hundred (300) grams of beef per week were provided for 4 weeks. Fat contents and fatty acids composition in beef samples and lipid profiles in the blood of subjects were analyzed by One-way ANOVA and Duncan's multiple test was used to determine significances among samples. Fat contents for IMF-1 through IMF-6 were 4.47, 8.36, 11.91, 13.23, 17.03 and 23.48%, respectively, and total MUFA intake for 4 weeks was 11.6, 25.2, 37.2, 42.8, 54.8 and 76.8 g, respectively. MUFA intake showed significant (p<0.05) negative (-) correlation with blood total cholesterol (-0.355) and LDL-cholesterol (-0.283). In conclusion, the results imply that dietary MUFA including oleic acid in beef cause favorable changes in blood lipoproteins in young male college students.

Ⅰ. INTRODUCTION

For over four decades, considerable scientific interest has given to the impact of dietary fat in the development of metabolic disorders which leads to cardiovascular disease (CVD). Saturated fatty acids (SFA) have been recommended to reduce in the diet. More recently, this dietary restriction has been extended to *trans*-fatty acids. In contrast, unsaturated fatty acids (UFA) have been considered to be beneficial to CVD. Long-chain omega (n)-3 polyunsaturated fatty acids (PUFA) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), especially, have been associated with cardiovascular health benefits. Monounsaturated fatty acids (MUFAs) are fatty acids containing a single double bond while PUFAs contain two or more double bonds and SFAs contain no double bonds. The *cis*-isomers are the predominant form of MUFA in food sources, and the most common *cis*-configured MUFA in daily nutrition is oleic acid ($C_{18:1}$ n-9), followed by palmitoleic acid ($C_{16:1}$ n-7), and vaccenic acid ($C_{18:1}$ n-7). Moreover, oleic acid represents the topmost MUFA provided in the diet (~90% of all MUFAs) (1). Numerous scientific evidences suggest that dietary MUFA reduces key risk factors for metabolic syndrome (1-3). Dietary MUFAs promote a healthy blood lipid profile, mediate blood pressure, and favorably modulate insulin sensitivity and glycemic control (4).

Korean cattle (Hanwoo, *bos Taurus coreana*) is a unique cattle breed with a high proportion (~30% for the highest) of intramuscular fat (IMF). Oleic acid ($C_{18:1}$) and palmitoleic acid ($C_{16:1}$) are two main MUFAs in *M. longissimus dorci* of Hanwoo which occupy more than

99% of total MUFA. Genetic backgrounds as well as feeding program consisting high grain feeds and mostly rice straw for roughages might be underneath of highly marbled Hanwoo beef.

The objective of current study was to clarify the effects of MUFAs in Hanwoo beef on human health. This study would be much more interested in the circumstances that total fat contents in Hanwoo beef are much higher than Western country raised beef.

Ⅱ. MATERIALS AND METHODS

Beef samples and subjects

Loin samples from three (3) individual beef cattle based on six (6) different intramuscular fat (IMF) levels, IMF-1, IMF-2, IMF-3, IMF-4, IMF-5 and IMF-6 (total 18 samples) were fed to 54 (3 subjects x 18 samples) male college students (Table 1).

Table 1. Experiment design

	IMF-1[1)]	IMF-2	IMF-3	IMF-4	IMF-5	IMF-6
Loin[2)], sample	3	3	3	3	3	3
Number of Subject/loin, person	3	3	3	3	3	3
Total subjects, person	9	9	9	9	9	9

[1)]Intramuscular fat (IMF)-1 and IMF-2; Imported beef having low fat contents. IMF-3, IMF-4, IMF-5 and IMF-6; Beef marbling score (BMS) 3, 5, 7 and 9 based on Korean Beef Grading Standard,
[2)]*M. longissimus dorsi* area between the 13th vertebrae thoracis and 1st vertebrae lumbar.

The study was approved by Institutional Review Board (IRB) of Clinical Research Ethics Committee, Yeungnam University.

Physiological backgrounds, age, height, weight, body mass index (BMI) and body fat mass, of the subjects are shown in Table 2.

Table 2. Physiological back grounds of the subjects involved intake experiment.

Items	Results
Gender	Male
Age	23.7±0.27
Height (㎝)	174.6±0.55
Weight (㎏)	71.4±1.22
BMI[1)]	23.4±0.36
Body fat mass (%)	19.6±0.75

Mean ± S.E.
[1)]BMI : Body mass Index.

Frequencies of smoking, alcohol consumption and daily diets including meat were collected by a questionnaire. The subjects were asked to maintain their routine daily life including physical activity and not to take beef besides experimental beef throughout the experimental period.

Subjects were randomly allocated into one of the following six groups: IMF-1 (fat 4.47%), IMF-2 (fat 8.36%), IMF-3 (fat 11.91%), IMF-4 (fat 13.23%), IMF-5 (fat 17.03%) and IMF-6 (fat 23.48%).

Fatty acids composition including oleic acid and MUFA in beef samples are shown in Table 3.

Table 3. Fatty acids composition in beef samples used in the experiment

(%)	IMF-1	IMF-2	IMF-3	IMF-4	IMF-5	IMF-6
Crude fat	4.47^{a}	8.36^{b}	11.91^{c}	13.23^{c}	17.03^{d}	23.48^{e}
C12:0	0.28^{ab}	0.14^{a}	0.24^{ab}	0.18^{ab}	0.52^{b}	0.14^{a}
C14:0	4.35^{ab}	3.98^{a}	4.80^{b}	4.16^{ab}	4.73^{b}	4.18^{ab}
C14:1	0.57^{d}	0.53^{d}	0.20^{b}	0.29^{c}	0.10^{a}	0.11^{a}
C16:0	28.44^{b}	26.82^{a}	29.39^{b}	28.61^{b}	28.94^{b}	28.59^{b}
C16:1	4.75^{a}	5.42^{b}	6.55^{cd}	6.20^{c}	7.01^{d}	6.45^{cd}
C18:0	18.07^{c}	14.55^{b}	10.28^{a}	9.85^{a}	9.34^{a}	10.15^{a}
C18:1	38.28^{a}	43.70^{b}	44.92^{bc}	47.19^{d}	46.23^{cd}	47.70^{d}
C18:2	2.63^{c}	3.87^{d}	2.47^{bc}	2.31^{bc}	2.04^{ab}	1.61^{a}
C18:3	1.27^{b}	0.52^{a}	0.40^{a}	0.44^{a}	0.40^{a}	0.49^{a}
C20:0	0.00^{a}	0.00^{a}	0.03^{ab}	0.15^{d}	0.04^{b}	0.11^{c}
C20:1	0.26^{c}	0.19^{b}	0.14^{a}	0.13^{a}	0.13^{a}	0.10^{a}
C20:4	0.40^{b}	0.14^{a}	0.18^{a}	0.24^{a}	0.15^{a}	0.13^{a}
SFA[1)]	51.84^{c}	45.51^{b}	45.18^{ab}	43.20^{a}	43.97^{ab}	43.41^{ab}
UFA[2)]	48.16^{a}	54.35^{b}	54.82^{bc}	56.80^{c}	56.03^{bc}	56.59^{c}
MUFA[3)]	43.86^{a}	49.83^{b}	51.81^{c}	53.81^{d}	53.47^{cd}	54.37^{d}
PUFA[4)]	4.30^{c}	4.52^{c}	3.04^{b}	2.99^{b}	2.58^{ab}	2.23^{a}
U/S[5)]	0.94^{a}	1.20^{b}	1.22^{bc}	1.32^{c}	1.28^{bc}	1.32^{c}
M/S[6)]	0.86^{a}	1.10^{b}	1.15^{bc}	1.25^{d}	1.22^{cd}	1.27^{d}
P/S[7)]	0.08^{bc}	0.10^{c}	0.07^{ab}	0.07^{ab}	0.06^{a}	0.05^{a}

[1)]Saturated fatty acid, [2)]Unsaturated fatty acid, [3)]Monounsaturated fatty acid, [4)]Polyunsaturated fatty acid, [5)]Unsaturated fatty acid/Saturated fatty acid, [6)]Monounsaturated fatty acid/Saturated fatty acid, [7)]Polyunsaturated fatty acid/Saturated fatty acid
a,b,c,d : Values in the row with different uppercase superscripts are significantly different (p<0.05).

Twice a week (Tuesday and Friday), the subjects were given designated beef dishes (Bulgogi; a traditional Korean cooking method of beef with soy sauce). Total 300 g/week were divided into two (150 g/time) and served each time.

Body mass index (BMI) and blood profiles

Before and after the experiment, body weight, fat mass, blood pressure and body mass index (BMI) of the

subjects were measured. Serum lipid profiles (total cholesterol, HDL-cholesterol, LDL-cholesterol, triglyceride), aspartate aminotransferase (AST), alanine aminotransferase (ALT), total protein and glucose were determined using chemistry analyzer (AU-5400, Olympus Optical Co., Tokyo, Japan).

Statistical analysis

Fat contents and fatty acids composition in beef samples and analytical items including lipid profiles in the blood of subjects were analyzed by One-way ANOVA using SPSS statistic software (5) and Duncan's multiple range test was used to determine significances among samples.

Ⅲ. RESULTS AND DISCUSSION

Intake of beef, fat, oleic acid and MUFA

Total amount of beef, fat, oleic acid and MUFA taken by each subject in each IMF group are shown in Table 4.

Table 4. Beef, fat, oleic acids, MUFA amount of intake in humans fed Hanwoo and imported beef for 4 weeks (g/4weeks)

	IMF-1	IMF-2	IMF-3	IMF-4	IMF-5	IMF-6
Beef intake	1,200	1,200	1,200	1,200	1,200	1,200
Fat intake	53.6	100.3	142.9	158.8	204.4	281.8
Oleic acids intake	20.5	43.8	64.2	74.9	94.5	134.4
MUFA[1)] intake	23.5	50.0	74.0	85.4	109.3	153.2

Mean
[1)]MUFA : Monounsaturated fatty acids.

Serum total protein, AST, ALT and glucose

Total protein, AST, ALT and glucose in serum of the subjects are shown in Table 5.

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

Serum lipid profiles, total cholesterol, HDL-cholesterol, LDL-cholesterol and triglyceride, of the subjects consumed designated beef for 4 weeks are shown in Table 6.

Table 5. Total protein, AST, ALT and glucose on serum pre-experiment and post-experiment in humans fed Hanwoo and imported beef for 4weeks

		IMF-1	IMF-2	IMF-3	IMF-4	IMF-5	IMF-6
Total Protein (g/dℓ)	Pre	7.6^{ab}	7.4^{ab}	7.7^{b}	7.3^{a}	7.5^{ab}	7.6^{ab}
	Post	7.4	7.4	7.4	7.2	7.4	7.4
	Changes	0.2*	-0.0	0.2*	0.1	0.1	0.2*
AST (IU/ℓ)	Pre	18.5	22.9	23.7	23.1	22.6	21.6
	Post	19.9^{ab}	21.8^{ab}	22.6^{b}	18.9^{a}	20.7^{ab}	20.6^{ab}
	Changes	-1.4^{b}	1.1^{ab}	1.1^{ab}	4.2^{a}*	1.9^{ab}	1.0^{ab}
ALT (IU/ℓ)	Pre	15.0^{a}	27.4^{b}	21.1^{ab}	22.1^{ab}	20.1^{ab}	18.5^{ab}
	Post	18.5	23.1	23.4	19.0	17.4	18.0
	Changes	-3.5*	4.3	-2.3	3.1	2.8	0.5
Glucose (mg/dℓ)	Pre	93.3	98.3	93.8	96.3	96.7	94.2
	Post	89.4^{a}	97.9^{b}	89.4^{a}	95.6^{ab}	89.9^{a}	88.8^{a}
	Changes	3.9*	0.4	4.3	0.8	6.8*	5.4*

Mean
Values in the same row with different superscripts are significantly different (p<0.05).
*Paired t-tests of one side (p<0.05).

Table 6. Serum total cholesterol, HDL-cholesterol, LDL-cholesterol and triglyceride of the subjects consumed beef for 4 weeks.

		IMF-1	IMF-2	IMF-3	IMF-4	IMF-5	IMF-6
Total cholesterol (mg/dℓ)	Pre	183.0	182.3	176.6	167.3	169.8	160.8
	Post	190.2^{b}	188.3^{ab}	176.0^{ab}	164.9^{a}	169.4^{ab}	167.3^{ab}
	Changes	-7.2*	-6.0	0.6	2.4	0.3	-6.5
HDL-cholesterol (mg/dℓ)	Pre	58.2	62.0	52.1	58.7	56.9	61.1
	Post	57.6	62.4	52.8	56.0	58.1	61.7
	Changes	0.6	-0.4	-0.7	2.7	-1.3	-0.7
LDL-cholesterol (mg/dℓ)	Pre	106.1	101.8	100.6	92.2	92.2	87.2
	Post	113.1	108.2	101.3	93.6	93.8	94.9
	Changes	-7.0*	-6.4	-0.8	-1.3	-1.6	-7.7
Triglyceride (mg/dℓ)	Pre	70.2	94.6	106.2	87.9	83.1	90.3
	Post	77.3	93.4	86.7	75.4	70.3	98.8
	Changes	-7.2	1.1	19.5	12.4	12.9	-8.5

Mean
Values in the same row with different superscripts are significantly different(p<0.05).
*Paired t-tests of one side(p<0.05).
[1)]AI(Atherogenic index)=(Total cholesterol–HDL cholesterol)/HDL cholesterol.

Correlation coefficients between intakes of oleic acid and MUFA and serum total cholesterol and LDL-cholesterol

Pearson correlation coefficients between oleic acid and MUFA intakes and total cholesterol and LDL-cholesterol, respectively, are shown in Table 7.

Table 7. Pearson's correlation coefficient between intakes of oleic acid and MUFA and serum total cholesterol and LDL-cholesterol of the subjects consumed beef for 4 weeks.

	Total cholesterol	LDL-cholesterol
$C_{18:1}/(C_{16:0}+C_{18:0})$	-0.382**	-0.316*
MUFA[1)]/$(C_{16:0}+C_{18:0})$	-0.385**	-0.318*

[1)]MUFA : Monounsaturated fatty acids.
*Correlation coefficient is significantly different (p<0.05).
**Correlation coefficient is significantly different (p<0.01).

Ⅳ. CONCLUSION

In conclusion, the results imply that MUFA including oleic acid contained in beef has negative (-) relationship with serum total cholesterol and LDL-cholesterol. The effects of oleic acid and MUFA on blood total cholesterol and LDL-cholesterol would be much higher if the amount of intake of fat is considered. Further studies to clarify the effects of MUFA and oleic acid in cholesterol metabolisms are necessary.

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