FATTY ACID COMPOSITION OF SUBCUTANEOUS FAT IN JAPANESE BLACK STEERS DURING FATTENING

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SUMMARY

The influence of season, fattening, feeding and anatomical location on fatty acid composition of depot fats in 8 Japanese black steer was investigated. Subcutaneous fat was sampled 6 times by biopsy for four steers receiving a high-concentrate diet (Group A) and four receiving a diet of concentrates plus whole-crop rice silage (Group B). After slaughter fat samples from four depot were analysed.

The concentration of total unsaturated fatty acids increased by 8-10% during the 12 month fattening period, and the percentage of palmitoleic acid and oleic acid were shown to be higher during the cool season than the warm season. The total unsaturated fatty acid percentage was about 5% higher for samples from Group A, but this difference e was not statistically significant. Significantly lower concentrations of unsaturated fatty acids were found in kidney fat relative to subcutaneous fat.

INTRODUCTION

The depot fat of cattle is mainly composed of neutral lipids such as triglycerides. The properties of these triglycerides are related to meat quality and their composition is affected by several factors such as nutrition, season, fattening, age, sex, breed and fat depot.

The effects of sex, breed and fat depot within the body have been reported in detail but the effects of season, age, fattening and feeding are less clear. In this report, an investigation of the influence of season, fattening, feeding and anatomical location on the fatty acid composition of the depot fat in Japanese Black Steers is described.

MATERIALS AND METHODS

(a)Composition of the feed

The eight Japanese Black Steers were kept for the experimental period from November 1985 to May 1986. All steers were sons of the same bull and were approximately 12 months of age at the start of the experiment. Four steers received mainly concentrates (Group A) and four received concentrates plus whole-crop rice silage (Group B). Tables 1 and 2 show the composition of the feeds and the fattening results, respectively.

(b)Sampling of subcutaneous fat

The subcutaneous fat was sampled using a needle biopsy technique six times at intervals of months from May 1985. The sampling position was lateral to the base of the tail. After slaughter, samples of subcutaneous fat (abdominal and over the longissimus muscle at the last rib), intermuscular fat in the loin region and kidney-outside fat were taken.

Table 1 Composition of the feeds used during the 3 stages of fattening (%)

Group	Concentrates	Whole-crop rice silage	Hay	Rice straw
Stage 1 (November to June)				
A	70	-	15	15
B	55	30	7.5	7.5
Stage 2 (July to December)				
A	80	-	10	10
B	70	20	5	5
Stage 3 (January to May)				
A	90	-	5	5
B	80	10	5	5

Table 2 Group means for body weight, average daily gain, carcass weight and marbling score in Groups A and B

Group	live weight (kg) initial	live weight (kg) final	carcass weight (kg)	daily gain (kg)	marbling score[a]
A	280	644	382	0.65	2.8
B	271	635	384	0.65	2.9

[a] The scoring system ranged from 0 to 5 with an increased level of marbling for higher values

Table 3 Fatty acid composition of subcutaneous fat samples obtained by biopsy during the last year of fattening

Fatty acid (%)	Month: May	July	Oct	Dec	Feb	April
Group A						
C14:0	5.9	5.3	4.3	4.2	4.2	3.8*
C14:1	2.9	2.6	2.1	2.5	2.9	2.4
C16:0	30.0	29.7	31.1	28.6	26.7*	27.7
C16:1	8.7	9.0	8.7	8.8	10.4	10.0
C17:0	0.4	0.7*	0.9*	0.9*	0.9*	0.6
C18:0	10.9	9.7	9.2	8.5	6.9*	7.0*
C18:1	39.6	40.5	41.8	44.9	46.0	46.4*
C18:2	1.5	2.6	1.9	1.7	2.0*	2.1
TUFA	52.7	54.6	52.0	57.9*	61.3*	60.9*
Group B						
C14:0	6.8	6.2	5.2	4.5*	5.2	4.8*
C14:1	2.1	2.2	1.6	2.0	2.5	2.2
C16:0	33.0	32.7	32.1	30.3*	30.0*	30.2*
C16:1	8.0	8.7	6.8*	9.1	9.7*	10.6
C17:0	0.8	0.6*	0.9	0.9	0.8	0.6
C18:0	13.1	11.0	13.3	8.5*	8.4*	8.1
C18:1	35.2	37.3	38.5	43.5*	41.9*	41.4*
C18:2	1.0	1.3	1.7*	1.3	1.7*	2.1
TUFA	46.3	49.5	48.6	55.9*	55.7*	56.4*

TUFA; Total Unsaturated Fatty Acid
* Significantly different from the corresponding value for May ($P < 0.05$)

(c)Fatty acid analysis of depot fats

The total lipids of the fat samples were extracted with $CHCl_3$- CH_3OH (2:1 v/v). An aliquot portion containing 10-100 mg of lipid was dissolved in 30 volumes of 4% H_2SO_4-CH_3OH and heated at 90°C for 4 hours. After heating, 2 ml of saturated saline solution and diethyl ether were added and shaken vigorously. The diethyl ether layer was separated and an aliquot was injected into an Hitachi Model 063 GLC equipped with F.I.D. The GLC conditions were: liquid phase = 15% DEGS Uniport B; Column = 2 m x 3 mm stainless steel; oven temp. = 190°C; detector temp. = 240°C; gas speed = 40 ml/min of N2 gas. The concentration of each fatty acid methyl ester is presented as a mean value for 4 steers.

Table 4 Fatty acid composition of several depot fats in Groups A and B at slaughter

Fatty acid (%)	Subcutaneous (abdomen)	Subcutaneous (back)	Intermuscular	Kidney (outside)
Group A				
C14:0	2.7	2.8	3.2	2.4
C14:1	2.0	2.8	1.2	0.6
C16:0	24.8	23.3	26.6	25.2
C16:1	8.5	10.7	5.2	2.4
C17:0	1.1	1.0	0.8	1.4
C18:0	5.8	4.4	12.9	22.8
C18:1	52.6	52.8	47.6	43.1
C18:2	2.6	2.3	2.4	2.2
TUFA	65.6^a	68.6^a	56.5^b	48.2^c
C16:1+18:0+18:1	66.9^a	67.9^a	65.8^a	68.3^a
C16:1/C18:0	1.5^a	2.5^a	0.4^b	0.1^b
C18:1/C18:0	9.1^a	12.1^a	3.7^b	1.9^c
Group B				
C14:0	3.3	3.1	3.8	2.9
C14:1	1.8	2.3	1.1	0.5
C16:0	26.6	22.9	29.2	27.0
C16:1	8.7	11.1	5.0	2.4
C17:0	0.9	1.2	0.9	1.4
C18:0	5.9	5.0	15.7	26.1
C18:1	50.1	52.4	42.0	37.7
C18:2	2.7	2.0	2.3	2.1
TUFA	63.3^a	67.7^a	50.4^b	42.7^c
C16:1+18:0+18:1	64.7^a	68.5^a	62.8^a	66.2^a
C16:1/C18:0	1.5^a	2.2^a	0.3^b	0.1^b
C18:1/C18:0	8.6^a	10.4^a	2.7^b	1.5^b

^{a,b,c}; means in the same row with common superscripts do not differ significantly ($P < 0.05$)

RESULTS AND DISCUSSION

1. Time-course variation by biopsy

The weight of the fat obtained by biopsy increased with fattening from about 10 mg to 30 mg. The concentrations of fatty acid methyl esters in the subcutaneous fat are shown in Table 3. For both Groups A and B, the percentage of saturated fatty acids, palmetic acid (16:0), the stearic acid (18:0), were lower in the coldest season from December to April than at other times. In contrast, the unsaturated fatty acids, palmitoleic (16:1) and oleic (18:1) acid, were higher during these cold months. In the warm season from May to October, these results were opposite. Link et al., (1970a) reported the results of monthly sampling on the fatty acid composition of the subcutaneous fat of cattle by biopsy. Their results were similar with values for C16:0 and C18:0 being lowest in the cold season from November to May and vice versa in the hot season from July to September.

Waldman et al., (1968) reported that the proportion of unsaturated fatty acid of subcutaneous fat increased with fattening. Our results showed a similar tendency (Table 3). By comparison of initial and final lipid sampling times for both Groups A and B, it is clear that the total unsaturated fatty acid concentration gradually increased during this period of fattening, to the extent of 8-10%. The value for the main saturated fatty acid (C18:0) decreased and C18:1 increased. The change in C18:1 concentration was greatest and was largely responsible for the increase in the total unsaturated fatty acids.

These results are similar to those of Line et al., (1970b), as they reported that the value of C18:0 decreased in the intermuscular lipid with fattening and the value of C18:1 increased. Hecker et al., (1975) investigated the effect of animal age on the fatty acid composition of subcutaneous fat from three breeds of cattle and showed that the total unsaturated fatty acids increased. They suggested that this increase in unsaturated fatty acids was due to stronger desaturase activity. Leat and Embleton (1970) reported that as cattle fattened and grew older interchanges took place with the conversion of stearic acid (C18:0) to palmitoleic acid (C16:1) and to oleic acid (C18:1). Thus the sum of C16:1, C18:0 and C18:1 remained about constant, but there were increases in the ratios of C16:1/C18:0 and C18:1/C18:0. A similar pattern was shown in this study (Table 3). In the results reported here the effects of season and fattening were not separated clearly, but are generally consistent with the reports reviewed above.

2. Effects of anatomical site

Table 4 shows the fatty acid composition of several depot fats in Groups A and B. Generally the proportion of unsaturated fatty acids increased with closer proximity to the body surface. For subcutaneous fats of both Groups A and B, the oleic acid (C18:1) concentration was higher and the stearic acid (18:0) concentration was lower than for other depots. The total unsaturated fatty acids decreased at sampling sites deeper in the body. These values were significantly higher in the outer site than the inner one (Table 4).

It has been suggested that the cause of fatty acid changes with increasing body depth include the different in body temperature (Terrell et al., 1969), in the stage of development of each depot (Leat, 1979), and in the activities of various enzymes (Leat and Embleton, 1970.

3. Effects of Feeding

The properties of depot fats of monogastric animals are more easily affected by the chemical composition of feeds, than is the case for ruminants. For cattle, fat composition can be affected by some kinds of feed. For example, high concentrate diets increase the total unsaturated fatty acid content of body fats. Table 3 shows that the total unsaturated fatty acid concentration of Group A (high-concentrate diet) was almost 5% higher

than that of Group B (concentrates plus whole-crop rice silage), but this difference was not statistically significant. A similar tendency was shown for all fat samples taken at slaughter (Table 4). The total saturated fatty acid concentration was greater than 70% for the feed given to Group A, while for Group B the concentration of total unsaturated fatty acids in the feed was about 50%. The percentage of oleic acid (C18:1) of depot fats was increased by concentrate feeding (Group A) and the levels of saturated fatty acids were decreased. These differences were greatest in the intermuscular and kidney-outside fats (Table 4), but were not statistically significant. Rumsey et al., (1972) reported similar results for cattle fed concentrate and alfalfa hay cubes. Although the concentrates fed contained a high level of saturated fatty acids, their effect on the composition of animal depot fats was to decrease the level of saturation. It is suggested that the effect of diet on the fatty acid composition of depot fats is determined not only by the nature of the lipid in the feed, but also by the physical form of the feed, the non-lipid components of the feed and the nature of rumen metabolism.

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