THE INFLUENCE OF FEED ENERGY LEVEL ON GROWTH AND CARCASS TRAITS IN BULLS OF TWO BREED TYPES

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A serial slaughter experiment is described using 48 yearling bulls: 24 Hereford crossbred (HX) and 24 Beef synthetic (SY). Twelve bulls of each breed type were fed a high-energy, mainly grain diet (Hi) and the other 12 a pelleted alfalfa diet (Lo). The two breed types showed similar growth rate and feed efficiency, yet at constant carcass weight (375.2 kg) the HX were fatter (44.2 vs. 37.2 kg) and had less muscle (110.3 vs. 116.8 kg) in the dissected side than the SY. The Hi diet resulted in greater growth rate (1.46 vs. 1.06 kg/day) and feed efficiency (9.5 vs. 12.7 kg/kg), in both breed types, than the Lo diet and resulted in a greater rate of fat thickness accumulation ($P = 0.001$). At constant carcass weight (375.2 kg), the Hi diet gave more fat (46.9 vs. 34.5 kg) and less msucle (109.0 vs. 118.0 kg) and bone (24.6 vs. 28.0 kg) in the dissected side than the Lo diet in both breed types. It is concluded that biological type and diet can be manipulated independently to produce optimum carcass grades at various carcass weights.

Key words: Fatness, feed energy, growth, carcass, bulls, beef production

[Influence de la valeur énergétique des aliments sur la croissance et les caractères de la carcasse des taureaux de deux races.]
Titre abrégé: Valeur énergétique des aliments et race des taureaux.
Suit la description d'une expérience dans le cadre de laquelle on a abattu une série de 48 taurillons d'un an: 24 hybrides Hereford (HX) et 24 bovins de boucherie de race synthétique (SY). Douze taureaux de chaque type ont reçu un aliment à haute valeur énergétique, principalement du grain (Hi), les autres étant nourris d'agglomérés de luzerne (Lo). Les taurillons des deux types ont montré un taux de croissance et un indice de consommation similaires. Cependant, à poids de carcasse identique (375,2 kg), les taurillons HX étaient plus gras (44,2 contre 37,2 kg) et avaient une musculature moins développée (110,3 contre 116,8 kg) que les taurillons SY pour le côté disséqué. Le régime Hi entraîne une hausse du taux de croissance (1,46 contre 1,06 kg/j) et de l'indice de consommation (9,5 contre 12,7 kg/kg) chez les deux types, de même qu'il se caractérise par un dépôt accru de graisse ($P = 0{,}001$). A poids de carcasse identique (375,2 kg), le régime Hi augmente la couche de gras (46,9 contre 34,5 kg) et réduit la musculature (109.0 contre 118,0 kg) ainsi que l'ossature (24,6 contre 28,0 kg) du côté disséqué pour les taurillons des deux types. On en conclut que le type biologique et le régime peuvent être modifiés séparément pour la production de carcasses de la meilleure catégorie, à divers poids.

Mots clés: Couche de gras, valeur énergétique des aliments, croissance, carcasse, taureaux, production de boeuf

Many factors influence the cost of production in a beef feedlot but a common and normally profitable aim is to minimize costs by using breed types and feed formulations which maximize growth rate. This inevit-

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ably leads to greater feed efficiency, but can also lead to overfatness particularly in breeds with a high propensity to fatten (Price et al. 1980; Barber et al. 1981). The maximum price per kilogram in Canada is achieved by carcasses with both an optimum fat cover (currently those which grade Canada A1 or Canada A2) and an optimum carcass weight (generally between about 250 and 317 kg) with price penalties for over- and under-fatness as well as over- and under-weight. Choosing the appropriate slaughter weight and fatness to maximize returns therefore involves understanding the interactions between the rate of accumulation of fat and of liveweight in cattle of different biological types on different diets. Estimating maximum profit involves among other things taking into account the size of the various discounts for weight and fatness since maximum return per kilogram and maximum gross margin do not always coincide.

Most research into the effects of feed energy and biological type have used the serial slaughter at a fixed end-point approach to obtain carcass data (Barber et al. 1981; Kempster et al. 1982). This involves slaughtering animals when they reach a predetermined age, liveweight or fat thickness. Such fixed end-point experiments are unable to indicate what the effect of the experimental treatment would have been at any end-point other than the one chosen. This design has the further disadvantage of confounding the effects of time with the effects of the end-point factor. A random time-of-slaughter design allows the study of rates of change in tissue weights relative to any covariate desired (e.g. time, liveweight, carcass weight, bone weight). In addition, the size of any component in the carcass can be adjusted, within the range of the data, to estimate the sizes which would be expected at any desired end-point. It is also possible to compare growth rate and feed efficiency using this design.

The present random sequence, serial slaughter experiment was designed to study the effects of dietary energy level on rates of change in live animal and carcass traits of bulls of a fatter and a leaner breed type.

MATERIALS AND METHODS

The experiment used 48 bulls, selected at the end of a 140-day feedlot performance test, aged approximately 1 yr. They consisted of 24 bulls of each of two breed types: Hereford crossbreds (HX) with a breed composition of at least 50% Hereford, and Beef Synthetic (SY), a composite which has stabilized at approximately 36% Angus, 34% Charolais, 20% Galloway and 10% of other breeds. Twelve bulls of each breed type were allocated at random to a mainly grain concentrate diet (Hi) and the other 12 to a pelleted, dehydrated alfalfa diet (Lo). Both diets (Table 1) were fed ad libitum in pens of six bulls each, with water freely available. The design was, therefore, fully replicated with two pens per breed × diet combination. Until Day 1 of the experiment all 48 bulls had been eating the Hi diet, and on that day they were all weighed (initial weight) and the Lo groups were switched to the Lo diet. During the course of the experiment all bulls were weighed individually at 2-wk intervals without restriction of feed or water. At the same time remaining feed was weighed to establish the pen feed consumption during the previous 2 wk. Average daily gain (ADG) was calculated as the within-bull regression of liveweight on time. Feed conversion rate was the total feed consumed in the pen divided by the total weight gained in the pen for the duration of the trial.

The bulls were slaughtered in random order, beginning 4 wk after the initial allocation to treatments. To ensure a wide range of slaughter weight and fatness the 24 Hi bulls were dispatched at a rate of two a fortnight and the 24 Lo bulls at one a fortnight because of their anticipated slower growth and fattening rates (Fig. 1). This method ensured that the cattle were selected in a random sequence, spread over a long time period, and that factors such as liveweight, fat cover and time on feed had no influence on selection for slaughter.

Bulls were weighed in the normal manner on the day before slaughter and leftover feed was weighed at the same time. The bulls were held overnight without feed or water and then trucked 150 km for slaughter in a commercial packing plant. They were weighed on arrival (slaughter

Table 1. Composition of experimental diets

	High energy 10% roughage diet†	Low energy 100% roughage diet†
Ingredients (kg/tonne)		
Rolled barley	620	–
Rolled oats	200	–
Alfalfa pellets‡	100	1000
Rapeseed meal	58	–
Calcium carbonate	10	–
Dicalcium phosphate§	5.2	–
Vitamin mash (A, D3, E)¶	2.6	–
Trace-mineralized salt//	2.6	–
Molasses	1.6	–
Total	1000	1000
Analyses on DM basis		
Dry matter (%)	91.0	92.0
Crude protein (%)	14.3	17.4
Acid detergent fiber (%)	13.5	32.1
Calcium (%)	0.54	1.65
Phosphorus (%)	0.37	0.21
Gross energy (MJ/kg DM)	17.8	16.3
Digestible energy (MJ/kg DM)	14.2	10.9
Metabolizable energy (MJ/kg DM)	11.6	8.9

†Assumed 80% digestibility for high energy diet and 67% digestible for low energy diet.
‡Dehydrated ground alfalfa with ethoxyquin, an anti-oxidant water-soluble vitamin A preservative.
§Mixture of monocalcium phosphate and dicalcium phosphate containing a minimum of 21% phosphorus and 15–18% calcium.
¶In each kilogram of diet: vitamin A, 5000 IU; vitamin D, 825 IU; vitamin E, 5 IU.
//Containing 96.5% salt, 0.400% Zn, 0.160% Fe, 0.120% Mn, 0.033% Cu, 0.007% I and 0.004% Co.

weight) and slaughtered within an hour. After overnight chilling the carcasses were appraised and graded by Agriculture Canada personnel. The quartered (11th/12th rib) left sides of the carcasses were taken to the University Meat Laboratory where they were broken into primal cuts as described by Jones et al. (1980), and each cut was dissected into bone, muscle and fat.

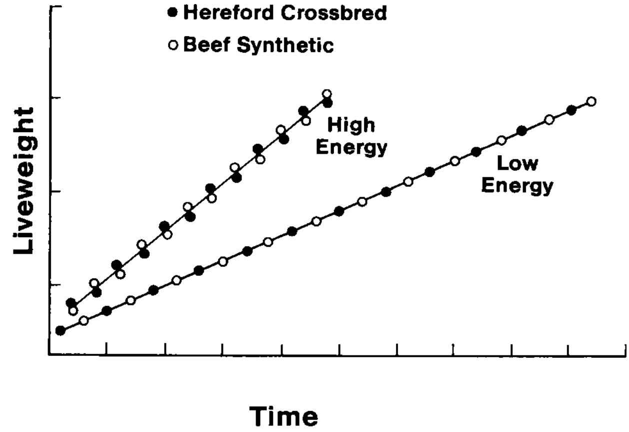

Fig. 1. Schematic representation of slaughter schedule.

The data were initially subjected to least squares analysis of variance (Harvey 1976) to establish the overall effects of breed type, diet and their interaction. The experimental design also allowed the use of covariance analysis to study the rates of change in the live and carcass traits relative to some fixed reference, such as initial or final liveweight, carcass weight or days on test.

RESULTS

One bull in the Lo HX group died of feedlot bloat in the 26th week of the experiment; all data relating to that bull were removed from the analyses.

Table 2 shows the means and standard errors of the weights and ages of the bulls at the time of allocation to treatments, and the number of days spent on feed by each group. ADG and feed efficiency were similar in the two breed types over the course of the trial (Table 3). Diet, however, exerted a significant influence on feedlot performance: greater ADG ($P<0.001$) accompanied by better feed efficiency ($P<0.001$) in the Hi group, though it should be noted that by design, their time on test was shorter than that of the Lo group. There was no significant interaction of breed type and diet on feedlot performance (Table 3).

The slaughter and carcass analyses (Table 3) indicated no breed type differences in slaughter or carcass weight, but the SY group had a greater side muscle weight ($P=0.045$) and a tendency towards a greater longissimus muscle area ($P=0.067$) and lesser fat thickness ($P=0.079$) than the HX group. The Hi diet gave greater carcass weights ($P=0.017$), and fatter carcasses ($P<0.001$) than the Lo diet, but diet had no significant effect on muscle or bone weights. There were no significant interactions of breed type with diet for any of the slaughter or carcass data.

No attempt was made to analyze statistically the carcass grading data, but arranging them in order of measured fat thickness (Table 4) indicated that HX carcasses were fatter than SY carcasses and that the Hi diet resulted in fatter carcasses than the Lo diet.

Least squares analyses of covariance indicated that gain on test, adjusted to a common time on test (159.8 days) was not significantly affected by breed-type, but was affected by diet, the Hi group having a greater ($P=0.002$) rate of gain (Table 5). There were no breed type or diet effects on slaughter weight adjusted to a common initial weight, or on the regression (b) of carcass weight on slaughter weight (Table 5). However, at the mean slaughter weight (618.0 kg), adjusted carcass weight was greater in the SY than the HX bulls ($P=0.023$) and in the Hi than in the Lo diet ($P=0.007$).

There were no significant differences between breed types for any of the relationships shown in Table 6, though adjusted to the mean carcass weight, the HX carcasses had greater fat depths ($P=0.029$) and side fat weight ($P=0.005$), and lower side muscle weight ($P=0.014$) than the SY carcasses. Adjusted to a common side bone weight the SY bulls had greater side muscle weights.

The relationships between marbling score and carcass weight, and fat depth and carcass weight were both affected by diet ($P<0.01$); the Hi diet causing a more rapid accumulation of fat than the Lo diet. Adjusted to the mean carcass weight (375.2 kg), the Hi diet caused increases in fat depth ($P<0.001$) and side fat weight ($P<0.001$)

Table 2. Means and standard errors at the time of allocation to treatments

	No. of bulls	Initial wt. (kg)	Initial age (days)	Days on experiment
Hi HX	12	494.7 ± 11.4	360.8 ± 4.1	133.7 ± 23.3
Lo HX	11	457.0 ± 11.9	348.7 ± 4.2	176.8 ± 24.3
Hi SY	12	477.9 ± 11.4	355.9 ± 4.1	136.6 ± 23.3
Lo SY	12	469.2 ± 11.4	359.7 ± 4.1	190.3 ± 23.3

Table 3. Least squares means and standard errors of feedlot performance and carcass data

	No. of bulls	ADG on test (kg/day)	Feed efficiency on test (kg/kg)	Final weight (kg)	Slaughter weight (kg)	Carcass weight (kg)	Avg fat depth (mm)	Marbling† scores	L. dorsi area (cm^2)	Side muscle weight (kg)	Side bone weight (kg)	Side fat weight (kg)
Breed-type												
HX	23	1.23 ± 0.06	11.3 ± 0.4	651.9 ± 20.3	616.6 ± 19.3	372.4 ± 11.2	16.6 ± 1.8	7.4 ± 0.2	87.6 ± 2.4	108.1 ± 3.2	25.4 ± 0.8	44.5 ± 2.4
SY	24	1.28 ± 0.06	10.8 ± 0.4	657.1 ± 20.8	620.2 ± 19.8	381.8 ± 11.5	12.0 ± 1.8	7.7 ± 0.2	94.2 ± 2.4	117.3 ± 3.2	26.7 ± 0.8	38.6 ± 2.5
		(P = 0.581)	(P = 0.397)	(P = 0.861)	(P = 0.897)	(P = 0.560)	(P = 0.079)	(P = 0.264)	(P = 0.067)	(P = 0.045)*	(P = 0.258)	(P = 0.092)
Diet												
Hi	24	1.46 ± 0.06	9.5 ± 0.4	678.3 ± 20.8	645.2 ± 19.8	397.0 ± 11.5	19.9 ± 1.8	7.2 ± 0.2	92.3 ± 2.5	113.3 ± 3.2	25.8 ± 0.8	50.6 ± 2.4
Lo	23	1.06 ± 0.06	12.7 ± 0.4	630.6 ± 20.3	591.7 ± 19.3	357.3 ± 11.2	8.7 ± 1.7	7.9 ± 0.2	89.3 ± 2.3	112.1 ± 3.3	26.3 ± 0.8	32.6 ± 2.4
		(P<0.001)*	(P<0.001)*	(P = 0.108)	(P = 0.060)	(P = 0.017)*	(P<0.001)*	(P = 0.804)	(P = 0.389)	(P = 0.804)	(P = 0.645)	(P<0.001)*
Breed × diet												
Hi HX	12	1.43 ± 0.09	10.2 ± 0.6	684.5 ± 28.8	652.8 ± 27.3	395.3 ± 15.8	23.4 ± 2.6	7.1 ± 0.2	88.9 ± 3.5	109.6 ± 4.5	25.4 ± 1.2	52.9 ± 3.4
Lo HX	11	1.02 ± 0.09	12.4 ± 0.6	619.3 ± 28.8	580.4 ± 27.3	349.6 ± 15.8	9.8 ± 2.6	7.7 ± 0.2	86.3 ± 3.3	106.9 ± 4.7	25.3 ± 1.2	36.2 ± 3.4
Hi SY	12	1.46 ± 0.09	8.7 ± 0.6	672.2 ± 30.1	637.5 ± 28.6	398.8 ± 16.5	16.5 ± 2.6	7.2 ± 0.2	95.7 ± 3.5	116.9 ± 4.5	26.1 ± 1.2	48.3 ± 3.5
Lo SY	12	1.10 ± 0.09	12.9 ± 0.6	641.9 ± 28.8	602.9 ± 27.3	364.9 ± 15.8	7.6 ± 2.6	8.2 ± 0.2	92.4 ± 3.2	117.7 ± 4.5	27.2 ± 1.2	29.0 ± 3.4
		(P = 0.788)	(P = 0.095)	(P = 0.552)	(P = 0.498)	(P = 0.712)	(P = 0.359)	(P = 0.412)	(P = 0.917)	(P = 0.665)	(P = 0.601)	(P = 0.701)

†Visual assessment of longissimus muscle: 10 = no visible marbling, 1 = highly marbling.
*Level of probability considered to be significant.

Table 4. Grades assigned to carcasses in the experiment

		Number in each grade†						
	No.	A4	A3	A2	A1	B1‡	C1§	E¶
Breed type								
HX	23	4	2	1	12	4	0	0
SY	24	3	0	1	15	0	3	2
Diet								
Hi	24	7	2	1	13	1	0	0
Lo	23	0	0	1	14	3	3	2
Breed × diet								
Hi HX	12	4	2	1	4	1	0	0
Lo HX	11	0	0	0	8	3	0	0
Hi SY	12	3	0	0	9	0	0	0
Lo SY	12	0	0	1	6	0	3	2

†The progression from A4 to E represents decreasing fatness, except as indicated below.
‡The Hi HX carcass in this column had a fat level appropriate for A1 but was downgraded to B1 for medium-dark-colored muscle. The other three had B1 fat levels.
§All carcasses were judged youthful but lacking sufficient fat for a B1 grade.
¶One E carcass had no measurable fat cover. The other had a fat level appropriate for A3 but was downgraded for "stag" quality and coarse texture.

Table 5. Least squares analyses of covariance to test the effects of breed type and diet on live animal and carcass traits

Factor	Gain on test (kg)	Slaughter wt (kg)	Carcass wt (kg)	Carcass wt (kg)
Least squares mean	185.2	611.9	376.2	376.2
Covariate	Days on test	Initial wt	Initial wt	Slaughter wt
Covariate mean	159.8 days	474.6 kg	474.6 kg	618.0 kg
R^2	0.887	0.320	0.368	0.965
RMS	970.6	7210.9	2359.7	129.8
Breed type				
b† HX	1.05±0.09	0.94± 0.4	0.58± 0.2	0.56±0.03
SY	1.08±0.08	0.68± 0.7	0.45± 0.4	0.55±0.03
	(*P*=0.838)	(*P*=0.752)	(*P*=0.311)	(*P*=0.675)
y‡ HX	185.4± 6.5	605.2±18.6	366.2±10.6	372.2± 2.4
SY	185.1± 6.7	618.6±17.8	381.1±10.2	380.2± 2.4
	(*P*=0.999)	(*P*=0.602)	(*P*=0.773)	(*P*=0.023)*
Diet				
b Hi	1.27±0.10	1.35± 0.5	0.81± 0.3	0.58±0.02
Lo	0.86±0.07	0.26± 0.6	0.22± 0.3	0.53±0.03
	(*P*=0.002)*	(*P*=0.146)	(*P*=0.081)	(*P*=0.181)
y Hi	223.4± 6.9	628.3±18.3	387.0±10.5	381.2± 2.5
Lo	147.1± 6.6	595.5±18.6	360.2±10.7	371.2± 2.5
	(*P*<0.001)*	(*P*=0.216)	(*P*=0.163)	(*P*=0.007)*

†*b* = coefficient of regression.
‡ *y* = estimated value of dependent variable at covariate mean.
*Level of probability considered to be significant.

Table 6. Least squares analyses of covariance to test the effects of breed type and diet on carcass traits

Factor	Marbling score	Avg fat depth (mm)	L. dorsi area (cm²)	Side muscle wt (kg)	Side bone wt (kg)	Side fat wt (kg)	Side muscle wt (kg)
Least squares mean	7.7	13.4	90.7	112.6	26.3	40.7	112.6
Covariate	Carcass wt	Carcass wt	Carcass wt	Carcass wt	Carcass wt	Carcass wt	Side bone wt
Covariate mean (kg)	375.2	375.2	375.2	375.2	375.2	375.2	26.0
R^2	0.506	0.647	0.270	0.739	0.812	0.757	0.817
RMS	0.424	38.2	94.5	73.8	3.4	62.2	51.8
Breed type							
b† HX	−0.003±0.003	0.06±0.03	0.05±0.03	0.25±0.03	0.07±0.01	0.13±0.03	3.53±0.4
SY	−0.001±0.003	0.05±0.03	0.08±0.05	0.26±0.04	0.07±0.01	0.14±0.04	3.17±0.4
	(P=0.667)	(P=0.324)	(P=0.639)	(P=0.793)	(P=0.999)	(P=0.745)	(P=0.521)
y‡ HX	7.5± 0.2	15.8± 1.5	87.9± 2.2	110.3± 1.9	26.0± 0.4	44.2± 1.7	110.4±1.5
SY	7.8± 0.2	11.0± 1.5	92.9± 2.2	116.8± 1.8	26.6± 0.4	37.2± 1.7	115.4±1.5
	(P=0.213)	(P=0.029)*	(P=0.104)	(P=0.014)*	(P=0.293)	(P=0.005)*	(P=0.026)*
Diet							
b Hi	−0.009±0.002	0.11±0.02	0.09±0.03	0.21±0.03	0.10±0.01	0.18±0.03	3.71±0.4
Lo	0.004±0.000	0.00±0.03	0.04±0.05	0.31±0.05	0.09±0.01	0.10±0.04	3.00±0.4
	(P=0.005)*	(P=0.001)*	(P=0.462)	(P=0.079)	(P=0.110)	(P=0.105)	(P=0.201)
y Hi	7.3± 0.2	18.0± 1.5	90.8± 2.3	109.0± 1.9	24.6± 0.1	46.9± 1.7	114.3±1.5
Lo	8.0± 0.2	8.8± 1.5	90.1± 2.2	118.0± 2.0	28.0± 0.4	34.5± 7.8	111.5±1.5
	(P=0.005)*	(P<0.001)*	(P=0.827)	(P=0.002)*	(P<0.001)*	(P<0.001)*	(P=0.186)

†*b* = coefficient of regression.
‡*y* = estimated value of dependent variable at covariate mean.
*Level of probability considered to be significant.

and decreases in marbling score ($P = 0.005$), side muscle weight ($P = 0.002$) and side bone weight ($P < 0.001$) (Table 6).

DISCUSSION

The experiment was designed to study changes in live animal performance and body composition over a wide range of weights and ages representing the full range likely to be encountered in commercial beef production.

Since there were no significant interactions between breed type and diet for any of the traits measured during the study, these two factors can be considered separately.

Effects of Breed Type

Analysis of the breed type data showed no significant differences between the two breed types for feedlot performance (Table 3), and it may be assumed that costs of production for these two types of cattle would be similar. Study of the carcass data, however, showed important differences in tissue content (Table 3). The HX group, though similar in liveweight and age to the SY group, had less muscle ($P = 0.045$), and a tendency towards more fat. Although the carcass grades could be transformed to numerical scores for statistical analysis (e.g. Jones and MacLeod 1981), the complexity of the relationships among weight, fat thickness, subjective characteristics and grade would make detailed interpretation of the results difficult. Table 4 shows, however, that over a similar range of age and liveweight, the HX group had more carcasses grade fatter than Canada A2 (6 vs. 3) and fewer carcasses grade leaner than Canada B1 (0 vs. 5) than the SY group. It would be anticipated that to achieve any particular grade consistently HX carcasses should be lighter than SY carcasses.

Covariance analysis allowed a study of the rates of change during the trial. Table 5 shows no breed effect on rate of gain adjusted for time on test or in slaughter or carcass weight adjusted for differences in initial weight. This agrees with the results from the earlier analyses (Table 3). The SY bulls yielded significantly heavier carcasses than the HX bulls when adjusted to a common slaughter weight (Table 5), suggesting higher dressing percentage. Greater dressing percent may result from greater fatness (Geay 1978), which is undesirable; or from greater muscularity (Kauffman 1978), which appears to be the case in the present study.

No significant differences were detected in the rates of change, relative to carcass weight, of any of the traits shown in Table 6. However, when adjusted to a constant carcass weight, the HX bulls had significantly greater fat depth and side fat weight, confirming that the breed difference observed in carcass fatness was real, and not a result of differences in carcass weight. Similarly, the SY bulls showed significantly greater muscularity than HX at constant carcass weight (Table 6). The breed composition of the SY bulls (34% Charolais) would be expected to give a more muscular animal than the HX breed composition (at least 50% Hereford); greater muscularity, together with faster growth, having been the original incentive for using Charolais cattle in beef cross-breeding programs. The fact that the greater muscularity of the SY bulls was not associated with an increase in bone weight meant that they had greater muscle:bone ratios in the carcass. This was manifested as a breed difference ($P = 0.026$) in side muscle weight adjusted to a common side bone weight (Table 6).

It is concluded that while the two breed types of cattle used in this study had similar growth rates and feed conversion efficiency over a liveweight range from about 450 to about 800 kg, they did not produce similar carcasses. While it was clearly not difficult to achieve optimum fat levels (defined as grades Canada A1 and Canada A2) with either breed type, the HX bulls reached this fat level at a lighter weight than the SY bulls. In an economic environment with high cost of production relative to selling price, the HX types of cattle would be preferred. In an environment where the margins favored taking cattle to heavier weights, the SY type would be preferred. Producers would also need to take into account any discounts applied to under-and over-weight carcasses in estimating their margins.

Effects of Diet

The initial weight of the Lo bulls was less than that of the Hi bulls (Table 2), but in view of the range of liveweights over which the trial was conducted, this is of minor importance. By design the Hi bulls were on test for a shorter period and, as expected, the Hi diet resulted in a more rapid gain, greater estimated feed efficiency and fatter carcasses than the Lo diet (Table 3). The slaughter weights ($P = 0.060$) and carcass weights ($P = 0.017$) were greater for the Hi than the Lo bulls (Table 3). The Hi diet produced a greater weight of carcass per unit of slaughter weight than the Lo diet (Table 5). This is presumably a reflection of the greater alimentary tract content associated with lower energy feeds. The effect of dietary energy content on dressing percent is well established (Preston and Willis 1970; Price et al. 1980) and normally results from the dual effect of greater gut fill and less fat accumulation on lower energy diets. The Hi carcasses were notably fatter than the Lo carcasses, but differences in side muscle and bone content of the carcasses were not pronounced (Table 3). This agrees with well-established growth theory which indicates that bone and muscle have higher priority than fat for limited nutrients (Palsson 1955). The difference in fat content resulted in clear differences in grade (Table 4); the Hi diet yielded nine overfat and no underfat carcasses, compared with no overfat and eight underfat carcasses from the Lo diet. The majority of carcasses in both groups had optimum fat levels (Canada A1/A2), however, reflecting the grade stability of bull carcasses (Price et al. 1980) even over this very wide weight range.

In the present experiment dietary energy level influenced the rate of accumulation of carcass fat; marbling score ($P = 0.005$), fat depth ($P = 0.001$) and side fat weight ($P = 0.105$) all increased more rapidly in the Hi carcasses (Table 6). Similarly, adjusted to a common carcass weight, these same fat measures were all significantly greater in cattle fed the high energy diet ($P \leq 0.005$ in all cases). No diet-induced differences were found in the rate of increase in longissimus muscle area, side muscle or side bone weight relative to carcass weight, or in the rate of increase in muscle weight relative to bone weight. It is generally accepted that the relative growth of muscle and bone are under genetic more than nutritional control, so that nutritionally induced differences in the rate of accumulation of non-fat tissue relative to carcass weight are unlikely. However, at constant carcass weight significant differences in adjusted side muscle ($P = 0.002$) and bone weight ($P = 0.001$) were apparent. This result can be explained as a fatness effect; at a constant weight the carcass with more fat (Hi) must have less muscle and bone. Since there was no effect of diet on muscle:bone ratio (Table 6) both of these tissues shared in offsetting the extra weight of fat in the Hi carcasses.

Dietary energy level clearly influenced production efficiency, with low energy diets reducing growth rate and feed efficiency, but giving leaner carcasses at any particular weight. Because of the lack of any significant interaction between the effects of breed type and feed energy level, it is concluded that these two could be used to manipulate production to ensure optimum fat at optimum carcass weight. However, any reduction in feed energy level would carry the penalty of increased cost of production.

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