PATTERNS OF MUSCLE, BONE, AND FAT ACCRETION IN THREE BIOLOGICAL TYPES OF FEEDLOT BULLS FED THREE DIETARY ENERGY LEVELS

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The effect of three types of diet on the carcass composition of 71 feedlot bulls of three biological types (Dairy Cross (DX), Hereford Cross (HX), and Beef Cross (BX)) was studied over a 2-yr period. Diets consisted of pelleted alfalfa with 0, 35 or 85% grain. Serial slaughter and carcass dissection into eight wholesale cuts and component tissues were carried out over an age range of 392–636 days. Interactions of biological type with diet-year were generally not significant for actual weight of muscle, bone and fat, or for weight of these tissues at a constant side subcutaneous fat weight of 16 kg. There were few significant effects of biological type or diet-year on the ratio of actual weight of subcutaneous to intermusclar plus body cavity fat. HX bulls had significantly less muscle and less bone than BX or DX, based on actual weights, but the rate of tissue accretion relative to side subcutaneous fat was the same for the three biological types. Animals on the lowest level of dietary energy had less weight of fat than did those on an 85% grain diet, but diet-year growth coefficients of tissue weights relative to side subcutaneous fat weight were generally homogeneous. It was concluded that effects of dietary energy were consistent over the biological types studied and for most of the wholesale cuts.

Key words: Feedlot bulls, diet, biological types, tissue growth

[Croissance des tissus musculaires, osseux et adipeux chez trois types biologiques de traurillons d'engrais soumis à trois niveaux différents d'éngergie alimentaire.]
Titre abrégé: Croissance des tissus musculaires, osseux et adipeux chez des taurillons d'engrais.

Nous avons étudié, sur une période de deux années, les effets de trois types de régimes sur la composition de la carcasse de 71 taurillons d'engrais appartenant à trois types biologiques (type laitier (DX), type Hereford (HX) et type à viande (BX)). Les régimes étaient faits de luzerne agglomérée contenant 0, 35 ou 85% de grains. Nous avons procédé à l'abattage en série des sujets de l'âge de 392 jours à 636 jours et avons découpé les carcasses en huit morceaux de gros pour séparer ensuite les tissus qui les composaient. Les interactions entre le type biologique d'une part et le régime et l'année d'autre part n'étaient généralement pas significatives pour le poids réel des muscles, des os et du gras ni pour le poids de ces tissus compte tenu d'un poids donné constant du gras sous-cutané de la demi-carcasse de 16 kg. Le type biologique et le régime et l'année n'ont eu que peu d'incidences significatives sur le rapport du poids réel du gras sous-cutané sur le poids total réel du gras intermusculaire et du gras de la cavité générale. Les sujets HX avaient significativement moins de tissus musculaires et osseux, en poids réels, que les BX et

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les DX, mais le taux de croissance des tissus par rapport au gras sous-cutané de la demi-carcasse était le même pour les trois types biologiques. Les sujets qui recevaient le moins d'énergie alimentaire contenaient moins de gras que ceux dont le régime était constitué à 85% de grains, mais les coefficients de croissance des tissus par rapport au poids du gras sous-cutané de la demi-carcasse étaient généralement homogènes d'un groupe régime-année à l'autre. Nos résultats portent à conclure que les effets de l'énergie alimentaire sur la croissance des tissus sont les mêmes peu importe le type biologique et peu importe, dans la plupart des cas, le morceau de gras choisi.

Mots clés: Taurillons d'engrais, régime, types biologiques, croissance des tissus

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Beef carcass quality depends in part on the relative proportions of bone, muscle, and fat. It is now fairly well established that breed differences exist for the partitioning of fat into different depots, with 'dairy' breeds depositing less fat subcutaneously than 'beef' breeds (Kempster et al. 1976a; Jones et al. 1980a). Breed differences were observed for fat distribution among wholesale cuts (Jones et al. 1980b). Significant but small differences among sire groups were noted for the proportions of bone and muscle in different cuts by Berg et al. (1978a,b). In general, breed differences in the distribution of muscle and bone seemed to be less pronounced than those seen for fat (Koch et al. 1982).

The effect of differing levels of dietary energy on the partitioning and distribution of fat, and on the distribution of muscle and bone relative to fat in the different cuts of animals of different breeds has not been well established. Different biological-types of cattle may show different patterns of growth under different nutritional regimes. To ensure meeting carcass grading requirements with minimum cost, specific management schemes should be adapted to each biological-type. The following study was undertaken to examine the effects of three levels of dietary energy on muscle, bone and fat partitioning and distribution in three biological-types of cattle.

MATERIALS AND METHODS

In two successive years, a total of 71 bull calves from the University of Alberta Ranch at Kinsella that had been born in May and June were weaned in October. Following an adjustment period of about 4 wk to an ad libitum high energy diet, the calves were kept on the diet for 140 days. At the end of this period the cattle were about 11 mo old and they were randomly reassigned, with half of them being switched to a low energy diet in each year, giving four diet-year groupings. The composition of the high energy diets (79H and 80H) was the same in both years, (85% grain, 15% pelleted alfalfa (Table 1)). The low energy diet fed in 1979 (79L) contained only pelleted alfalfa, while that fed in 1980 (80L) contained 35% grain. The bulls consisted of three biological-types: Dairy Cross (DX) with 25% or more of 'dairy' breeding (Holstein, Brown Swiss, Guernsey and Jersey); Hereford cross (HX), with 25% or more of Hereford breeding (the remainder being mainly Angus and Charolais); and Beef Cross (BX), a synthetic stabilized at approximately 38% Angus, 34% Charolais and 20% Galloway.

As described by Price et al. (1984), a sequence of serial slaughter was carried out to ensure that slaughter occurred over a long time period and that animals were selected for slaughter at random. Generally, in each 2-wk period, one animal from the low energy diet and two animals from the high energy diet were slaughtered in a commercial abbatoir. The overall range in age at slaughter was from 392 to 636 days of age. Numbers of observations and mean values for age and weight at slaughter are shown in Table 2. The left half of each carcass was separated into eight wholesale cuts and each cut was physically separated into muscle, bone plus connective tissue, subcutaneous fat (SC Fat), intermuscular fat (IM Fat) and body cavity fat (BC Fat), as described by Jones et al. (1980c).

Shank and sirloin did not contain body cavity fat. A few animals had no body cavity fat in the flank, two had none in the chuck, and six had none in the round. For analysis such zero values

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Table 1. Composition of diets

	High energy diets 1979 and 1980	Low energy diets 1979	1980
Ingredients (kg/tonne)			
Rolled barley	620	–	262
Rolled oats	200	–	88
Alfalfa pellets†	100	1000	600
Rapeseed meal	58	–	36.3
Calcium carbonate	10	–	6.3
Dicalcium phosphate‡	5.2	–	3.3
Vitamin mix (A, D_3, E)	2.6	–	1.6
Trace-mineral salt	2.6	–	1.6
Molasses	1.6	–	1.0
Total	1000	1000	1000
DM content (%)	91.0	92.0	91.0
Composition: dry matter basis			
Crude protein (%)	14.3	17.4	15.9
Calcium (%)	0.54	1.65	1.23
Phosphorus (%)	0.37	0.21	0.37
DE (MJ/kg DM) calculated	14.2	10.9	11.9

† Dehydrated ground alfalfa with Ethoxyquin®.
‡ Containing minimum of 21% phosphorus and 15-18% calcium.

were set to an arbitrary very low non-zero value to allow the inclusion of this trait for comparisons.

Side subcutaneous fat weight was chosen as the covariate to reduce the problem of the part-whole relationship encountered when using total side fat. Use of subcutaneous fat also allowed a comparison similar to that of a constant finish or grading standard, although the depth of fat deposited would of course depend upon the size of the animal.

Statistical Analysis

MODEL 1. Least squares analysis of variance was used (Harvey 1976). The model included the fixed effects of biological type, diet-year, and the interaction of biological type and diet-year.

MODEL 2. The rate of growth of one part relative to another was examined using the allometric equation (Huxley 1972). The model included the same fixed effects as Model 1, as well as the within-biological-type and within-diet-year regressions of $\log_{10}$ of the trait on $\log_{10}$ total side subcutaneous fat. If no significant differences were found among the within-group regressions, a common regression was fitted. Any significant differences ($P<0.05$) in adjusted means were tested using Scheffé's procedure (Neter and Wasserman 1974).

RESULTS AND DISCUSSION

Comparison on Basis of Actual Tissue Weights

Over the range of the experiment, the HX bulls, being lighter, had significantly less muscle and less bone than the other two biological types but all had the same amount of fat (Table 2). The smaller size of HX was reflected in the weight of most of the cuts, although significant differences were not always seen. Animals on the lowest level of dietary energy (79L) had less side subcutaneous, intermuscular, and body cavity fat than those on the higher levels of energy (79H and 80H), with 80L bulls being intermediate. No effect of dietary energy was seen for side muscle or bone weights. 79L bulls were intermediate in sirloin weight, but had the lightest weight for all other cuts though the difference was not always significant (Table 2).

No significant biological-type by diet-year interactions occurred for actual weight of muscle, bone and fat in the side or in wholesale cuts. Thus over a range of slaughter ages and weights, higher energy

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Table 2. Least squares means and standard errors of carcass traits for 71 feedlot bulls (Model 1)

	Biological type			Diet-year			
Trait	HX	DX	BX	79L	80L	79H	80H
Number of observations	19	16	36	23	9	24	15
Age at slaughter (days)	497 ± 18	526 ± 19	534 ± 12	544 ± 16	517 ± 26	490 ± 15	525 ± 19
Livewt. at slaughter (kg)	585 ± 25	658 ± 26	653 ± 17	595 ± 21	622 ± 35	648 ± 21	663 ± 26
Carcass weight (kg)	356 ± 15*a*	397 ± 15*ab*	401 ± 10*b*	358 ± 13	377 ± 21	396 ± 12	409 ± 15
Side muscle weight (kg)	105 ± 4*a*	118 ± 4*b*	120 ± 3*b*	111 ± 3	114 ± 6	112 ± 3	120 ± 4
Side bone weight (kg)	24.5 ± 1.0*a*	28.0 ± 1.0*b*	27.7 ± 0.7*b*	26.3 ± 0.9	27.3 ± 1.4	25.6 ± 0.8	27.6 ± 1.0
Side subcutaneous fat (kg)	18.0 ± 2.2	17.6 ± 2.3	18.0 ± 1.5	13.0 ± 1.9*a*	15.3 ± 3.1*ab*	22.6 ± 1.8*b*	20.6 ± 2.3*b*
Side intermuscular fat (kg)	18.8 ± 1.5	20.4 ± 1.0	20.4 ± 1.5	15.9 ± 1.3*a*	18.5 ± 2.1*ab*	22.7 ± 1.2*b*	22.4 ± 1.5*b*
Side body cavity fat (kg)	6.6 ± 0.5	7.8 ± 0.6	6.4 ± 0.4	5.2 ± 0.5*a*	6.1 ± 0.8*ab*	8.5 ± 0.4*c*	7.8 ± 0.6*bc*
Shank weight (kg)	9.1 ± 0.4*a*	10.2 ± 0.4*ab*	10.4 ± 0.3*b*	9.5 ± 0.4	9.9 ± 0.6	9.9 ± 0.4	10.3 ± 0.4
Brisket weight (kg)	22.3 ± 1.4	23.6 ± 1.5	26.0 ± 1.0	21.1 ± 1.3*a*	23.2 ± 2.0*ab*	24.9 ± 1.2*ab*	26.6 ± 1.5*b*
Prime rib weight (kg)	20.1 ± 0.8	22.9 ± 0.8	20.9 ± 0.6	19.1 ± 0.7*a*	20.7 ± 1.1*ab*	23.0 ± 0.7*b*	22.4 ± 0.9*b*
Chuck weight (kg)	41.3 ± 1.7*a*	47.0 ± 1.8*b*	46.0 ± 1.2*b*	42.7 ± 1.5	44.3 ± 2.5	44.5 ± 1.5	47.5 ± 1.8
Flank weight (kg)	14.0 ± 0.8	15.4 ± 0.8	15.5 ± 0.6	12.0 ± 0.7*a*	15.1 ± 1.1*b*	15.2 ± 0.7*b*	17.5 ± 0.8*b*
Sirloin weight (kg)	7.5 ± 0.3*a*	8.5 ± 0.3*b*	7.7 ± 0.2*a*	8.0 ± 0.2	7.6 ± 0.4	8.3 ± 0.2	7.6 ± 0.3
Loin weight (kg)	24.8 ± 1.7	26.7 ± 1.8	27.9 ± 1.2	24.6 ± 1.5	24.8 ± 2.4	28.7 ± 1.4	27.8 ± 1.8
Round weight (kg)	34.0 ± 1.3*a*	37.9 ± 1.4*ab*	38.9 ± 1.0*b*	35.3 ± 1.2	36.2 ± 1.9	37.5 ± 1.1	38.8 ± 1.4

a–c Means for each effect followed by different letters are significantly different by Scheffé's test ($P<0.10$).

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diets led to more fat deposition for the three biological-types studied.

Lister (1976) used a 'fat partition index' (the ratio of subcutaneous fat to the sum of intermuscular plus perinephric plus inguinal fat) to classify animals by metabolic type. He found that Hereford cattle, classed as early fattening, had a higher index than did Dairy types. In the present study, the ratio of subcutaneous fat to intermuscular plus body cavity fat (SF/NSF) was compared for each cut and for the side, and few significant differences were found. HX animals had a higher SF/NSF ratio than did DX or BX for the loin (Fig. 1). Although the ratio of SF/NSF in the side was slightly higher for HX than for DX, the probability of the biological-types being different was 0.31. In these data, non-subcutaneous fat did not include perinephric plus inguinal fat, as they are not part of the Canadian beef carcass. No significant differences among dietary energy levels were seen for side SF/NSF ratio. SF/NSF ratios were different ($P \leq 0.05$) for three of the cuts (Fig. 2); however, the pattern of differences was not consistent. Although the three biological-types used in our study cannot be statistically differentiated into metabolic groups, the carcass SF/NSF ratios are in general agreement with the index values given by Lister (1976) for Angus, Hereford × Friesian, and Charolais.

Rate of Tissue Accretion Relative to Side Subcutaneous Fat Weight

The effect of the interaction of biological-type and diet-year on the growth coefficients was not tested in the present study because numbers of observations in some groups were too small to fit the Model 2 regression accurately. A preliminary analysis of the data on cut fat weights with total side fat as the covariate showed significant differences among the regression coefficients for only flank subcutaneous fat, flank

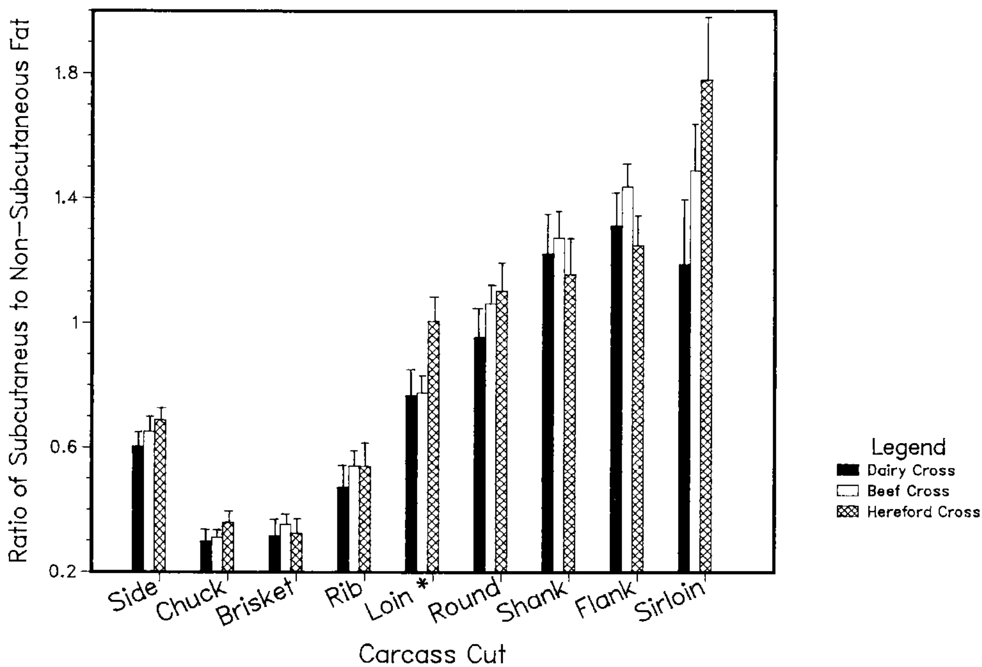

Fig. 1. Least squares means and standard errors for the ratio of cut subcutaneous to non-subcutaneous fat for each biological-type. (*significant at $P \leq 0.05$.)

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intermuscular fat, and loin intermuscular fat.

Regressions on log side subcutaneous fat were homogeneous within diet-year for side muscle, bone, intermuscular and body cavity fat, and for the same traits for all cuts except the flank. This also held true for the within-biological-type regressions. Kempster et al. (1976b) observed homogeneous growth coefficients among steer breed groups for thin flank subcutaneous fat regressed on side subcutaneous fat weight. His pooled *b* value for this trait at 1.20 ± 0.03 was higher than the values found here, which ranged from 0.66 ± 0.10 for HX to 1.02 ± 0.13 for DX.

For most of the carcass rate of fattening and of muscle and bone deposition relative to subcutaneous fat was the same for the three biological-types and for the three levels of dietary energy considered in this study. When accretion of fat in the cuts was expressed relative to total side fat weight, some significant but small differences among breed groups in fattening rate of male cattle have been found (Jones et al. 1980a,b; Kempster et al. 1976a; Berg et al. 1978c). In a study of Holstein and Angus cattle on two dietary energy levels, the rate of subcutaneous and intermuscular fat deposition was lower for Angus cattle on the low energy diet than for those on the high energy diet, but no difference was observed for Holsteins (Fortin et al. 1981).

The bulls in this study were also taken to a higher level of total fat than in the other studies mentioned. An overall geometric mean of 41.4 kg for total side fat was found, as compared to 18.6 kg for Fortin et al. (1981), 17.0 kg for Berg et al. (1978c), and 29.2 kg for Kempster et al. (1976a). At higher levels of carcass fat, breed or dietary differences in rate of fattening may not be as evident as at lower levels. Pooled growth coefficients (Table 3) showed that muscle and bone accretion were both proceeding at

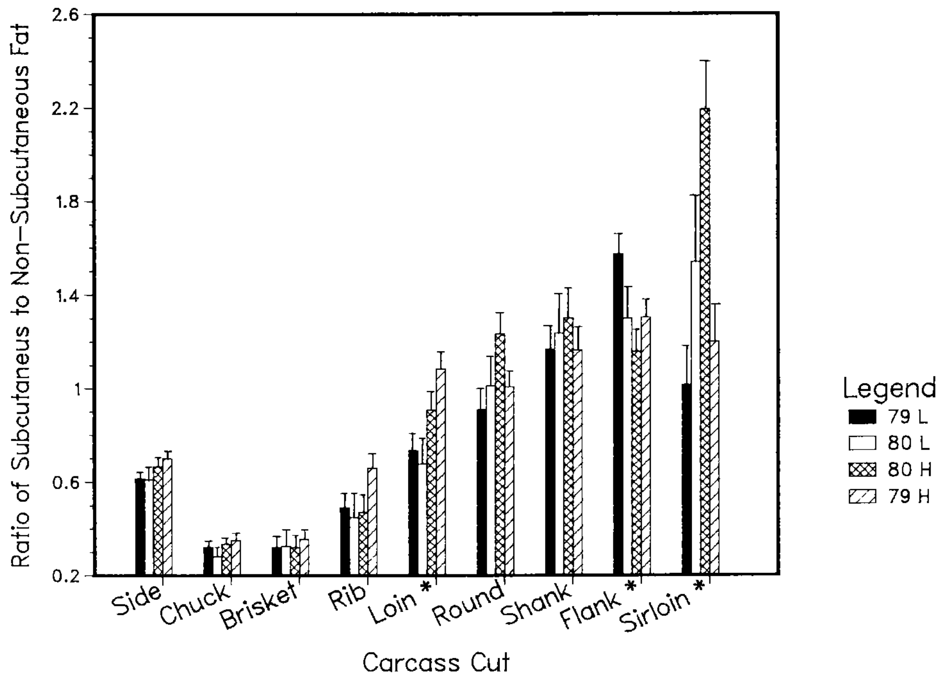

Fig. 2. Least squares means and standard errors for the ratio of cut subcutaneous to non-subcutaneous fat for each diet-year. (*significant at $P \leq 0.05$.)

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Table 3. Parameter estimates from the allometric regression on log side subcutaneous fat weight (Model 2)

Trait	Pooled regression coefficient b	SEb	R^2	Significance levels: Biol. type B	Diet-year D	B×D
Carcass weight	0.24	0.03	0.59	0.002	0.603	0.542
Muscle weight						
Side	0.07	0.04	0.25	0.006	0.476	0.844
Shank	0.06	0.06	0.17	0.051	0.970	0.715
Brisket	0.12	0.06	0.32	0.002	0.389	0.611
Rib	−0.03	0.05	0.21	0.040	0.176	0.557
Chuck	0.10	0.05	0.25	0.020	0.223	0.916
Flank	–†	–	–	–	–	–
Sirloin	−0.05	0.04	0.33	0.010	0.219	0.501
Loin	0.19	0.05	0.31	0.007	0.588	0.933
Round	0.03	0.04	0.24	0.003	0.709	0.601
Bone weight						
Side	0.15	0.04	0.34	0.008	0.080	0.774
Shank	0.13	0.04	0.31	0.007	0.300	0.321
Brisket	0.28	0.08	0.38	0.007	0.053	0.640
Rib	0.09	0.05	0.25	0.017	0.854	0.075
Chuck	0.17	0.05	0.28	0.114	0.092	0.970
Flank	–	–	–	–	–	–
Loin	0.20	0.05	0.33	0.036	0.057	0.746
Round	0.12	0.05	0.29	0.009	0.174	0.608
SC fat weight						
Shank	0.46	0.08	0.48	0.560	0.604	0.695
Brisket	1.22	0.07	0.88	0.205	0.441	0.365
Rib	1.11	0.08	0.86	0.583	0.002	0.611
Chuck	1.02	0.07	0.83	0.257	0.338	0.566
Flank	–	–	–	–	–	–
Sirloin	0.75	0.09	0.66	0.127	0.609	0.458
Loin	1.44	0.06	0.93	0.232	0.001	0.770
Round	0.92	0.05	0.90	0.078	0.080	0.049
IM fat weight						
Side	0.58	0.04	0.85	0.099	0.440	0.268
Shank	0.42	0.09	0.36	0.925	0.942	0.919
Brisket	0.67	0.08	0.72	0.804	0.543	0.907
Rib	0.58	0.09	0.70	0.134	0.038	0.210
Chuck	0.55	0.05	0.80	0.059	0.288	0.258
Flank	0.70	0.10	0.69	0.541	0.039	0.025
Sirloin	0.32	0.11	0.38	0.087	0.006	0.881
Loin	0.90	0.10	0.72	0.000	0.020	0.105
Round	0.42	0.06	0.62	0.354	0.186	0.502
BC fat weight						
Side	0.60	0.05	0.85	0.000	0.016	0.409
Brisket	0.68	0.09	0.70	0.092	0.282	0.091
Rib	0.22	0.11	0.43	0.000	0.207	0.625
Chuck	0.33	0.12	0.54	0.128	0.000	0.024
Flank	0.56	0.13	0.62	0.094	0.001	0.631
Loin	0.85	0.12	0.57	0.064	0.577	0.418
Round	0.48	0.14	0.36	0.061	0.065	0.859

† – indicates the common regression was not valid, due to nonhomogeneity of regression coefficients ($P<0.05$).

a much lower rate than that of subcutaneous fat in the side and in each of the cuts, as expected in animals of this age. The brisket, loin, and chuck showed the greatest gains in both muscle and bone.

Intermuscular and body cavity fat had a lower growth impetus than subcutaneous fat (Table 3). Subcutaneous fat was deposited faster relative to the side in the loin, brisket and rib than in the other cuts. Berg et al. (1978c) compared their findings with those of several authors, and observed that growth coefficients for cut fat relative to the side fat were generally higher in the loin and rib area, with foreshank growth coefficients being low.

Influences on Tissue Distribution at a Constant Side Subcutaneous Fat Weight

At a constant side subcutaneous fat weight of 16 kg, significant or near significant biological-type × diet-year interactions occurred for only five traits (Table 3). These were rib bone, round subcutaneous fat, flank intermuscular fat, and brisket and chuck body cavity fat. Thus, in general, any effects of altering dietary energy level can be considered to be consistent across the biological groups when adjusted to a common side subcutaneous fat weight. Geay et al. (1976) found evidence of a genotype × dietary energy level interaction for early maturing Salers and late maturing Charolais for fat weight at a constant carcass weight, with Charolais showing little fattening increase at higher dietary energy levels. However, those were young bulls (9–15 mo of age), while the bulls in the present study were from 13 to 21 mo of age at slaughter.

The effect of biological-type was significant for side muscle and bone weight, cut muscle weight for all cuts except the shank, and bone weight for all except the chuck (Table 4) when compared at a common subcutaneous fat weight. HX animals had less muscle and less bone at this level of fat than did the other two types. There were few differences between the the BX and DX. Muscle and bone growth patterns have usually been studied relative to side muscle or side bone weight (e.g. Berg et al. 1978a,b). However, the pattern shown here is consistent with the Hereford animals being earlier fattening types.

Table 4. Geometric least squares means for each biological type at a common side subcutaneous fat weight (x = 16 kg)

	Biological-type		
Cut	HX	DX	BX
Muscle (kg)			
Side	104*a*	117*b*	119*b*
Shank	5.1	5.7	5.8
Brisket	11.3*a*	12.2*ab*	13.7*b*
Rib	11.5*a*	13.4*b*	12.6*ab*
Chuck	27.5*a*	31.8*b*	31.4*b*
Sirloin	5.7*a*	6.7*b*	6.0*a*
Loin	14.2*a*	15.4*ab*	16.8*b*
Round	21.4*a*	24.1*b*	25.0*b*
Bone (kg)			
Side	24.1*a*	27.8*b*	27.4*b*
Shank	2.8*a*	3.2*b*	3.2*b*
Brisket	2.4*a*	2.7*ab*	3.1*b*
Rib	3.0*a*	3.5*b*	3.1*a*
Chuck	5.6	6.3	6.1
Loin	3.5*a*	4.0*b*	4.0*b*
Round	6.5*a*	7.6*b*	7.6*b*
SC fat (kg)			
Shank	0.6	0.6	0.6
Brisket	1.7	1.8	1.9
Rib	1.6	1.6	1.5
Chuck	1.8	1.8	1.6
Sirloin	1.0	0.9	0.8
Loin	2.7	2.5	2.4
Round	2.6	2.6	2.8
IM fat (kg)			
Side	17.7	19.7	19.2
Shank	0.5	0.5	0.5
Brisket	4.5	4.6	4.7
Rib	2.4	2.7	2.2
Chuck	4.9	5.6	5.3
Sirloin	0.6	0.8	0.6
Loin	1.0*a*	1.1*a*	1.5*b*
Round	2.3	2.6	2.5
BC fat (kg)			
Side	6.2*a*	7.4*b*	6.0*a*
Brisket	1.0	1.2	1.2
Rib	0.8*a*	1.0*a*	0.6*b*
Chuck†	0.4	0.5	0.4
Loin	1.8	2.4	1.8
Round†	0.2	0.3	0.3

† Some values of this trait were 0 kg.
a,b Means followed by different letters are significantly different by Scheffé's test ($P<0.10$).

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Table 5. Geometric least squares means for each diet-year at a common side subcutaneous fat weight (x = 16 kg)

	Diet-year			
Cut	79H	80H	80L	79L
Muscle (kg)				
Side	109	117	114	112
Shank	5.5	5.6	5.5	5.5
Brisket	11.8	13.1	12.3	12.2
Rib	12.3	13.3	12.7	11.7
Chuck	28.0	31.1	31.2	30.4
Sirloin	6.3	5.8	6.0	6.4
Loin	14.7	15.7	15.5	15.8
Round	23.2	24.4	23.2	23.2
Bone (kg)				
Side	24.4	26.7	27.5	27.1
Shank	2.9	3.1	3.2	3.1
Brisket	2.4	2.8	2.9	3.0
Rib	3.1	3.1	3.3	3.2
Chuck	5.5	6.1	6.2	6.2
Loin	3.5	3.7	4.1	4.0
Round	6.7	7.5	7.4	7.3
SC fat (kg)				
Shank	0.6	0.6	0.6	0.6
Brisket	1.7	1.7	2.0	1.8
Rib	1.9*a*	1.4*b*	1.4*b*	1.6*ab*
Chuck	1.7	1.7	1.6	1.9
Sirloin	0.8	0.9	0.9	0.8
Loin	2.8*a*	2.4*ab*	2.1*b*	2.9*a*
Round	2.4	2.8	2.8	2.7
IM fat (kg)				
Side	19.1	19.3	19.2	17.9
Shank	0.5	0.5	0.5	0.5
Brisket	4.6	4.8	4.7	4.3
Rib	2.8*a*	2.5*ab*	2.3*ab*	2.1*b*
Chuck	5.1	5.5	5.4	5.0
Sirloin	0.8*a*	0.5*b*	0.6*ab*	0.8*a*
Loin	1.0*a*	1.2*ab*	1.3*b*	1.3*b*
Round	2.7	2.3	2.4	2.5
BC fat (kg)				
Side	6.9*a*	6.8*a*	6.4*ab*	5.9*b*
Brisket	1.2	1.3	1.1	1.0
Rib	0.9	0.8	0.8	0.7
Chuck	0.6*a*	0.4*b*	0.3*b*	0.4*b*
Loin	2.1	1.9	1.8	2.2
Round	0.3	0.2	0.4	0.2

a, b Means followed by different letters are significantly different by Scheffé's test ($P < 0.10$)

The different levels of dietary energy caused no significant differences ($P<0.05$) in muscle weight (Table 3 and 5), and only a few for bone weight ($P=0.05$ to $P=0.10$). Animals on the 79H diet had a tendency to less bone in the side, brisket, chuck and loin.

Few differences were seen among either biological-types or diet-years for the weight of fat adjusted to a basis of 16 kg of subcutaneous fat in the side. BX had more intermuscular fat in the loin than either of the other biological-types (Table 4). DX had more body cavity fat in the side, although

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this did not show up as significant for the individual cuts. Thus even when kidney and pelvic fat are not included, 'dairy' bulls with a portion of traditional beef breeding seem to show the higher levels of internal fat relative to subcutaneous fat noted by others (Kempster et al. 1976a).

Although high energy diets increased the total amount of fat in the carcass, as discussed earlier, they had little effect on the partitioning of fat among the depots or on fat distribution in the body. Bulls on both high and low energy diets in 1979 had less subcutaneous fat in the rib and loin than low energy 1980 animals, and some differences were seen for intermuscular fat in the rib, loin and sirloin (Table 5), but there was no consistent effect of dietary energy on the fat depots compared at a constant side subcutaneous fat weight. More side body cavity fat was deposited in animals on the high energy diets than on the lowest energy diet (Table 5). It may be simpler for animals on high energy diets to store excess fat in the body cavity, where there is less pressure from other tissues.

It seems that although HX bulls are smaller, with less muscle and bone than DX and BX animals, the rate of accretion of muscle, bone and fat relative to side subcutaneous fat is similar in all three biological-types of this age range. It may require analysis of a much larger number of animals to be able to detect significant differences in growth coefficients. Decreasing dietary energy gave reduced amounts of fat in all depots, a trend which occurs in all three biological-types studied. Patterns seen for side tissues are reasonably consistent for tissues in most of the eight cuts.

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