

Fatty Acid Composition of Subcutaneous Adipose Tissue from Male Calves at Different Stages of Growth¹

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ABSTRACT: The objective of this investigation was to compare fatty acid composition of calves from *Bos taurus* and *Bos indicus* cows across different stages of growth. Hereford (H) and Brahman (B) embryos were transferred to H or B cows (n = 58) to produce purebred Brahman (BB), purebred Hereford (HH), Hereford × Brahman (HB), and Brahman × Hereford (BH) offspring. Calves were castrated at 2 to 3 wk of age. Before weaning (210 d of age), calves were fed native grasses. After weaning, calves were fed a concentrate diet in dry-lot pens. Adipose tissue was obtained by biopsy at two times: at weaning during forage feeding and 3 mo after weaning when placed on feed. A third sample was collected from the fed steers at slaughter (approximately 430 d of age). Samples obtained by biopsy and after death were collected from the perianal region. Fatty acid composition for each sample was determined as the normalized percentage area means from the duplicate measures. Generally,

BB calves grew slowest and BH steers grew fastest ($P < .05$). The BH steers exhibited 15 and 20% heavier ($P < .05$) carcasses per day of age than H-sired steers and BB steers, respectively. Adipose tissue samples from calves from Brahman sires or dams were less saturated ($P < .05$) than samples from calves from Hereford sires or dams. Differences in degree of unsaturation primarily were due to the percentages of monounsaturated fatty acids (MUFA). As calves became older, MUFA increased markedly, polyunsaturated fatty acids increased slightly (due to inverse, nearly proportional changes in 18:2 and 18:3), and saturated fatty acids decreased by 10 percentage units ($P < .001$). Thus, adipose tissue from Brahman and Hereford purebred and crossbred calves became markedly more unsaturated early postweaning; this change was less dramatic in the purebred Hereford calves.

Key Words: Fatty Acids, Cows, Beef, Adipose Tissue, Breeds

J. Anim. Sci. 1996. 74:1256-1264

Introduction

Genetic selection in cattle breeding herds may allow improved fatty acid composition, thus enhancing the position of beef in the marketplace. However, fatty acid research in beef cattle primarily has been confined to English breeds of cattle, and only a few studies have evaluated fatty acid composition in *Bos*

indicus breeds (Larick et al., 1989; Huerta-Leidenz et al., 1993). In addition, interpretation of the literature is difficult because of the inevitable confounding of age, live weight, fatness, plane of nutrition, developmental traits, and other factors that affect lipid metabolism.

A previous report from our laboratory documented differences in fatty acid composition between *Bos taurus* and *Bos indicus* beef cows (Huerta-Leidenz et al., 1993). The objective of this study was to compare fatty acid composition of the male progeny of those cows, which are offspring from a rotational mating of two sire and two dam breeds, across different stages of growth.

Materials and Methods

Animals. Calves were reared at the Texas A&M Agricultural Research Center at McGregor as part of a project involving rotational crossbreeding. Mating

¹Tech. Art., Texas Agric. Exp. St. Partially funded by the King Ranch, Inc., Kingsville, TX, and the Houston Livestock Show and Rodeo, Houston, TX.

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Received May 1, 1995.

Accepted January 26, 1996.

systems were described by Baker et al. (1990). Briefly, Hereford and Brahman cows were superovulated and inseminated with semen from eight different bulls (Hereford or Brahman). The embryos were transferred into Brahman or Hereford cows to produce purebred Brahman (**BB**), purebred Hereford (**HH**), Hereford × Brahman (**HB**) and Brahman × Hereford (**BH**) offspring. This design produced eight fetus-recipient combinations, but only those calves from breed-matched recipients and donors were used for this investigation.

Bulls were selected based on expected progeny differences (**EPD**) to produce calves with varied growth rates. Male calves ($n = 58$) were selected for this study, and calves were castrated at 2 to 3 wk of age. Before weaning (approximately 210 d of age), calves were fed native grasses. After weaning, calves were fed a concentrate diet in dry-lot pens (control diet of Huerta-Leidenz et al., 1991). Steers were slaughtered at an average age of 430 d, which was based on a projected final body weight of 450 kg. Time on the concentrate diet was constant across breed-types (220 d).

Steers were weighed at 28-d intervals, and fat thickness was estimated using real-time ultrasound and a 2.5-MHz transducer (Johnson and Johnson 210DX Ultrasound, Englewood, CO). Ultrasound measurements of longissimus muscle cross-sectional area and overlying s.c. adipose tissue were taken between the 12th and 13th cervical ribs and recorded on video tape (Panasonic AG-2400 Portable VCR, Secaucus, NJ). Two ultrasound measurements were recorded for each steer at each time period. On the basis of s.c. adipose tissue thickness, as determined by final ultrasound measurement, steers were allotted to slaughter so that the fattest steers from each breed-type were slaughtered first and the leanest were slaughtered last. The steers were slaughtered over a 10-d period, five or six steers per day. The four breed-types were assigned to slaughter to ensure an equal distribution of breed-types over the 10-d slaughter period.

Sample Collection. Adipose tissue biopsy samples were obtained at weaning (i.e., during forage feeding) and 3 mo after weaning. A third sample was collected immediately after slaughter. Postmortem samples were removed from the same anatomical location as the biopsy samples.

Biopsy samples were collected from the perianal region, 5 cm below the ischiatic tuber. To cause minimal discomfort, each steer was restrained in a squeeze chute, the perianal region was disinfected with a betadine scrub solution, and the steer was anesthetized via an epidural-block (2% lidocaine HCl solution). A sterile surgical scalpel was used to make a small incision through which a .5- to 1.0-g sample of s.c. adipose tissue was collected. Incision sites were closed using metal staple sutures, and a furacin spray was applied to prevent infection. Each animal then

was monitored by a veterinarian, and normal healing occurred in approximately 1 wk.

Biopsy samples were divided into two sections, frozen in liquid nitrogen, and shipped to the Texas A&M University laboratory. Postmortem carcass samples were packed in dry ice and also transferred to the laboratory. All samples were stored at -20°C until fatty acid analyses were conducted (approximately 3 mo postmortem).

Fatty Acid Analysis. Subcutaneous adipose tissue (100 mg) was extracted (in duplicate) according to the method of Folch et al. (1957), and the extracted lipids were methylated according to the Morrison and Smith (1964) procedure, modified as described by Sturdivant et al. (1992). Subsequently, the fatty acid methyl esters were analyzed with a Packard Chrompack gas chromatograph (model 437a, Chrompack, Claritan, NJ) equipped with a stainless steel column (3 mm × 10 m) packed with Chromasorb W-Aw 80/100. Injector and detector temperatures were 225°C and 215°C , respectively. Oven temperature was 180°C . The flow rate of the carrier gas (nitrogen) was 22 mL/min. To each sample, a known amount of an internal standard (methyl laurate) was added. A standard of known composition was analyzed to verify the identity of the fatty acids in the samples. Fatty acid peaks determined by gas chromatography were then used to calculate amounts of fatty acids according to calculations described by Slover and Lanza (1979).

Statistical Analysis. Analysis of variance was conducted using SAS (1985). Variation in ultrasound measurements of s.c. adipose tissue thickness and longissimus muscle cross-sectional area and various growth traits was partitioned into the effect of breed and nested for the effect of sire within breed.

Fatty acid data were subjected to analysis of variance using a repeated measures design with animals as incomplete block. Data were evaluated individually, in saturation groups (saturates, unsaturates, monounsaturates, polyunsaturates), and in various ratios. Sampling period was considered a repeated factor over time, within animal. Significant animal breed and animal breed × sampling period variance was partitioned. The interactions breed of dam × sampling period, breed of sire × sampling period, and breed of dam × breed of sire × sampling period were determined only if the breed × sampling period interaction was significant ($P < .05$). When F -tests were significant, means were separated using the Tukey-Kramer procedure for unequal cell sizes (SAS, 1985).

Results and Discussion

Postweaning Growth and Carcass Measurements

Animal Growth. Although all breed-types had similar body weights at the first measurement (d 73), HH

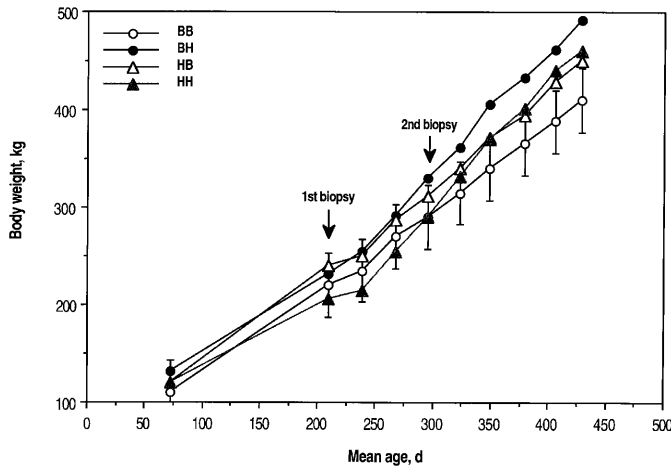


Figure 1. Changes in body weight during the course of the experiment. Purebred Hereford (HH) steers had lower ($P < .05$) weaning weights (d 210) than Brahman \times Hereford (BH) or Hereford \times Brahman (HB) steers; purebred Brahman (BB) weaning weights were intermediate. At slaughter, BH steers had greater ($P < .05$) final body weights than BB steers, and body weights for HB and HH steers were intermediate. Pooled mean square error bars (SEM) are affixed to the data points for the BB steers. Biopsy times are indicated.

calves were significantly lighter than BH and HB calves at weaning (Figure 1). Overall daily weight gains were .93, 1.08, .98, and .98 kg/d for BB, BH, HB, and HH steers, respectively (root mean square error = .11; data not shown in tabular format). Thus, the BB steers gained more slowly ($P < .05$) than BH steers, and the daily gains of the HB and HH steers were intermediate. Similarly, body weights by the end of the study were least for the BB steers and greatest for the BH steers (Figure 1).

The experiment was designed so that all breed-types would have the same time on feed (220 d) and would be the same age (430 d). However, the BB steers were significantly younger at slaughter than the HH steers (Table 1). Embryos were transferred to cows at the same time, and all calves were born during the spring of 1987. However, as indicated in a preliminary report for a portion of these animals (Baker et al., 1990), sire and recipient breed significantly affected gestation length. The Brahman recipient cows carried the fetuses up to 6 d longer than the Hereford recipients (Baker et al. 1990). Thus, calves of all breed-types were born in the same calf crop, but the differences in gestation length caused the significant differences in age at slaughter between BB and HH steers.

The differences in age at slaughter do not explain the differences in final body and carcass weights. Although HH steers were older than BB steers, their body and carcass weights were not different (Figure 1 and Table 1). The differences in rate of gain between

BB and BH steers, clearly apparent in Figure 1, caused the significant differences in final body and carcass weights.

These data suggest a genetic basis for differences in rate of gain. Crouse et al. (1989) reported that *Bos indicus* steers had lighter live weights than *Bos taurus* steers at similar ages, and our results are consistent with their findings. The greater rate of gain in the BH steers corroborates the findings of Koch et al. (1982), who reported greater weights for F₁ Brahman \times Hereford offspring compared with *Bos taurus* types. The advantageous effects of crossbreeding on growth rates have been documented by others (e.g., Preston and Willis, 1982).

Carcass and Ultrasound Measurements. There was good agreement between carcass (Table 1) and ultrasound measurements (Figure 2) of s.c. adipose tissue thickness and longissimus muscle cross-sectional area. The rate of s.c. adipose tissue accretion was still increasing in BH and HH calves by the end of the study, whereas s.c. adipose tissue accumulation in BB and HB calves had virtually ceased by wk 5 (Figure 2A). By slaughter, BB and HB steers had the least s.c. adipose tissue thickness at the 12th–13th rib, and BH and HH steers had significantly greater ($P < .05$) s.c. adipose tissue thickness. Total s.c. fatty acid content (g/100 g s.c. adipose tissue), which is the sum of all identifiable fatty acids, was significantly less in BB steers than in BH steers. The HB and HH steers were intermediate (Table 1).

To our knowledge, this study represents the first attempt to utilize ultrasound to compare s.c. adipose tissue accretion in *Bos taurus* and *Bos indicus* cattle. Whereas previous studies demonstrated that *Bos indicus* influence caused decreased carcass fat thickness (Crouse et al., 1989), this investigation demonstrated clearly that s.c. adipose tissue accretion at the 12th–13th rib was not linear in Hereford and Brahman calves born to Brahman dams. This finding may be unique to this population of cattle. Lunt et al. (1985) serially slaughtered HB steers from 169 to 421 kg live weight and demonstrated nearly linear increases in s.c. adipose tissue thickness at the 12th–13th rib. Cattle of this investigation and that of Lunt et al. (1985) were raised in the same location under nearly identical conditions, so the basis for the obvious differences between studies is not readily apparent. The HB steers of Lunt et al. (1985) also had acquired nearly twice the carcass fat thickness (11.9 mm) by the final slaughter period that we observed in our HB steers (5.4 mm), suggesting that differences in populations of cattle, rather than measurement techniques, were responsible for the different patterns of s.c. adipose tissue accretion.

Longissimus muscle cross-sectional (ribeye) area did not differ ($P > .05$) across breed-types at the various times postweaning (Table 1; Figure 2B). Crouse et al. (1989) also demonstrated that ribeye areas of Brahman and Brahman crossbreed cattle did

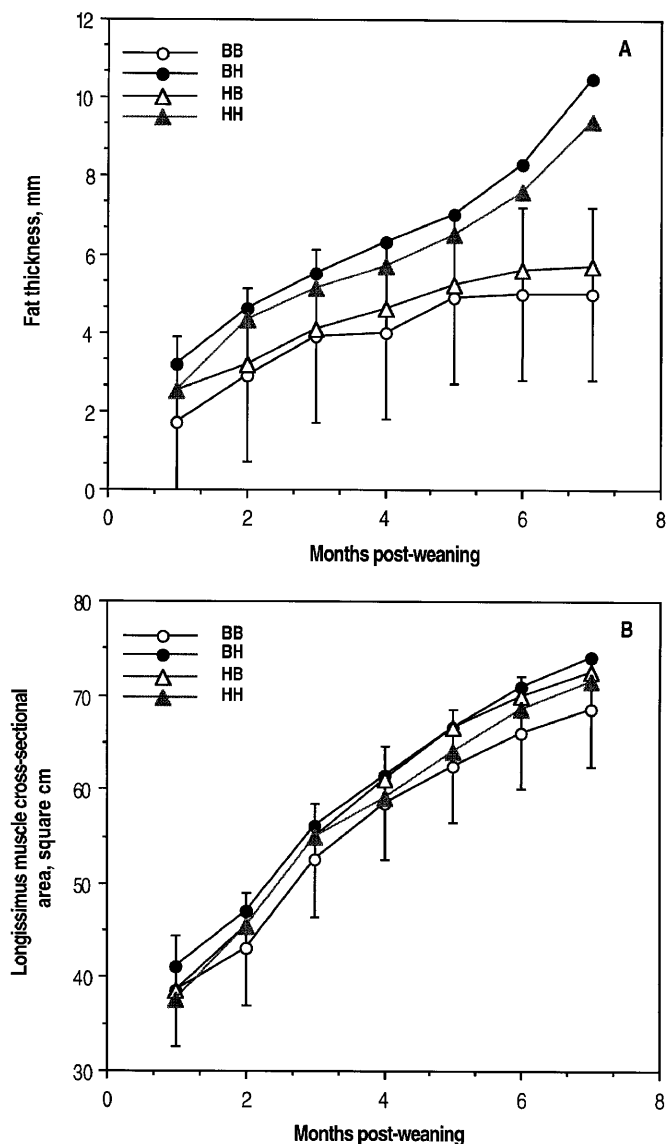


Figure 2. A) Subcutaneous adipose tissue thickness. B) Longissimus muscle cross-sectional area. Measurements were taken at the indicated times postweaning by real-time ultrasound between the 12th and 13th thoracic ribs. Pooled mean square error bars (SEM) are affixed to the data points for the BB steers. Brahman \times Hereford (BH) steers deposited s.c. adipose tissue at a greater ($P < .05$) rate than purebred Brahman (BB) or Hereford \times Brahman (HB) steers. Similarly, there was a trend ($P < .10$) for purebred Hereford (HH) steers to gain s.c. adipose tissue at a greater rate than BB or HB steers.

not differ from ribeye areas of Angus or Hereford cattle. Therefore, the rapid postweaning growth of the BH steers relative to the other breed-types was caused at least in part by the rapid accretion of s.c. adipose tissue, particularly during the latter phases of growth.

There was a significant dam effect for USDA yield grade; calves born of Hereford dams had greater numerical yield grades than calves raised by Brahman

dams (Table 1). These yield grades were numerically lower than those reported by Crouse et al. (1989), due primarily to lower percentages of kidney, pelvic, and heart fat. However, the differences among breed types were similar to those reported by Crouse et al. (1989). The effect of the Brahman dams was apparent in marbling scores and USDA quality grades. Quality grades for BB and HB were lower ($P < .05$) than for BH and HH steers; the HH steers produced carcasses with the greatest quality grades (Se⁵³). Thus, marbling scores and consequent USDA quality grades followed the same pattern as s.c. adipose tissue thickness.

Fatty Acid Composition During Growth

Analysis of Variance. Breed of the steer affected most fatty acid variables, although not the most abundant fatty acids, palmitic acid (16:0) and oleic acid (18:1) (Table 2). Partitioning of breed of dam (D), breed of sire (S), and the D \times S interaction indicated that, in most cases, effects of breed could be attributed to the breed of dam. Excluding palmitoleic acid (16:1), fatty acid variables were affected by sampling period at the $P < .1$ level.

The nested effect of sire within breed [Sire (B)] was not significant for any trait, but the interaction of sampling period \times Sire (B) was significant for myristoleic (14:1) and linolenic (18:3) acids (Table 2). Less than half of the fatty acid variables were affected ($P < .05$) by the interaction of calf breed (B) \times sampling period (P). Partitioning of calf breed into its variance components (D, S, and D \times S) revealed that the D \times S \times P interaction was significant for 16:0, stearic acid (18:0) plus 18:1, the unsaturated:saturated fatty acid (UFA:SFA) ratio, and the monounsaturated (MUFA):SFA ratio. For 14:1 and 18:0, the interaction of B \times P was attributed to the interaction effects of S \times P and D \times P. Partitioning of the calf breed effect into its different components only in the presence of a significant ($P < .05$) breed effect was a more conservative approach and should have offered more protection against type I statistical error. Therefore, the partitioned model was used for discussing the significant ($P < .05$) effects of breeds, sampling periods, and their interactions. Other significant but irrelevant interaction effects (sire nested under breed \times sampling period) will not be discussed.

Effect of Breed across Sampling Periods. Breed of sire and breed of dam acted independently of each other for some fatty acid variables across sampling periods. Subcutaneous adipose tissue samples from Brahman-sired calves contained less saturated fatty acids and more total unsaturated fatty acids and MUFA ($P < .05$) than samples from Hereford-sired calves (Table 3). Differences in degree of unsaturation apparently were due to the percentages of MUFA, because Brahman-sired calves had a greater percentage MUFA than Hereford-sired calves ($P = .035$). Similar breed differences in total saturated fatty acids and more

Table 1. Carcass measurements and fatty acid content of subcutaneous adipose tissue at slaughter

Item	Breed ^a				Root MSE ^b
	BB	BH	HB	HH	
No. of carcasses	14	13	14	17	
Age at slaughter, d	416.8 ^e	427.9 ^{ef}	428.1 ^{ef}	442.3 ^f	18.3
Hot carcass wt, kg	240.1 ^e	300.2 ^f	262.2 ^e	268.3 ^{ef}	33.1
Actual fat thickness, mm	4.5 ^e	10.5 ^f	5.4 ^e	9.2 ^f	3.0
Adjusted fat thickness, mm	7.0 ^e	11.6 ^f	7.6 ^e	10.8 ^f	3.2
Total fatty acid content, g/100 g	57.9 ^e	66.2 ^f	63.6 ^{ef}	63.8 ^{ef}	4.8
Longissimus muscle cross-sectional area, cm ²	66.0 ^e	73.4 ^e	73.6 ^e	71.1 ^e	8.0
Kidney, pelvic and heart fat, %	1.7 ^e	2.4 ^f	1.7 ^e	1.9 ^{ef}	.6
USDA yield grade	2.2 ^e	2.9 ^f	2.2 ^{ef}	2.7 ^{ef}	.6
Marbling score ^c	Tr ^{71e}	Sl ^{39f}	Sl ^{16e}	Sl ^{74g}	51.6
USDA quality grade ^d	Std ^{63e}	Se ^{26f}	Se ^{03e}	Se ^{53g}	76

^aBB = purebred Brahman, BH = Brahman × Hereford, HB = Hereford × Brahman, HH = purebred Hereford.

^bRoot MSE = root mean square error.

^cMarbling scores: Tr = traces and Sl = slight; degrees = 0–99.

^dQuality grade: Std = standard and Se = Select; degrees = 0–99.

^{e,f,g}Within a row, means lacking a common superscript differ ($P < .05$).

Table 2. Repeated measures analyses for the normalized fatty acid data, using sampling period as a repeated factor^a

Dependent variable	R ²	Model										
		Source ^b										
		Calf Breed [B]	Breed of dam [D]	Breed of sire [S]	D × S	Sire nested under B [Sire (B)]	Period [P]	B × P	D × P	S × P	D × S × P	P × Sire (B)
Fatty acid, %												
14:0	.95	***	***	NS ^c	NS	NS	***	*	NS	NS	NS	NS
14:1	.93	***	**	NS	NS	NS	***	*	*	*	NS	*
16:0	.86	NS	ND ^c	ND	ND	NS	***	***	NS	NS	***	NS
16:1	.82	***	***	NS	NS	NS	*	NS	ND	ND	ND	NS
18:0	.85	***	***	*	NS	NS	***	*	*	*	NS	NS
18:1	.91	NS	ND	ND	ND	NS	***	NS	ND	ND	ND	NS
18:2	.86	NS	ND	ND	ND	NS	***	NS	ND	ND	ND	NS
18:3	.89	**	***	NS	NS	NS	***	NS	ND	ND	ND	*
UFA ^c	.89	*	*	*	NS	NS	***	NS	ND	ND	ND	NS
MUFA ^c	.87	*	*	*	NS	NS	***	NS	ND	ND	ND	NS
PUFA ^c	.78	NS	ND	ND	ND	NS	***	NS	NS	ND	ND	NS
SFA ^c	.89	*	*	*	NS	NS	***	NS	ND	ND	ND	NS
18:0 + 18:1	.93	***	***	NS	NS	NS	***	**	NS	NS	**	NS
Ratios												
UFA:SFA	.88	*	*	*	NS	NS	***	*	NS	NS	**	NS
MUFA:SFA	.87	*	*	*	NS	NS	***	*	NS	NS	**	NS
PUFA:SFA	.83	NS	ND	ND	ND	NS	***	NS	ND	ND	ND	NS

^aN = 171 observations, all breeds and periods included.

^bEffects in the first row under the subheading Source correspond to the model components without partitioning the effect of calf breed (B). When the effect of B became significant ($P < .05$), it was partitioned into the effects of D, S, and D × S and their interactions with P, as displayed in the second row.

^cNS = nonsignificant ($P > .05$); ND = not determined. UFA = unsaturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; SFA = saturated fatty acids.

* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 3. Fatty acid composition of perianal subcutaneous adipose tissue as affected by breed of sire and breed of dam^a

Item	Breed of sire or dam		Root MSE ^b	Significance level
	Brahman	Hereford		
No. of calves	37	32		
Sire effect				
Total saturates	43.7	45.6	2.7	.023
Total unsaturates	56.2	54.3	2.7	.022
Total MUFA ^c	53.0	51.4	2.6	.035
Dam effect				
14:0	6.0	5.2	.6	.001
16:1	8.2	6.8	.8	.001
Total saturates	43.9	45.5	2.7	.023
Total unsaturates	56.1	54.4	2.7	.022
Total MUFA	53.0	51.3	2.6	.035

^aData are percentages of fatty acids, pooled across sampling periods.

^bRoot MSE = root mean square error.

^cMUFA = monounsaturated fatty acids.

total unsaturated fatty acids and MUFA ($P < .05$) were observed for the independent effect of breed of dam (Table 3). Despite the higher proportion of total SFA in s.c. adipose tissue from calves of Hereford cows, the percentage of 14:0 was higher ($P < .001$) in Brahman samples. The effects of breed of dam on 14:0 and 16:1 would have little practical significance because of the low concentration of these fatty acids in s.c. adipose tissue.

Biopsy samples of s.c. adipose tissue from the mature Brahman and Hereford cows from which these calves were derived yielded essentially identical results (Huerta-Leidenz et al., 1993). The percentages of all saturated fatty acids (except 14:0) were lower, and all unsaturated fatty acids were higher, in s.c. adipose tissue from Brahman cows than in s.c. adipose tissue from Hereford cows. Total fatty acids (g/100 g s.c. adipose tissue) also were lower in Brahman cows than in Hereford cows.

Sampling Period Comparisons. The significant effect of sampling period on the percentage of 16:1 was undetected by the Tukey-Kramer mean separation procedure. Therefore, minor changes observed in the percentage of 16:1 across sampling periods (Figure 3A) should be considered statistically null ($P > .05$). Percentages of 18:1 and 18:2 increased with age and weight, whereas a decrease was observed for the percentage of 18:3. In general, as steers grew older, MUFA increased markedly, polyunsaturated fatty acids (PUFA) increased slightly (due to the increase in 18:2), and SFA were reduced by 10 percentage units ($P < .001$) (Fig. 3B).

The positive association between 18:1 content and chronological age, carcass weight or total carcass fat percentage has been demonstrated previously (Link et al., 1967; Waldman et al. 1968). Similarly, Hecker et al. (1975) demonstrated that 12:0, 14:0, and 18:0 decreased with growth. A reduction in 18:0 after the 1st yr of age in intramuscular and subcutaneous adipose tissue of Angus and Hereford cattle (Hecker

et al., 1975) also was observed in subcutaneous and kidney fat of Jersey cattle (Leat, 1975). Waldman et al. (1968), Link et al. (1970a,b), and Hecker et al. (1975) reported decreased concentrations of PUFA with growth, whereas others reported that 18:2 tended to increase with time on feed (Dryden et al., 1973; Clemens et al., 1974). The latter studies indicated that the overall increase in unsaturation was due primarily to increased MUFA. The current investigation indicates that these changes in fatty acid composition apparently begin early in life.

Breed × Sampling Period Interaction Effects. The interaction between breed of sire and breed of dam and sampling period is apparent in Figure 4. As indicated above, there was a highly significant ($P < .001$) D × S × P interaction for the percentage of 16:0. Subcutaneous adipose from BH calves exhibited a more marked postweaning reduction in the percentage of 16:0 than did s.c. adipose tissue from BB, HB, or HH calves (Figure 4A). Also, the s.c. adipose tissue from BB and HB calves had higher 16:0 percentages at weaning. Correspondingly, 18:0 plus 18:1 percentages were lower at weaning in BB and HB than in HH and BH s.c. adipose tissue. The percentages of 18:0 plus 18:1 increased to the same level (55 to 60%) with age and weight in all four breed-types, and thus there was a substantially greater magnitude increase in the BB and HB calves (Figure 4B). Changes in these major fatty acids and the D × S × P interaction were reflected in the MUFA:SFA and UFA:SFA ratios (Figure 5). Both ratios increased with advancing age, but the magnitude was less in the HH calves. Thus, s.c. adipose tissue from HH steers persistently exhibited lower UFA:SFA and MUFA:SFA ratios, suggesting that any contribution of Brahman breeding (either as sire or dam) resulted in less saturated s.c. adipose tissue.

The BH and HH steers were similar in several aspects: their postweaning rates of growth were rapid; they were accumulating s.c. adipose tissue at an

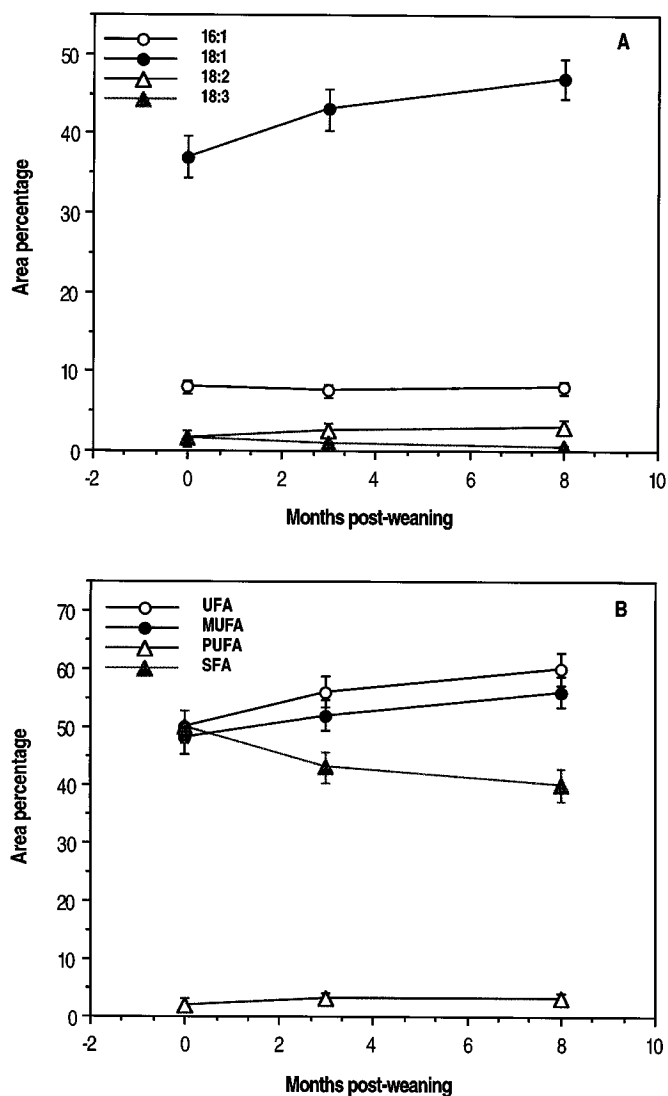


Figure 3. Changes in specific fatty acids and classes of fatty acids during postweaning growth of steer calves. A) Oleic (18:1) and linoleic acid (18:2) increased with age, whereas linolenic acid (18:3) declined with age (all $P < .05$). B) Total unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) increased ($P < .05$) with postweaning age. Conversely, total saturated fatty acids (SFA) declined 10 percentage units ($P < .001$) during this period. Data are pooled across breed-type. Pooled mean square error bars (SEM) are affixed to each data set, although they are obscured by the symbols for 18:3.

increasing rate prior to slaughter; they had nearly twice the actual and adjusted fat thicknesses of BB and HB steers; and their adipose tissue contained more 18:0 plus 18:1 early postweaning than BB and HB steers. For each of these differences the BH steers exhibited more dramatic differences (both numerically and statistically) than the HH steers compared with the BB and HB steers. Additionally, the s.c. adipose

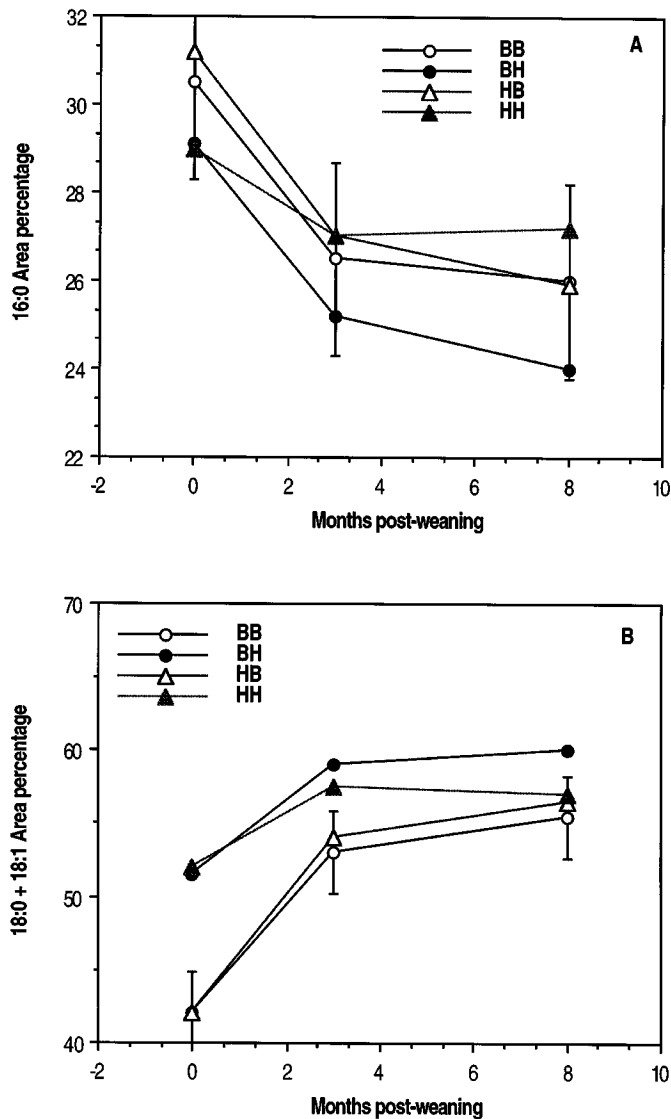


Figure 4. Changes in specific fatty acids, as affected by breed-type. A) There was a significant ($P < .001$) breed-type \times sampling period interaction for 16:0; s.c. adipose tissue from BH calves exhibited a more rapid decline in 16:0 than did adipose tissue from the other breed-types. B) Percentages of 18:0 plus 18:1 were lower in BB and HB calves at weaning, but increased more rapidly postweaning ($P < .05$), than in BH and HH calves. Pooled mean square error bars (SEM) are affixed to the data points for the BB steers. Breed-type abbreviations as in Figure 1.

tissue from BH steers contained more fatty acids per 100 g of adipose tissue than the BB steers. These results indicate that for the BH steers and (to a lesser extent) the HH steers, breed-type differences we observed for fatty acid composition were related to the extent of lipid filling of the s.c. adipocytes.

Our results are consistent with the negative relationship of chronological age with the percentage of

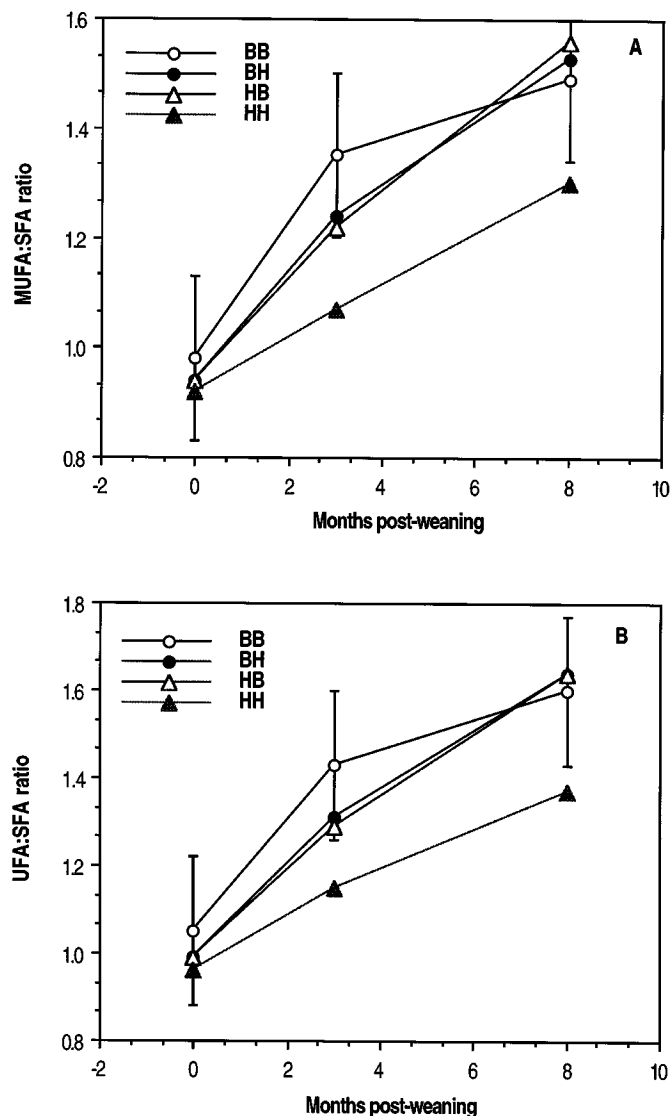


Figure 5. Changes in fatty acids classes, as affected by breed-type. A) The monounsaturated fatty acid:saturated fatty acid (MUFA:SFA) ratio increased more slowly ($P < .05$) in HH calves than in the other breed-types. B) An identical pattern was observed for the unsaturated fatty acid:saturated fatty acid (UFA:SFA) ratio. Pooled mean square error bars (SEM) are affixed to the data points for the BB steers. Breed-type abbreviations as in Figure 1.

16:0 reported by Waldman et al. (1968). A significant reduction of 16:0 during growth also was reported by Clemens et al. (1974). However, others reported that the percentage of 16:0 in adipose tissue remains essentially unchanged during growth (Clemens et al., 1973; Hecker et al., 1975; Leat, 1975; Chang et al., 1992). We previously demonstrated that the fatty acid concentration of perianal (tailhead) s.c. adipose tissue increased from 10 g fatty acids/100 g adipose tissue to nearly 80 g fatty acids/100 g adipose tissue during a 180-d period after weaning in Simmental calves

(Chang et al., 1992). During this period, the percentage of 16:0 remained virtually unchanged at approximately 26%. The breed-type interactions we observed for 16:0 may account for the conflicting reports in regard to changes in 16:0 with age.

The significant ($P < .001$) age and weight effect reported here and previously (Link et al., 1967; Waldman et al., 1968) suggests that age at slaughter may be important in determining the 18:1 concentration of s.c. adipose tissue. This may explain the notably elevated 18:1 concentration of s.c. adipose tissue from the Japanese Black breed-type (Suyama et al., 1984; Tanaka, 1985a,b; Yoshimura and Namikawa, 1983, 1985a,b,c; Sturdivant et al., 1992). Japanese Black, and other breed-types raised for the Japanese market, typically are fed for over 500 d (e.g., Lunt et al., 1993), so these cattle are substantially older than cattle raised for the U.S. market (typically 16 to 18 mo of age). However, we previously provided evidence that the greater percentage of 18:1 in s.c. adipose tissue of Japanese Black (Sturdivant et al., 1992) and the related American Wagyu (May et al., 1993), relative to North American Breed types, has a genetic basis. More recently, we demonstrated that Japanese Black steers have greater percentages of 18:1 than Holstein, Japanese Brown, or Charolais steers even after fatty acid percentages were adjusted for mean carcass fat percentages (Zembayashi et al., 1995). We conclude that, whereas age may be an important determinant of fatty acid composition of s.c. adipose tissue in early postweaning steers (as demonstrated by the present investigation), breed-type is equally or more important in determining fatty acid composition at slaughter.

The reciprocal relationship over time postweaning between 16:0 and 18:0 plus 18:1 suggests that fatty acid elongase (which converts 16:0 to 18:0) and fatty acid desaturase (which converts 18:0 to 18:1) become more active during the postweaning period. We detected fatty acid elongase and desaturase activities in bovine s.c. adipose tissue in slaughter-weight cattle (St. John et al., 1991; Chang et al., 1992), but we have no information concerning the postnatal and early postweaning activities of these enzyme systems. Subcutaneous adipose tissues from slaughter-weight Angus and Braford heifers have virtually identical elongase and desaturase specific activities (St. John et al., 1991); however, there also were no differences between these breed-types in fatty acid composition. It is tempting to hypothesize that the breed-type differences observed in the present investigation were due to inherent differences in these enzyme systems.

Implications

The interactions between fatty acid percentage, breed-type (especially breed of dam) and sampling age and weight indicate that it will be very difficult to

ascribe genetic control over the fatty acid composition of tissues in beef cattle without more mechanistic studies. Furthermore, because subcutaneous adipose tissue frequently is trimmed before consumption of beef, selecting for cattle with greater percentages of saturated or unsaturated fatty acids in subcutaneous adipose tissue may have little practical significance.

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