FATTY ACID COMPOSITION OF BOVINE LIPIDS AS INFLUENCED BY DIET, SEX AND ANATOMICAL LOCATION AND RELATIONSHIP TO SENSORY CHARACTERISTICS[1]

David B. Westerling and H. B. Hedrick

University of Missouri-Columbia 65211

SUMMARY

The fatty acid composition of bovine intramusclular and subcutaneous lipids were determined from fat samples obtained from steers and heifers that received three dietary treatments consisting of fescue grass and grain. Cooked samples from the *longissimus* muscle were evaluated by a sensory panel. Both intramuscular and subcutaneous fat from grass-fed animals contained more saturated fatty acids, palmitic and stearic, and less unsaturated fatty acids, primarily oleic, than did fat from animals that received a grain diet. Subcutaneous fat contained more palmitic and oleic acids and less linoleic, linolenic, 11-eicosenoic and arachidonic than intramuscular fat. Fat from steer carcasses contained more linoleic and arachidonic than fat from heifer carcasses. Sensory panel scores were negatively associated with total saturated fatty acids, mainly stearic and palmitic which were highest in grass-fed animals, and positively associated with total unsaturated fatty acids, due mainly to the higher levels of oleic of grain-fed animals.

(**Key Words:** Fatty Acids, Bovine Lipids, Beef Quality.)

INTRODUCTION

Studies have been conducted which show that fatty acid composition of bovine fat is influenced by dietary regimen (Sumida *et al.*, 1972; Rumsey *et al.*, 1972; Skelley *et al.*, 1973), sex (Waldman *et al.*, 1968), breed (Rumsey *et al.*, 1972), and season of the year (Link *et al.*, 1970). Other studies have been conducted to determine palatability of beef as influenced by fatty acid compositon of muscles from animals fed a "feedlot ration" (Dryden and Marchello, 1970; Waldman *et al.*, 1968).

The objectives of the present study were to determine the effects of grass and grain diets on the fatty acid composition of intramuscular and subcutaneous fat of steers and heifers and to determine the relationships between fatty acid composition of these depots and sensory panel scores.

MATERIALS AND METHODS

Fifty-four steers and heifers, predominantly Herefords, were assigned to three dietary treatments. The 18 animals in each group consisted of nine steers and nine heifers. All animals were grazed on predominantly fescue grass for 180 days. One group of animals was slaughtered and the remaining two groups were placed on full-feed under drylot conditions. The diet consisted of 15% cottonseed hulls (IRN 1-01-599), 82.4% corn (IRN 4-02-992), 1.04% urea (IRN 5-05-070) and 1.56% vitamin and mineral supplement. One group received this diet for 56 days, and the other group for 112 days. Live animal and carcass characteristics of the animals are presented in table 1.

After slaughter the carcasses were held at 2 to 3 C for 10 days. Samples of *longissimus* muscle and the subcutanious fat (composite of inner and outer layers) dorsal to the muscle (2nd to 3rd lumbar vertebrae) were obtained from the shortloins 10 days postslaughter. The lean tissues were finely ground and the fat tissue was finely chopped and lipids extracted with anhydrous ether from these samples as prescribed by AOAC (1975). Fatty acids were determined as methyl esters by the gas-liquid chromatographic procedure of Gerhardt and Gehrke (1977).

Boneless rib roasts (9th to 12th thoracic vertebrae) were prepared from the right side of each carcass, frozen and stored at −18 C for 2 to 4 months. When the roasts were removed

[1] Contribution from Missouri Agricultural Experiment Station. Journal Series No. 8213 Apparoved by the Director.

TABLE 1. MEAN LIVE ANIMAL AND CARCASS CHARACTERISTICS OF STEERS AND HEIFERS

Dietary treatment	Age at slaughter, days	Live weight, kg	Fat thickness 12th rib, cm	Marbling score	Quality grade	Yield grade
Group 1, Fescue pasture 180 days	643	282	.25	3.8	3.7	1.5
Group 2, Fescue pasture 180 days and 56 days grain	690	344	.45	8.6	7.2	2.0
Group 3, Fescue pasture 180 days and 112 days grain	754	420	.81	12.2	8.7	2.2

[a]Marbling score of practically devoid = 5, traces– = 7,, traces + = 9, et cetera.

[b]Quality grade of 4 = Standard–, 7 = Good–, 8 = Good +, et cetera.

from frozen storage they were allowed to thaw for 2 days at 2 C and then roasted at 163 C in a gas heated oven to an internal temperature of 70 C. Upon reaching the desired internal temperature the roasts were removed from the oven and allowed to stand at room temperature for approximately 15 minutes. A slice was removed from the caudal end of the roasts in order to remove the browned surface. Samples (1.2 cm cubes) were removed from the *longissimus* muscle and served to an experienced eight-member sensory panel. Panelists scored the samples for flavor, juiciness and tenderness using a six-point hedonic scale (very desirable = 6, to very undesirable = 1).

An anlaysis of variance for the effect of replication, sex, management and sex × management was done following the procedure described in Snedecor and Cochran (1967). Means were separated using Duncan's new multiple Range Test (1955).

RESULTS AND DISCUSSION

Data in table 2 illustrate the percentages of fatty acids in subcutaneous and intramuscular fat. These data represent the combined means of both sexes from the three groups. Subcutaneous fat contained more (P<.05) palmitic and oleic and less linoleic, linolenic, 11-eicosenoic and arachidonic acids than intramuscular fat. However, no significant difference existed between the two fat depots for total saturated or total unsaturated fatty acids.

Waldman *et al.* (1968) reported that *longissimus* intramuscular fat contained more staurated fatty acids than subcutaneous fat and the difference was due mainly to a replacement of oleic by stearic and to a lesser extent by a decrease of palmitoleic in the intramuscular depots. Although there were no differences in total saturated or unsaturated fatty acids between subcutaneous and intramuscular depots in the present study there was less oleic in intramuscular than in subcutaneous fat.

TABLE 2. PERCENTAGES OF FATTY ACIDS IN SUBCUTANEOUS AND INTRAMUSCULAR FAT DEPOSITS OF STEERS AND HEIFERS

Fatty acid	Subcutaneous	Intramuscular
C16:0	28.35[a]	27.51[b]
C16:1	4.84	5.12
C18:0	16.69	17.08
C18:1	46.77[a]	42.89[b]
C18:2	2.97[a]	5.30[b]
C18:3	.02[a]	.55[b]
C20:1	.38[a]	1.39[b]
C20:2	.00	.01
C20:3	.00	.002
C20:4	.00[a]	.16[b]
Total saturated	45.03	44.59
Total unsaturated	54.98	55.43

[a,b]Means on the same line bearing different superscripts are different (P<.05).

The combined means of fatty acids in subcutaneous and intramuscular fat and those of the three dietary management groups of steers and heifers are presented in table 3. Fat from steers had more (P<.05) linoleic and arachidonic acids than did fat from heifers. No differences

TABLE 3. PERCENTAGES OF FATTY ACIDS IN COMBINED SUBCUTANEOUS AND INTRAMUSCULAR FAT DEPOSITS OF STEERS AND HEIFERS

Fatty acid	Steer	Heifer
C16:0	28.06	27.79
C16:1	5.04	4.91
C18:0	16.72	17.04
C18:1	44.28	45.39
C18:2	4.58[a]	3.69[b]
C18:3	.29	.27
C20:1	.89	.88
C20:2	.002	.01
C20:3	.002	.00
C20:4	.14[a]	.02[b]
Total saturated	44.79	44.84
Total unsaturated	55.23	55.18

[a,b]Means within the same line bearing different superscripts are different (P<.05).

were observed between the two sexes in total percentages of saturated and unsaturated fatty acids.

The data of Waldman *et al.* (1968) indicated that fat deposits of steers were higher in palmitic and stearic and lower in oleic acids than those of heifers. In the present study, steers had slightly less stearic and oleic acids than heifers.

The percentages of fatty acids of subcutaneous and intramuscular fat for each management group are presented in table 4. Total saturated fatty acids decreased (P<.05) from management group 1 to group 3 for both subcutaneous and intramuscular fat. In contrast, the percentage of total unsaturated fatty acids increased (P<.05) in both subcutaneous and intramuscular deposits. Palmitic and stearic acids were present in both fat deposits in greater (P<.05) percentages in group 1 than in group 3. For subcutaneous and intramuscular fat, the increased total unsaturates between management groups was due mainly to high (P<.05) percentages of oleic acid in groups 2 and 3 than in group 1. Linoleic increased in the subcutaneous fat and decreased in intramuscular fat from group 1 to groups 2 and 3. Essentially no linolenic was present in subcutaneous fat, but was present in intramuscular fat and decreased in percentage from group 1 to groups 2 and 3. The percentage of 11-eicosenoic decreased in subcutaneous fat from group 1 to groups 2 and 3 and did not significantly change in intramuscular fat. Arachidonic was not present in subcutaneous but was present in intramuscular and decreased from group 1 to groups 2 and 3. C_{14} acids were detectable in subcutaneous and intramuscular depots but were a very small proprotion of the total fatty acids in the fat depots in this study.

The differences in fatty acid composition observed in the present study attributable to diet are in agreement with the report of Rumsey *et al.* (1972). These studies show that cattle fed forage diets have more saturated fatty acids in their fat than cattle fed a concentrate diet.

Sensory panel evaluations revealed no differences in flavor, juiciness and tenderness between

TABLE 4. PERCENTAGES OF FATTY ACIDS IN SUBCUTANEOUS AND INTRAMUSCULAR FAT DEPOSITS AS RELATED TO MANAGEMENT GROUP

	Subcutaneous[a]			Intramuscular[a]		
Fatty acid	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
C16:0	30.22[b]	27.59[cd]	27.23[cd]	28.40[c]	27.36[cd]	26.76[d]
C16:1	4.96	4.63	4.92	5.37	4.79	5.18
C18:0	20.18[b]	15.67[cd]	14.21[e]	20.26[b]	16.47[c]	14.52[de]
C18:1	41.34[b]	48.91[cd]	50.07[c]	36.76[e]	44.79[f]	47.13[df]
C18:2	2.19[b]	3.23[c]	3.48[cd]	6.35[e]	5.16[f]	4.39[cf]
C18:3	.00[b]	.00[b]	.06[b]	.79[c]	.52[d]	.33[d]
C20:1	1.11[b]	.00[c]	.03[c]	1.69[b]	.84[bc]	1.64[b]
C20:4	.00[b]	.00[b]	.00[b]	.37[c]	.06[b]	.06[b]
Total saturated	50.41[b]	43.26[c]	41.44[d]	48.66[b]	43.83[c]	41.28[d]
Total unsaturated	49.61[e]	56.77[cd]	58.56[bc]	51.33[e]	56.21[d]	58.74[b]

[a]Combined means of heifers and steers.

[b,c,d,e,f]Means within the same line bearing different superscripts are different (P<.05).

TABLE 5. MEANS OF SENSORY SCORES SHOWING DIFFERENCES DUE TO SEX (A), MANAGEMENT GROUP (B), AND THE RELATIONSHIP BETWEEN SEX AND MANAGEMENT GROUP (AB)

Variable[a]	A		B			AB					
						Steer			Heifer		
	Steer	Heifer	1	2	3	1	2	3	1	2	3
Flavor score	4.31	4.38	3.86^{b}	4.33^{c}	4.85^{d}	3.76^{b}	4.38^{cd}	4.78^{ce}	3.96^{bdf}	4.28^{cdf}	4.92^{e}
Juiciness score	4.69	4.37	4.53	4.25	4.81	4.82^{bc}	4.12^{c}	5.14^{b}	4.24^{bc}	4.38^{bc}	4.48^{bc}
Tenderness score	4.49	4.39	4.33	4.19	4.79	4.28	4.24	4.94	4.38	4.14	4.64

[a]Larger numbers are associated with greater desirability.

[b,c,d,e,f]Means within the same line for each effect bearing different superscripts are different (P<.05).

steers and heifers (table 5). The panelists scored meat from animals fed fescue (Group 1) less desirable in flavor than meat from animals fed concentrate diets (Groups 2 and 3). Also, meat from animals fed the concentrate diet for 112 days (Group 3) was more desirable in flavor than animals fed the concentrate diet for 56 days (Group 2). The less desirable flavor of meat from forage-fed animals compared to the concentrate-fed animals is in agreement with reports presented at the Southern Regional Forage-Fed Beef Research Workshop (Stuedemann *et al.*, 1975). No significant differences were observed for juiciness or tenderness among the three groups by the panelists, except that meat from group 2 steers was less juicy than that of group 3 steers.

The increase in flavor scores from group 1 to groups 2 and 3 parallels the increase in marbling scores (table 1). In reviews of meat palatability, Blumer (1963) and Pearson (1966) concluded that degree of marbling in beef had little or no effect on tenderness, but that increases in marbling did imporve flavor and juiciness.

Correlations for sensory scores with the percentages of fatty acids in intramuscular and subcutaneous fat are presented in table 6. The percentages of total saturated fatty acids in both fat deposits were negatively associated (P<.01) with flavor scores, but not significantly associated with juiciness or tenderness scores. Percentages of total saturates were highest in the pasture-fed group 1 and lowest in the high concentrate group 3 (table 4). The data suggest that stearic and palmitic acids had a negative effect on flavor and oleic had a positive effect on flavor. These relationships existed for both intramuscular and subcutaneous deposits, even though subcutaneous fat samples *per se* were not included in the samples given the panelists. Dryden and Marchello (1970) also observed a negative relationship between palmitic acid and overall palatability of bovine *longissimus* muscle.

A negative correlation (P<.01) was noted between the percentage of linoleic of intramuscular fat and flavor scores. Percentage of linoleic acid in intramuscular fat decreased more from group 1 to group 3 than in the subcutaneous fat (table 4).

TABLE 6. CORRELATION COEFFICIENTS BETWEEN SENSORY SCORES AND PERCENTAGES OF FATTY ACIDS IN SUBCUTANEOUS AND INTRAMUSCULAR FAT

	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:1	C20:2	C20:3	C20:4	Total saturated	Total unsaturated
						Intramuscular fat						
Flavor score	−.52**	−.17	−.60**	.67**	−.63**	−.17	−.04	.20	.00	−.29	−.66**	.66**
Juiciness score	−.08	−.03	−.06	.04	−.15	.06	.07	−.13	.00	.41**	−.08	.09
Tenderness score	−.36	−.19	−.09	.26	−.29	1.7	−.09	−.11	.00	.05	−.23	.23
						Subcutaneous fat						
Flavor score	−.52**	−.02	−.56**	.69**	.15	.24	−.43**	.00	.00	.00	−.65**	.65**
Juiciness score	−.02	−.04	.04	−.01	−.07	−.03	.09	.00	.00	.00	−.08	−.03
Tenderness score	−.24	−.06	−.11	.19	.17	.03	−.14	.00	.00	.00	−.20	.20

**Significant ($P<.01$).

LITERATURED CITED

AOAC. 1975. Official Methods of Analysis (12th Ed.). Official Analytical Chemists, Washington, DC. ists, Washington, DC.

Blumer, T. N. 1963. Relationship of marbling to the palatability of beef. J. Anim. Sci. 22:771.

Dryden, F. D. and J. A. Marchello. 1970. Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. J. Anim. Sci. 31:36.

Duncan, David B. 1955. Multiple range and multiple F test. Biometrics 11:1.

Gerhardt, Klaus O. and Charles W. Gehrke. 1977. Rapid microdetermination of fatty acids in biological materials by gas-liquid chromatography. J. Chromatography 143:335.

Link, B. A., R. W. Bray, R. G. Cassens and R. G. Kauffman. 1970. Fatty acid composition of bovine skeletal muscle lipids during growth. J. Anim. Sci. 30:726.

Pearson, A. M. 1966. Desirability of beef—its characteristics and their measurements. J. Anim. Sci. 25:843.

Rumsey, T. S., R. R. Oltjen, K. P. Bovard and B. M. Priode. 1972. Influence of widely diverse finishing regimens and breeding on depot fat composition in beef cattle. J. Anim. Sci. 35:1069.

Skelley, G. C., W. C. Standford and R. L. Edwards. 1973. Bovine fat composition and its relation to animal diet and carcass characteristics. J. Anim. Sci. 36:576.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. 6th Ed., p. 346. The Iowa State Univ. Press, Ames.

Stuedemann, John A., Dale L. Huffman, J. C. Purcell and Odell L. Walker. 1975. Forage-fed beef: Production and marketing alternatives in the south. Southern Regional Association of State Agr. Exp. Sta., Bull. 220.

Sumida, D. M., D. W. Vogt, E. H. Cobb, I. I. Iwanaga and D. Reimer. 1972. Effect of breed type and feeding regime on fatty acid composition of certain bovine tissues. J. Anim. Sci. 35:1058.

Waldman, R. C., G. G. Suess and V. H. Brungardt. 1968. Fatty acids of certain bovine tissue and their association with growth, carcass and palatability traits. J. Anim. Sci. 27:632.