Effects of Feeding Level of Concentrate and Age on the FAS Activities of Adipose Tissues in Hanwoo Steers

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ABSTRACT : An experiment was conducted to examine the effect of different feeding levels of concentrate (85, 100 and 115%) and age (15, 18 and 24 month) on fatty acid synthetase (FAS) activities in the 4 locations of adipose tissues (intermuscular, ITER; intramuscular, ITRA; kidney, KIDN and subcutaneous, SUBC) of 36 Korean native cattle (Hanwoo) steers. Steers of 100% feeding group were fed the amount of concentrate to meet the daily nutrient requirements, and the steers of second and third groups were fed concentrates at the levels of 85% and 115% of that of control group, respectively, up to 18 month of age. Thereafter, the steers were fed *ad libitum* up to 24 month of age. Feeding level of concentrates tended to affect the FAS activity of various adipose tissues in Hanwoo steers of each age. The FAS activity of ITER adipose tissue had the decreasing trend as the age of steers advanced while those of ITRA and SUBC adipose tissues had the slightly increasing tendency with age. The FAS activity based on the pooled data increased with the feeding level of concentrates (115%) in which the activities from all 4 adipose depots were higher than those with the lowest (85%) feeding level. Similar trend was observed from the pooled data of feeding level of concentrates by age of steers in which the FAS activities for all 3 ages were increased with feeding levels of concentrates. But the response in the FAS activity to the feeding level varied with age. *(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 12 : 1696-1700)*

Key Words : FAS Activity, Adipose Tissue, Age, Concentrate Feeding Levels, Hanwoo Steers

INTRODUCTION

Growth of beef cattle at the fattening period is closely associated with the storage of fat, and are known to be affected mainly by the energy level (Prior and Jacobson, 1979; Smith and Crouse, 1984; Mills et al., 1989) and probably by the age and/or body weight (Ingle et al., 1973; Pothoven and Beitz, 1973).

An increased feed intake or energy level increased the concentration of lipogenic enzymes (Goodridge, 1986; Katsurada et al., 1986) and their activities (Pothoven and Beitz, 1973, 1975; Goodridge, 1986). In the other hand, restriction of feed intake decreased the activity of numerous lipogenic enzymes (Ingle et al., 1973; Haugebak et al., 1974; Pothoven and Beitz, 1975). Adipose tissues from sheep and steers fed a high concentrate diet had higher activities of G-6-P dehydrogenase and NADP-isocitrate dehydrogenase than those from sheep and steers fed hay (Young et al., 1969; Martin et al., 1973). Pothoven et al. (1975) also found the decreased fatty acid synthesis capacity from the adipose tissues of restricted-fed steers compared with *ad libitum*-fed ones. Previous report (Mills et al., 1989) indicated that the fatty acid synthetase (FAS) activity in growing steers coordinately adapt to the level of feed consumed.

An age or body weight (BW) of the animal could be among the factors affecting the rate of fatty acid synthesis. Pothoven et al. (1975) found that the lipogenic enzyme activities in subcutaneous (SUBC) fat of steers increased steadily up to 363 kg body weight and then decreased rapidly thereafter. Smith et al. (1987) also found that the rate of lipid synthesis was higher for 4 to 6 months lambs that for mature ones. The rate of fatty acid synthesis per unit weight of adipose tissue decreased with increasing animal weight in sheep and steer, respectively (Ingle et al., 1973; Pothoven and Beitz, 1973).

However, examination has not been made for FAS activity in adipose tissue of Hanwoo (Korean native cattle) steers relating to the feed intake level and the age. Therefore, the objective of the present investigation was to examine the effect of feeding levels of concentrate and age of steers on the FAS activity of adipose tissues in Hanwoo steers.

METERIALS AND METHODS

Animals and diets

Fourty-eight Hanwoo (Korean native cattle) steer calves (6 month of age, mean BW 139±5.3) were allotted by body weight (BW) to one of three levels of concentrate feeding and were housed in individual pens. Steers of 100% feeding group were fed the amount of concentrate to meet the daily nutrient requirements as suggested by Feeding Standard of Hanwoo (1992) and the steers of second and third groups were fed concentrates at the levels of 85% and 115% of that of control group, respectively, up to 18 month of age. Thereafter, the steers were fed *ad libitum* up to 24 month of age. The steers were fed the corresponding concentrates depending upon the growing stages (Grower up to 12 month of age; Finisher I during 13 to 18 month of age and Finisher II during 19 to 24 month of age) twice daily. All the steers

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were fed the rice straw *ad libitum*. Chemical compositions of concentrate for each growing stage were in table 1.

Preparation of adipose tissues

Adipose tissues were taken from the inner layer of SUBC-fat (F) and kidney (KIDN)-F, and approximately 100 g of *Longissimus* muscle between13 and 14 ribs of Hanwoo steers were taken at 15, 18 and 24 months of age for each group (3 heads/age/feeding group, total 27 steers) immediately after being slaughtered, and were placed in the liquid N and carried to the lab. All the adipose tissues including those of intermuscular (ITER)-F and intramuscular (ITRA)-F which were separated from the *Longissimus* muscle at the laboratory were kept frozen (-75°C) until incubated for the measurement of FAS activities. Body weight and carcass characteristics relating to the fat of Hanwoo steers by the age are shown in table 2.

Adipose tissue incubation

Adipose tissues of SUBC-F, KIDN-F and ITER-F were incubated for the Hanwoo steers of all feeding stages but incubation with adipose tissue of ITRA-F at the 15 month of age was not made due to the difficulty of taking fat from *Longissimus* muscle.

Fatty acid synthetase was assayed by the spectrophotometrical method as suggested by Miller et al. (1991). In brief, the adipose tissues were placed in 0.1 M potassium phosphate buffer (pH 7.4, 37°C) in a 1 : 3 volume basis and homogenized (Polytron, PT 3100). The homogenized tissue solution was centrifuged (3,000 × g) for 30 min and collected the supernatant (homogenate). Solution mixure of 1.3 ml Tris buffer (pH 7.4), 0.1 ml NADPH (6.5 mg/ml) and 1.3 ml distilled-deionized water was placed in a cuvette and pre-warmed in a water bath (37°C). The solution of 0.1 ml homogenate was added to the pre-warmed solution mixture and left reacted for 3 min, then measured absorbance at 340 nm (Beckman DU 650). After 0.1 ml of acetyl-CoA (4.41 mg/ml) and malonyl CoA (2.61 mg/ml) solution was added to the solution mix in a cuvette and left reacted for 3 min, and read the absorbance again at 340 nm. The FAS activity was expressed as mmol/min/g adipose tissue.

Statistical analyses

The results obtained were subjected to least squares analysis of variance according to the general linear models procedure of SAS (1985) and significances were compared by S-N-K Multiple Range Test (Steel and Torrie, 1980).

Table 1. Chemical composition (%, DM basis) of experimental concentrates for Hanwoo steers by feeding stage

Chemical composition[1)]	Concentrates by feeding stage[2)]		
	Grower	Finisher I	Finisher II
Dry matter	91.49	90.62	90.00
Crude protein	15.58	13.72	12.11
Ether extracts	4.08	4.96	6.10
Ca	0.80	0.67	0.65
P	0.56	0.41	0.38
TDN	68.90	70.00	70.50

[1)] Contents of Ca, P and TDN in concentrates are suggested values by the feed manufacturer.

[2)] Hanwoo steers were fed concentrates of Grower, Finisher I, and Finisher II during 7 to 12, 13 to 18 and 19 to 24 month of age, respectively.

RESULTS

The FAS activities in the adipose tissue of the various locations of Hanwoo steers by age were influenced by the addition level of concentrates are shown in table 3. The FAS activity of ITER adipose tissue had the decreasing trend as the age of steers advanced while those of ITRA and

Table 2. Body weight and carcass characteristics relating to the fat of Hanwoo steers

Age (month)	Items	Feeding levels of concentrate (%)		
		85	100	115
15	Live weight, kg	296.7	290.0	290.0
	Carcass weight, kg	169.0	170.0	174.7
	Fat of *Longissimus* muscle, %	2.06	2.62	2.62
	Backfat thickness, cm	0.20	0.27	0.20
18	Live weight, kg	390.0	370.0	396.7
	Carcass weight, kg	213.7	202.3	214.3
	Fat of *Longissimus* muscle, %	4.26	5.88	4.79
	Backfat thickness, cm	0.40	0.33	0.47
24	Live weight, kg	510.0	507.5	560.0
	Carcass weight, kg	291.3	278.3	322.3
	Fat of *Longissimus* muscle, %	8.73	8.47	8.38
	Backfat thickness, cm	0.85	0.63	1.23

Table 3. Effect of feeding levels of concentrates by age on FAS activity (mmol/min/g adipose tissue) of adipose tissues in Hanoo steers[1]

Location of Adipose tissue	Feeding levels of concentrate (%) 85	100	115	SEM[2]	Pr > F[3]
		15 month of age			
Intermuscular	342.6^{a}	331.6^{a}	382.2^{a}	35.79	0.066
Kidney	255.9^{b}	138.4^{b}	251.0^{b}	23.13	0.063
Subcutaneous	123.5^{cB}	157.4^{bB}	218.2^{b}	19.64	0.026
SEM[2]	19.13	21.78	24.97	-	-
Pr > F[3]	0.0005	0.0090	0.0480	-	-
		18 month of age			
Intermuscular	246.5^{aB}	232.4^{B}	328.3^{A}	9.69	0.0004
Intramuscular	206.6^{aB}	245.2^{B}	441.8^{A}	46.70	0.019
Kidney	250.4^{a}	224.9	264.0	47.79	0.594
Subcutaneous	168.4^{b}	261.3	223.5	20.96	0.112
SEM[2]	19.75	40.95	86.13	-	-
Pr > F[3]	0.0002	0.1390	0.4930	-	-
		24 month of age			
Intermuscular	191.2^{bB}	167.9^{bB}	281.7^{abA}	21.20	0.003
Intramuscular	394.6^{aA}	313.4^{aB}	312.3^{aB}	22.00	0.027
Kidney	186.0^{b}	185.9^{b}	242.0^{b}	12.55	0.065
Subcutaneous	286.1^{ab}	279.2^{ab}	231.0^{b}	35.33	0.359
SEM[2]	18.83	18.19	15.83	-	-
Pr > F[3]	0.0030	0.0480	0.0006	-	-

[1] Values in the same column (small letters) or row (capital letters) with different superscripts differ as shown in probability levels.
[2] Standard error of the means.
[3] Probability levels.

SUBC adipose tissues had the slightly increasing tendency with age. The FAS activity of KIDN adipose tissue, however, was not consistent.

Feeding level of concentrates affected, in some part, the FAS activity of various adipose tissues in Hanwoo steers of each age (table 3). The highest activities were observed in the ITER adipose tissues from the steers fed concentrates of 115% for all 3 ages. The activity of ITRA adipose tissue showed the different trend between ages where an increased feeding level of concentrates stimulated ($p<0.019$) the FAS activity in the 18 month of Hanwoo steers while reversed trend was observed in the 24 month of steers ($p<0.027$). Similar tendencies to those of ITRA adipose tissues were shown in the FAS activities of SUBC adipose tissues between 15 and 24 months of steers. The FAS activity of KIDN adipose tissue, however, was not shown any consistent tendency among three feeding levels of concentrates.

Mean values derived from the three feeding levels of concentrates indicated that there were some trends in the FAS activities among locations of adipose tissues (table 3). In the steers of 15 month, highest activity was observed from the ITER adipose tissue and was followed by the adipose tissues of KIDN and SUBC, and those from the ITRA adipose tissues were highest in both 18 and 24 month.

Pooled data of feeding level of concentrates by fat depot revealed that the FAS activity increased with the feeding level of concentrates in which the activities from all 4 depots were higher than those with the lowest (85%) feeding level (table 4). Similar trend was observed from the pooled data of feeding level of concentrates by age of steers in which the FAS activities for all 3 ages were increased with feeding levels of concentrates (table 5). But the response in the FAS activity to the feeding level varied with age in which the overall mean FAS activities increased with age at concentrates feeding level of 100% and 115%. Thereafter, the FAS activity at the relatively higher feeding levels (100% and 115%) decreased while that at lower feeding level (85%) increased. These changes in the FAS activity associated with feeding level and age, however, were not significant.

DISCUSSION

Obtained results from the current *in vitro* study indicate that the effects of feeding level of concentrates and the age of steers on the FAS activities of adipose tissue in Hanwoo steers are not consistent although the differences between feeding groups or ages are clear in many parts of results (table 3). This may be, in part, due to the fact that the mean body weight of steers fed 100% concentrate level when

Table 4. Pooled values of FAS activity (mmol/min/g adipose tissue) in adipose tissues of Hanwoo steers by feeding level of concentrates and by adipose tissue location[1)]

Location of Adipose tissue	Feeding levels of concentrate (%)			SEM[2)]	pr>F[3)]
	85	100	115		
Intermuscular	260.1[b]	243.9	330.7[a]	38.23	0.076
Intramuscular[4)]	300.6[a]	279.3	377.0[a]	36.35	0.103
Kidney	230.7[b]	183.1	252.3[b]	23.31	0.288
Subcutaneous	192.6[b]	232.6	224.2[b]	23.48	0.513
SEM[2)]	21.01	28.32	35.45	-	-
Pr>F[3)]	0.008	0.481	0.048	-	-

[1)] Values in the same column with different superscripts differ as shown in probability levels.
[2)] Standard error of the means.
[3)] Probability levels.
[4)] Mean values from the steers of 18 and 24 month of ages.

Table 5. Mean values of FAS activity (mmol/min/g adipose tissue) in adipose tissues of Hanwoo steers by the feeding levels of concentrates and by the age

Age of month	Feeding levels of concentrate (%)			SEM[1)]	Pr>F[2)]
	85	100	115		
15[3)]	240.6	209.1	283.8	46.62	0.404
18	217.9	240.9	314.4	38.87	0.166
24	264.5	236.6	266.7	26.29	0.240
SEM[1)]	25.42	26.32	25.18	-	-
Pr>F[2)]	0.477	0.583	0.313	-	-

[1)] Standard error of the means.
[2)] Probability levels.
[3)] Mean values of the 3 adipose tissue locations (intermuscular, kidney and subcutaneous fat) instead 4 locations (intermuscular, intramuscular, kidney and subcutaneous fat) for the steers of 18 and 24 month of ages.

slaughtered is lower than those of other groups (85% and 115%) as shown in table 2.

It has been well documented that an increased feed intake is associated with increased concentration of lipogenic enzyme protein (Goodridge, 1986; Katsurada et al., 1986), thus increased the activities of lipogenic enzymes (Pothoven and Beitz, 1973, 1975; Goodridge, 1986). These findings support the evidences that activities of lipogenic enzymes adapt to the level of energy intake. Restricted feeding has been shown to decrease the activities of numerous lipogenic enzymes (Ingle et al., 1973; Haugebak et al., 1974; Pothoven and Beitz, 1975). The obtained results from the present study extend the previous findings to include a wider range of feed intakes from below to above maintenance. In the current study, increased feeding level (115%) accelerated FAS activities of various locations of adipose tissues (ITER, ITRA and SUBC) at the steers of 15 and 18 months of age compared to restricted feeding level (85%). Pothoven et al. (1975) found that steers fed high-grain diets exhibited greater lipogenic enzyme activities than did steers fed high-roughage diets. Mills et al. (1989) also observed that lipogenic activities of biopsied adipose tissue from the tail-head area were lowest at maintenance feeding and below but increased linearly as intake increased above maintenance.

The rate of lipogenesis may have been affected by age of animals and the fat depots. Smith et al. (1987) reported that the rate of lipid synthesis was higher for 4 to 6 months lambs that for mature ones. Pothoven et al. (1975) also found that the enzyme (acetyl-CoA carboxylase and FAS) activities involved in the synthesis of SUBC and abdominal fat of steers increased steadily up to 363 kg body weight and then decreased rapidly to the lowest level of activity at the 505 kg body weight. The results of the present study also showed relatively higher FAS activities in the mean values at lower BW (15 and 18 months of age) than at greater BW (24 month) in various fat depots for the steers fed 100% and 115% concentrates (table 5). Reversed result was occurred at 24 month of age in which the overall FAS activity was higher for the steers fed 85% concentrates than for the steers fed higher levels of concentrates. The increased FAS activity may be due to the *ad libitum* feeding from 18 month of age for 6 months, thus feed intake might increase rapidly, resulting in the enhanced FAS activity.

In conclusion, feeding level of concentrates and age responded, to some extent, to the FAS enzyme activity in the various adipose tissues of Hanwoo steers, but it should be notified that the selection of representing steers in BW

associated with feeding level of concentrates at being slaughtered could enhance the consistency in the results of current study.

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