THE RELATIONSHIP OF NET ENERGY FOR PRODUCTION EFFICIENCY AND PERFORMANCE AND COMPOSITION OF STEERS AND HEIFERS OF TWO BIOLOGICAL TYPES

by

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INTRODUCTION

The efficiency of converting feed to edible product gain is an important factor in determining the profitability of any cattle feeding operation. While producers are interested in generating gain in the most economical manner possible, they should also be keenly aware that the compositional and quality characteristics of the finished product are major determinants of its value.

The market readiness of cattle has been primarily decided by visual evaluation along with such methods as feeding to a predetermined weight, age or number of days on feed. All of these systems, alone, or in combination, have been used with varying degrees of success in predicting the desired carcass composition after slaughter.

Because of the strong effect of composition of gain on feed efficiency (Klosterman, 1972 and Dikeman, 1973), and the proposal by Lofgreen and Garrett (1968) that the energy value of a feed used for production above maintenance is a constant, Lipsey (1977) proposed that the ratio of net energy for production per unit of gain (NEp/gain) should serve as a useful tool in predicting composition of the animal at slaughter.

Our objectives were: (1) to further clarify the relationship between NEp efficiency and body composition at slaughter, (2) to study the affects of different NEp efficiency endpoints on performance traits, carcass traits and palatability, (3) to determine if these differences exist between types of cattle slaughtered at a series of NEp efficiency endpoints, and (4) to determine if the differences exist between steers and heifers slaughtered at the same NEp efficiency endpoints. It is our hope that we can provide cattle feeders with a viable alternative system of predicting composition and, hence, the value of their cattle during the feeding process.

REVIEW OF LITERATURE

Factors Affecting Gross Feed Efficiency

Gross feed efficiency is a function of intake, maintenance requirements, and composition of gain (Ames, 1975). Smith *et al*. (1976) includes the additional factors of physiological age and the intrinsic efficiencies of digestion, absorption and the utilization of metabolites in the gross efficiency model.

Certainly the digestibility of a ration will have a marked effect on the animals' ability to use it efficiently. Associative effects are those which result in changes in the digestibility of a ration component due to changes in its percentage of the ration relative to other components (Schneider and Flatt, 1974). Due to adaptation of rumen microbes, a ration component may be more or less digestible when fed in a mixed ration than when fed alone. Forbes *et al*. (1928) stated that comparable determination of the dynamic effects of feeds can only be determined at the same plane of nutrition, and that the heat increment of a ration is not necessarily the sum of its component parts.

Fox and Black (1975) noted that fewer calories were required per unit of postweaning weight gain as more corn was added to the diet. They credited this to the reduction in the proportion of net energy going to maintenance; however, Vance *et al*. (1972) concluded, in a study evaluating rations containing various proportions of corn grain and corn silage, that efficiency of metabolizable energy (ME) used for either maintenance or gain increased with an increase in the percentage of corn grain in the ration.

Apart from associative effects and the influence of other factors, such as method of processing, there is little evidence suggesting substantial differences, within species, in animals' abilities to digest, absorb or metabolize feedstuffs. This was suggested by Armsby in 1917 and supported by French (1940) and Warwick and Cobb (1974), who concluded that genetically determined differences in ability to digest feedstuffs are of doubtful practical significance.

Smith _et al_. (1976) reported that breed group differences in efficiency among cattle adjusted to similar composition indicate that genetic variation may exist for intrinsic efficiency.

Garrett (1971a) found Herefords 12 and 20% more efficient than Holsteins in two trials in converting energy consumed above maintenance to energy stored as fat and protein.

Other studies between breeds have shown that Brahman and Brahman crossbred cattle are able to use metabolizable energy and protein more efficiently, especially on low protein diets, than Hereford or Hereford-Shorthorn crosses (Vercoe, 1970; Howes _et al_., 1963).

Maintenance Requirements

Maintenance requirements are a function of the basal metabolism of the animal (Lofgreen and Garrett, 1968) and are defined at the point of zero energy intake. Net energy for maintenance (NEm) requirements for both steers and heifers are determined as .077 Mcal of metabolizable energy per kilogram of metabolic size ($W^{.75}$).

As defined in the California net energy system (CNES) devised by Lofgreen and Garrett (1968), maintenance requirements are constant, varying only with the metabolic size of the animal. There is little doubt, however, that environment plays a large part in determining the amount of energy required to maintain an animal's body functions (Knox and Handley, 1973; Fox _et al_., 1977).

Cold stress, especially, would be expected to raise an animal's requirement for maintenance energy. Knox and Handley (1973) in a review of the CNES suggested that its accuracy could be improved by adjusting NEm requirements for cold environments. Applying a correction factor of Y=0.356X, where Y=difference from NEm of $43W^{0.75}$ and X=difference in effective environmental temperature from 46^{o}F, improved the accuracy of the system, but seasonal variation still existed. Fox _et al_. (1977) used a scale of one to seven to adjust NEm requirements for environment. These NEm requirement multipliers take into consideration a wide range of environmental variables such as mud, shade, chill stress, ventilation and bedding.

Howes _et al_. (1963) noted seasonal differences in the abilities of both Hereford and Brahman cattle to digest crude protein, suggesting that an overriding need for maintenance energy resulted in some crude protein from high protein diets to pass through the tract undigested in winter months.

Maintenance requirements as expressed by metabolic size don't appear to be affected by sex or biological type. The amount of metabolizable energy required for maintenance of steers and heifers was equal in two trials (Bull et al., 1970; Garrett, 1970). Dikeman et al. (1977) reported that maintenance requirements expressed as total digestible nutrients (TDN) were similar for different cattle types.

Armsby (1917) attributed any differences that might exist between individual animals in maintenance requirements to disposition and the amount of muscular activity, even at rest.

Intake

In animals of equal size and intrinsic efficiency, an increase in feed consumption will appear as an improvement in feed efficiency due to a decrease in the percentage of feed used for maintenance. In a study involving 182 Hereford and 256 Angus bulls, Brown and Gifford (1962) reported a positive correlation of .709 between feed consumption and feed conversion.

Intake is under both genetic and environmental control. Heritability of feed consumption in beef calves was reported by Bogart and England (1971) as $0.38 \pm .15$; however, such environmental factors as heat stress can prevent cattle from fulfilling their genetic potential for feed intake (Kibler et al., 1965). Koch et al. (1963) reported that genetic differences in feed consumption accounted for 25% of the variation in gain.

The relationship between consumption, gain and efficiency of feed conversion is a strong one in which no one of these factors can change without a resultant change in the other two, and the composition of gain also plays an important role. Bogart and England (1971) noted that much of the variation in feed efficiency is accounted for by variations in daily gain and daily consumption. In fact, the total R^2 value for this relationship over the four years of their trial was .786. A heritability coefficienct of .62 was reported by Koch et al., (1963) for efficiency expressed as daily gain adjusted for differences in feed consumed. High correlations between feed efficiency and both gain and feed capacity per unit of metabolic size were also reported by Guilbert and Gregory (1944).

While increased intake favors feed efficiency by diluting maintenance requirements as a percentage of total intake, there is evidence of a counteracting influence of decreased digestibility with an increased level of intake. As consumption increases, rate of passage also increases, resulting in decreased digestibility of the feedstuffs (Schneider and Flatt, 1975). Andersen et al. (1959) found in two experiments with steers that the digestibility of mixed diets decreased markedly as the level of consumption increased. Moe and Tyrrell (1973) also noted decreased nutrient availability at high intake levels.

Rate of Gain

Rate of gain, used as a tool for cattle selection, is likely to result in improvements in both consumption and efficiency. Koch et al. (1963) made this conclusion after a study involving 1,325 bull and heifer calves. They further reported that 38% of the variation in gain was directly due to feed efficiency. Combining efficiency and consumption, then, accounted for 75% of the variation in gain. This is similar to Bogart and England (1971) who reported an R^2 value of .824 for the combined effect of feed/gain and feed consumption on daily gain.

Dikeman (1973) reported that, in most trials involving cattle of similar mature size, faster gaining cattle tended to be more efficient and fatter. This is in contrast to data involving cattle differing in potential mature size and/or earliness of maturity. Although Guilbert and Gregory (1944) warned that absolute rate of gain is not a satisfactory index of efficiency in cattle of different types, research has continued to confirm the strong relationship between the two.

Woodward et al. (1942) reported that large type Hereford cattle required less feed per unit of gain in three of four years and had "somewhat faster gains" in all cases. In a study comparing Hereford and Holstein cattle Kidwell and McCormick (1956) concluded that at a given weight or age animals of larger mature size will gain more rapidly on less feed than animals of smaller mature size. Dikeman (1973) and Klosterman (1972) agree with this; however, Klosterman is quick to point out the test basis is critical when comparing performance of different types of cattle. When compared at constant ages or weights, cattle differing in maturing rates would be at different points on their respective growth curves and would be depositing different tissues at different rates. Only when comparing these animals at similar body composition can efficiency be fairly compared.

Several methods of adjusting data to compositional constants have been employed in research trials. Perhaps the most common of these is to feed cattle to the same quality grade or to adjust the data to a common percentage of fat in the longissimus (LD) muscle. Both of these versions can admittedly lead to some differences in overall composition. Nonetheless, data adjusted in this manner has shown little difference in efficiency among cattle of different types (Dikeman, 1973).

Data published by Smith et al. (1976) illustrate the effect of test basis when they found that, on an age constant basis, faster gaining breed groups tended to be more efficient than slower gaining breed groups, in spite of heavier weights maintained. When they adjusted the data to a constant 5% LD fat they found that efficiency was related to neither size nor growth rate; however, they did find that days on feed to reach 5% LD fat accounted for 74% of the variation in efficiency. This indicated the effects of the lower number of days of maintenance required and the lighter weights being maintained.

We cannot automatically assume differences between types of cattle for either rate or economy of gain regardless of test basis. Knox and Koger (1946) compared "compact", "medium" and "rangy" type Hereford steers and found no advantage for the rangy type in economy of gain. They found gain in proportion to initial weight a better measure of efficiency than rate of gain.

Stonaker _et al_. (1952) compared comprest and conventional type Hereford steers and found rate of gain and consumption were a function of size. In steers fed to equal fatness, efficiency of gain was equal.

Klosterman _et al_. (1968) studied the performance of Hereford and Charolais cattle and their crosses. Although Charolais gained faster they were no more efficient than Herefords when fed in drylot. This agrees with data published by Smith _et al_. (1977). In a trial involving five small-type British or dairy breeds, and seven large type European or dairy breeds, they found little difference between types of cattle when evaluated on either a weight or compositional constant basis. This is in contrast with data of Cole et al. (1963a) who reported significant type effects for all performance traits except daily gain in a study comparing six breeds and one cross involving British, Zebu and dairy breeding.

Hedrick (1968) compared steers and heifers, finding that steers gained faster than heifers except when slaughtered at equal fattness. Berg and Butterfield (1976) concluded that heifers mature at lighter weights than steers and tend to enter the fattening phase at lighter weights and will also fatten faster once they enter this phase.

Garrett (1970) studied the influence of sex on the energy requirements of steers and heifers for both maintenance and growth and concluded that the efficiency of utilization of ME was not greatly different between sexes for either component. This is in contrast to data by Bull et al. (1970), who noted ewes had significantly higher efficiency of ME for gain above maintenance than rams. Their mean pooled net efficiencies for this measurement were 65.5% for ewes and 57.6% for rams, with a slight advantage in gross efficiency also in favor of ewes.

Composition of Gain

The inclusion of composition of gain as a contributing factor in determining feed efficiency has been recognized by many researchers and, combined with the tools given us by the CNES, provides the conceptual basis for our research. The relationship is based on the fact that the energetic cost of synthesizing one gram of muscle tissue is less than that required to synthesize a gram of fat tissue. Stokes (1975) pointed out that Kcal for Kcal, fat synthesis is about twice as efficient as protein synthesis; however, due to different caloric densities, protein synthesis requires only about 12% more energy than fat synthesis per unit of weight. Muscle tissue, then, actually becomes the more economical tissue to synthesize because of its high water content (70 to 80% by weight) compared with fat tissue, which, at maturity contains very little water (Edwards et al. 1976, and Loveday et al. 1978).

Armsby (1917) was one of the first to recognize that fatness affects both rate and economy of gain. Edwards et al. (1976), in a study relating fatness to feed efficiency in sheep, concluded that carcass composition is significantly related to feed efficiency, with fatter lambs being less efficient. Dikeman (1973) found the above conclusion true in the case of pigs. However, in cattle of the same biological type, the more efficient animals tended to be fatter. This probably resulted from differences in appetite.

In any case, the percentage of fat in the carcass is a major factor affecting both carcass composition (Callow, 1948) and feed efficiency (Edwards, 1976).

Callow (1944) determined that for every 1.0% increase in fatty tissue there is a .7% decrease in muscular tissue and a .26% decrease in bone. He further concluded that late maturing breeds may, at the same dressing percentage, produce leaner carcasses than early maturing breeds. However, faster gaining animals within the same type would be fatter than slower gaining animals at the same live weight. Callow (1948) also studied carcass changes during growth and showed that percentages of chemical fat, protein and water are all closely related to total carcass fat. He also stated that cattle and sheep are in the fattening phase when they contain over 18% fatty tissue, and during this phase chemical fat and protein are increasing faster in the fatty tissues than in muscular tissue.

While the relationship between efficiency and composition appears to be sound, researchers through the years generally have declined to use one as a tool to measure the other. Blaxter (1962) suggested that partial efficiency (PE is the change in gain divided by the change in intake measured in kilocalories of ME) should be highly related to physiological maturity, which could be measured by carcass composition. This relationship combined with the fact that partial efficiency is independent of body size (Garrett _et al_. 1959) because maintenance requirements are taken out of the calculation indicates that some measure of partial efficiency should prove useful in predicting carcass composition. Lipsey (1977) used NEp efficiency as measured by the CNES in attempting to slaughter cattle of different biological types at similar carcass composition. He compared Hereford-Angus (HxA) reciprocal crosses with Gelbvieh and Maine-Anjou sired steers from HxA cows, by feeding the steers to an NEp efficiency endpoint of 8.0 Mcal NEp/kg of gain. His conclusion was that physiological maturity as expressed by carcass composition is highly related to utilization of energy available for growth, and if fed to the same NEp efficiency endpoint, carcass composition of steers of different maturing rates would be similar.

In a similar study conducted by Loveday (1977), Brown Swiss sired steers out of HxA cows were compared with HxA reciprocal crosses. NEp efficiency was measured over the entire feeding period in individual pens, and half the cattle of each type were slaughtered at each of two NEp efficiency endpoints. The endpoints used were 7.0 and 10.0 Mcal of NEp/kg of gain and results showed no significant differences in composition due to endpoint, although the cattle slaughtered at the first endpoint tended to have a higher percentage of separable lean and lower yield grade number. Loveday did, however, have significant differences between cattle types as the Brown Swiss sired steers averaged 5.0% more separable lean, 3.5% less separable fat, and lower yield grade numbers. He suggested that, in order to more accurately relate composition to current performance, NEp efficiency endpoints should be used on the last 70 days on feed.

It is widely recognized that cattle of different types, weights and sexes will be of different body composition, depending on the basis at which they are compared. Hedrick (1972) stated that inherent traits, slaughter weight, sex, management, and nutritional regimens all affect composition. Berg and Butterfield (1976) agree, further stating that to manipulate carcass composition by genetic or nutritional means depends largely on controlling the proportion of fat, and under normal circumstances, weight at slaughter will determine this proportion.

Haecker, in a series of experiments, studied the affect of weight on body composition of steers by measuring fat, ash, protein and water as both a percentage of total weight (1914) and empty body weight (1920). He found that, as a percentage of empty body weight, fat increased from 4.0% to 27.6% and protein and water decreased from 19.9% to 15.7% and 71.8% and 43.5% respectively, as steers increased in weight from 45 to 680 kilograms. Fat and protein were found to be equal at 364 kg., which is similar to findings of Jesse <u>et al</u>. (1976) who found equal percentages of fat and protein at 341 kg. in beef steers. Both agree that at the point where fat exceeds protein, fattening is the main function of weight gain.

Tulloh (1963), in summarizing carcass composition and its relation to body weight in cattle, pigs and sheep stated that composition appears to be mainly dependent on body weight regardless of age or nutritional background.

Burton and Reid (1969) support this in a study with sheep in which they concluded that much of the variability in composition was due to empty body weight with very little due to age. In their study, empty body weight was related to all carcass chemical compositional variables studied (ether extract, crude protein, water and gross energy), with R^2 values between .939 and .982. Further study by Reid and Robb (1971) with dairy heiiers showed body protein and fat similarly related to empty body weight, with R^2 values of .997 and .961 respectively. Empty body weights for their analysis were obtained from data produced by Ellenberger et al. (1950) using dairy heifers of varying genetic and nutritional backgrounds.

Waldman et al. (1971) determined the composition of Holstein steers at five weights from 91 to 950 kg. They found that while carcass ether extract and water percentages increased and decreased, respectively, at each successive slaughter weight, carcass protein percentage did not vary widely over the course of the trial.

There is little doubt that steers and heifers of similar breeding will, at the same weight, be somewhat different in composition. Berg and Butterfield (1976) stated that heifers mature at lighter weights and reach the rapid fattening stage earlier than steers. Besides the differences in weight at which the fattening process begins, it appears that heifers fatten faster than steers. Berg and Butterfield (1976) continue by stating that differences in muscle weight distribution between steers and heifers are small, and that fat is the tissue which plays the largest part in altering the carcass composition between sexes. Hedrick (1968) reported similar data that heifers' fat thickness increased at a faster rate over the feeding period.

In a study of Angus cattle, Suess _et al_. (1969) found the composition of a 386 kg. heifer similar to that of a 455 kg. steer. Carcass density tests have also shown that heifers are fatter than steers overall, with particularly more kidney fat (Garrett and Hinman, 1971b).

Different breeds and types of cattle can also be expected to display differences in fattening characteristics, with earlier maturing cattle entering the fattening phase at lighter weights (Berg and Butterfield, 1976). Callow (1962) found differences in percentage of fat among breeds of cattle, with Shorthorns being fatter than Herefords or Friesians. Branaman _et al_. (1962) compared beef type with dairy type and found that, although beef type dressed 3% higher, there were negligible differences in percentage of separable lean.

Cole _et al_. (1963b) compared six breeds and one cross of British, Zebu and dairy extraction and found significant differences between types for 36 or 42 compositional (physical and chemical) variables studied. British breed types had the lowest percentages of protein and separable muscle, and a significantly higher percentage of ether extract than either of the other types.

Differences in relative proportions of retail product, fat trim and bone between biological types of cattle have been found to be at their greatest when compared on a weight constant basis, and least when compared on a standard 5% LD fat basis (Koch et al., 1976).

Palatability

Palatability differences between biological types or sexes are unexpected providing similar feeding regimes are followed. Branaman et al. (1962); however, did find differences between beef and dairy type cattle for intensity of lean flavor, and quality and quantity of juiciness. Beef type cattle, in this trial, were superior in both traits. Klosterman et al. (1968) found no difference in tenderness of broiled steaks from Hereford and Charolais cattle under either of two systems of management, although differences in quality grade did exist.

Other trials have shown no significant differences in taste panel palatability between biological types of cattle (Koch et al., 1976; Dikeman et al., 1977; Smith et al., 1977). Similarly, few differences in palatability have been found between beef steers and heifers (Bradley et al., 1966).

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MATERIALS AND METHODS

Fifty-two cattle were selected from the U. S. Meat Animal Research Center (MARC) in Clay Center, Nebraska in November of 1976 and shipped to the beef research unit at Kansas State University on December 17. The cattle had been weaned at approximately 200 days of age and consisted of 26 steers and 26 heifers representing two biological types. The large, late-maturing type involved 26 Simmental sired calves out of 18 Maine-Anjou x Hereford, four Maine-Anjou x Angus or four Chianina x Angus dams. The small, early-maturing type was represented by 26 Hereford x Angus (HxA) reciprocal crossbreds.

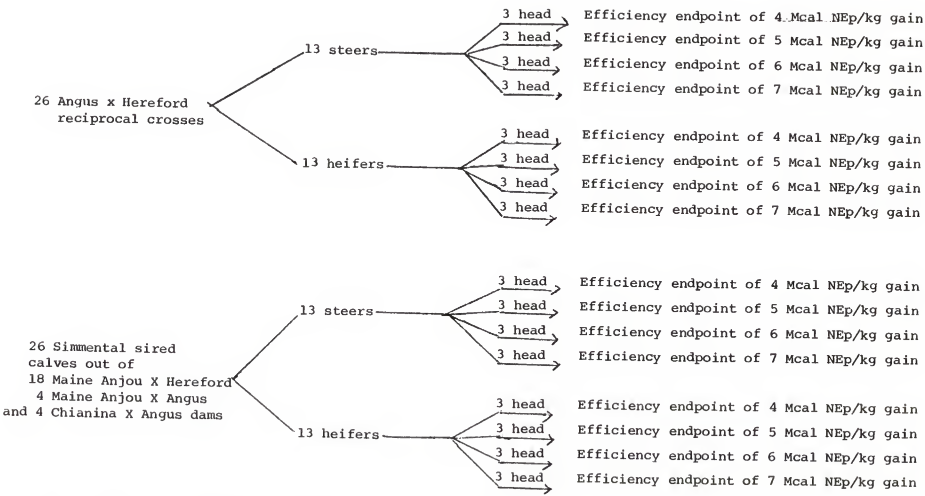
The cattle were group fed by sire breed until January 27, 1977 at which time they were weighed in a semi-shrunk state (denied feed for 18 hours before weighing). At this time each sex x type (13 cattle) group was segregated by weight into two pens with four cattle each, and one pen of five. During the first two weeks in these small group pens the cattle were gradually adjusted to the concentrate ration they would be fed during the subsequent individual feeding period. This ration consisted of 57% rolled corn, 20% dehydrated alfalfa, 17% soybean meal, 5.5% dry molasses and .5% salt. The ration was 87.7% dry matter (average analytical values and contained 2.01 Mcal of Net Energy for maintenance (NEm) or 1.29 Mcal of Net Energy for production (NEp) per kilogram of dry matter (Lofgreen and Garrett, 1968) as determined by NRC book values.

One animal from each pen was randomly assigned to each of four NEp efficiency slaughter endpoints (EP1 through EP4). The remaining animal of each sex x type was available for assignment to any endpoint, as needed. The cattle were weighed individually monthly during the period in small group pens.

On March 17, 1977, as individual pens became available at the beef research unit, all cattle were individually weighed, and 13 animals were assigned to individual feeding pens. These included most of the EP1 animals and some of those assigned to EP2. The remaining cattle were placed in individual pens on April 14, 1977.

Cattle were weighed and feed consumption recorded every two weeks while in individual pens. Because of our intention to measure NEp efficiency over the last 70 days of the feeding period, 8 weeks of data was gathered before a preliminary calculation of the animals' efficiency was made. Actual weights were adjusted by using quadratic regression and calculating best fit to correct for variation due to fill (Lipsey et al. 1978). At this time it was determined that EP1 through EP4 would represent 4.0, 5.0, 6.0 and 7.0 Mcal of NEp/kg of gain, respectively. Following the next weigh period (10 weeks of individual feeding) the first group of cattle became eligible for slaughter. NEp efficiency was again computed and any animals which had reached their designated endpoint efficiency were slaughtered within one week. This procedure was followed for the duration

Figure 1. Experimental Design



Three animals were originally assigned to each endpoint group with one animal of each sex and type as extra; however, seven animals were removed from the trial due to consistent weight losses and the extra animals were reassigned as needed.

of the trial, with the NEp efficiency being calculated over the last 70 days on feed. The exception to this was, if an animal was within one-tenth Mcal NEp/kg of gain of its assigned endpoint it was weighed again the following week and NEp efficiency was recalculated on an 11-week basis. This was to prevent animals from passing through their assigned endpoints. From time to time, however, an animal would move past its assigned endpoint into a higher endpoint. In these few cases the animals were reassigned to a higher endpoint with an animal of the same type and sex from that endpoint replacing it in the lower endpoint.

Any cattle which became ill and showed severe weight loss over one weigh period, or continued weight loss over two weigh periods, were eliminated from the project because NEp efficiency was negative for these cattle over these periods and significantly affected the average efficiency measured over 10 weeks.

At slaughter, hot carcass weight and weight of mesentery fat were recorded. Carcasses were ribbed 48 hr after slaughter with quality and yield grade data being collected. The 9-10-11th rib section was separated into soft tissue and bone with a .5 kg sample of ground soft tissue saved for chemical analysis. Steaks 2.5 cm thick were cut from the center of the <u>semitendinosus</u> muscle for taste panel analysis.

The soft tissue from the 9-10-11th rib was analyzed for moisture, ether extract and crude protein according to A.O.A.C. (1960) methods. Carcass chemical composition was predicted from the 9-10-11th rib composition (Hankins and Howe, 1946).

Taste panel analyses for palatability differences were conducted by a trained taste panel in accordance with the Guidelines for Cookery and Sensory Evaluation of Meat published by the American Meat Science Association (1977), with the exception that tested glass thermometers were used instead of thermocouples to measure internal temperature of the steaks.

All data were analyzed by least squares analysis of variance with t-tests for means separations. Additional analysis of covariance was applied to compositional and performance variables to correct for differences due simply to hot carcass weight. Linear regression equations were calculated to predict compositional variables from NEp efficiency data.

RESULTS AND DISCUSSION

Seven animals were removed from the study due to illness which resulted in chronic or severe short term weight loss. Of the remaining 45 cattle, 40 progressed gradually toward their assigned endpoints and produced what we considered to be reliable data. The remaining five cattle failed to reach their endpoints (all these cattle being EP4 and four out of the five being heifers). In early December, 1977 the meat slaughter facilities were to be inoperable for a period of at least six weeks. At this time two of these five cattle were actually at an EP1, and one was at an EP2. The remaining two cattle were below any of the designated endpoints at this time. These five animals had shown performance uncharacteristic of the rest of the cattle in that they had all progressed gradually toward EP4 and then began to show gradual improvement in efficiency, finally plateauing at a level much more efficient than their assigned endpoint, and maintaining this performance with very little change over a period of months. During this period these five animals became very obese, and it became obvious that carcass data collected would seriously effect the results. For example, by classing two of the cattle as EP1, the adjusted fat thickness mean increased by .3 cm, and the carcass ether extract percentage increased over 1.4%. For these reasons we eliminated data from these animals from the discussion.

It is possible that at some point the standard equation for determining maintenance requirements began to overestimate actual maintenance requirements of the cattle. Perhaps in obese animals, the maintenance of fatty tissue, especially during cold weather, is less expensive, although this disagrees with Blaxter (1962), who stated that the maintenance cost of fatty tissue is similar to that for the whole body.

Another possibility is that these animals began reinitiation of adipose tissue hyperplasia. This generation of new adipocytes would be mostly protein and water which could be laid down more economically than lipid, accounting for some improvement in efficiency over a period of time. In any case, the performance and carcass characteristics of these cattle preclude them from data analysis.

Differences Between Biological Types

Simmental (Simm) sired calves were significantly ($P<.01$) heavier at birth than Hereford-Angus (HxA) reciprocal crossbred calves (table 1). This difference increased to an average of 38.6 kg at weaning, and by the time the first cattle went into individual pens, Simm weighed 370.4 kg compared with 305.8 kg for HxA.

Over the entire period in individual pens Simm showed higher ($P<.05$) average daily gains (ADG), while total gain and days on feed over the period were not different ($P>.05$). These results disagree with those of Lipsey (1977). In addition, gross efficiency over the period was not different ($P>.1$) between biological types.

TABLE 1. PERFORMANCE[1] OF TWO BIOLOGICAL TYPES OF CATTLE FED TO A COMMON SERIES OF FOUR NEp EFFICIENCY ENDPOINTS

Type	Weight, kg			Data for entire individual feeding period				Data for last 70 days on feed[4]			
	Birth	Weaning	On test[2]	ADG, kg/day	Total gain, kg	Days on feed	Gross efficiency[3]	ADG, kg/day	Total gain, kg	Gross efficiency	Weight off test
Simm	41.7±1.0[a]	209.3±4.5[a]	370.4±6.5[a]	1.2±.05[a]	122.3±9.7	107±7	6.4±.2	1.2±.1[a]	84.5±3.5[a]	7.9±.2	532.4±10.7[a]
H X A	35.4±1.0[b]	170.7±4.6[b]	305.8±6.7[b]	1.0±.05[b]	114.3±10.0	113±8	6.6±.2	1.0±.1[b]	69.7±3.6[b]	8.1±.2	440.8±11.1[b]

[1]Least square means ± standard error of the mean.

[2]Weight on March 17 when first group of 13 went on feed.

[3]Measured as kg dry matter/kg gain.

[4]Last 77 days used where applicable.

[a, b]Means in same column bearing different superscripts are different ($P<.05$).

The last 70 days on feed produced much the same performance, with Simm gaining faster ($P<.05$), and with no difference ($P>.1$) in feed to gain ratio. Simm did gain an average of 14.8 kg more over the period, increasing their weight advantage ($P<.01$) at slaughter to an average 91.6 kg per animal.

Carcasses from Simm were heavier ($P<.01$), averaged .5 cm less ($P<.01$) adjusted fat at the 12th rib and 14.0 cm^2 more ($P<.01$) loin eye area than HxA carcasses (table 2). No differences existed for kidney, heart and pelvic fat percentage or quality grade.

Simm carcasses had yield grades averaging 3.2 compared with 3.9 for HxA ($P<.01$), and an advantage of .4% less ($P<.05$) mesentery fat. Predicted chemical composition of the edible portion (Hankins and Howe, 1946) confirm the differences in composition between types, with Simm carcasses containing 4.9% less ($P<.01$) ether extract, 1.1% more ($P<.01$) crude protein, and 3.7% more ($P<.01$) water than HxA.

In order that the effect of carcass weight be eliminated from the results for the compositional variables, an analysis of covariance was performed using hot carcass weight as the covariate (table 3). Significant ($P<.01$) differences still existed between types for all three chemical compositional variables, as well as yield grade; however, these differences were magnified when carcass weight was held constant.

TABLE 2. CARCASS CHARACTERISTICS AND CHEMICAL COMPOSITION[1,2] OF TWO BIOLOGICAL TYPES FED TO A COMMON SERIES OF FOUR NEp EFFICIENCY ENDPOINTS

	Cold carcass wt., kg	Percent		Adjusted fat thickness, cm	Loin eye area, cm^2	Yield grade[z]	Quality grade	Percent		
		Mesentery fat[3]	KHP fat[4]					Ether extract	Crude protein	Water
Simm	323.5±7.9[a]	2.3±.1[b]	3.5±.2	1.11±.10[b]	79.5±2.0[a]	3.1±.6[b]	8.5±.4	34.63±.72[b]	15.15±.15[a]	49.57±.56[a]
A x H	268.3±7.9[b]	2.7±.1[a]	3.5±.2	1.63±.10[a]	65.7±2.0[b]	3.8±.7[a]	8.8±.4	39.50±.79[a]	13.96±.16[b]	45.93±.61[b]

[1]Least squares means ± standard error of the mean.

[2]Chemical composition of carcass edible portion (Hankins and Howe, 1946).

[3]Percentage of live weight.

[4]Percentage of cold carcass weight.

[a, b]Means in same column bearing different superscripts are different ($P<.05$).

[z]7=Low good, 8=High good, 9=Low choice, etc.

TABLE 3. COMPOSITIONAL VARIABLES[1] OF TWO BIOLOGICAL TYPES CORRECTED FOR EFFECT OF HOT CARCASS WEIGHT[2]

Type	Percent[3] Ether Extract	Crude Protein	Water	Yield Grade
Simm	$33.64 \pm .83^{b}$	$15.41 \pm .17^{a}$	$50.27 \pm .66^{a}$	$2.9 \pm .2^{b}$
AxH	$40.11 \pm .81^{a}$	$13.83 \pm .16^{b}$	$45.49 \pm .64^{b}$	$4.1 \pm .1^{a}$

[1] Lest squares means ± standard error of the mean.

[2] Analysis of covariance with hot carcass weight as covariate.

[3] Percentage of edible portion (Hankins and Howe, 1946).

[a, b] Means in same column bearing different superscripts are different. ($P<.05$).

No differences were noted in palatability of _semitendinosus_ steaks from the two types of cattle (table 4).

Interactions between type, sex and endpoint did not occur in nearly all cases.

Differences Between Steers and Heifers

Steers averaged 2.9 kg heavier ($P<.05$) than heifers at birth; however, at weaning no difference ($P>.1$) existed between sexes (table 5). A weight advantage of 25.3 kg ($P<.01$) in favor of steers appeared when the first group of cattle went into individual pens.

ADG and F/G ratio were not different over the entire period in individual pens. Steers averaged 26.7 kg more ($P=.06$) gain over the period; however, steers were on feed 22 days longer ($P<.05$).

Over the last 70 days on feed, ADG and total gain were equal, while F/G ratio showed a .6 kg ($P<.05$) F/G ratio advantage for the heifers.

Steer carcasses were 41.2 kg heavier ($P<.01$) but were similar ($P>.1$) in adjusted fat thickness (table 6) compared with heifer carcasses. Steers did have 7.2 cm^2 more ($P<.05$) loin eye area and .5% less ($P<.05$) kidney, heart and pelvic fat resulting in a slight, but insignificant ($P>.1$) advantage in yield grade for steer carcasses.

Quality grade was not different ($P>.1$) between steers and heifers; however, heifer carcasses had more ($P<.05$) mesentery fat surrounding the rumen.

TABLE 4. Least Squares Means For Taste Panel Analysis[1]

Endpoint	Muscle fiber tenderness	Connective tissue amount	Overall tenderness	Juiciness	Flavor intensity
1	5.9	6.6	6.2	5.5	6.0
2	6.0	6.7	6.1	5.7	6.1
3	5.9	6.5	6.0	4.9	6.0
4	5.5	6.3	5.6	5.6	6.1
Sex					
Steers	5.9	6.6	6.1	5.8	6.0
Heifers	5.8	6.6	6.0	5.6	6.0
Type					
Small	5.8	6.6	6.0	5.6	5.9
Large	5.9	6.6	6.1	5.8	6.1
	8=Extremely tender 7 6 5 4 3 2 1=Extremely tough	8=None 7 6 5 4 3 2 1=Abundant	8=Extremely tender 7 6 5 4 3 2 1=Extremely tough	8=Extremely juicy 7 6 5 4 3 2 1=Extremely dry	8=Extremely Intense 7 6 5 4 3 2 1=Extremely bland

[1]Means were not different (P>.05).

TABLE 5. PERFORMANCE[1] OF STEERS AND HEIFERS FED TO A COMMON SERIES OF FOUR NEp EFFICIENCY ENDPOINTS

Sex	Weight, kg			Data for entire individual feeding period				Data for last 70 days on feed[4]			
	Birth	Weaning	On test[2]	ADG, kg/day	Total gain kg	Days on feed	Gross efficiency[3]	ADG kg/day	Total gain kg	Gross efficiency	Weight off test kg
Steers	40.0 ± 1.0^{a}	192.6 ± 4.5	350.7 ± 6.6^{a}	$1.1 \pm .04$	131.6 ± 9.8^{y}	121 ± 7^{a}	$6.4 \pm .2$	$1.1 \pm .1$	76.8 ± 3.6	$8.3 \pm .2^{a}$	518.3 ± 10.9^{a}
Heifers	37.1 ± 1.0^{b}	187.4 ± 4.5	325.4 ± 6.6	$1.1 \pm .04^{b}$	104.9 ± 9.8^{z}	98 ± 7^{b}	$6.6 \pm .2$	$1.1 \pm .1$	77.5 ± 3.6	$7.7 \pm .2^{b}$	454.9 ± 10.9^{b}

[1] Least squares means ± standard error of the mean.

[2] Weight on March 17 when first group of 13 went on feed.

[3] Measured as kg of dry matter/kg gain.

[4] Last 77 days on feed used where applicable.

[5] Differed at .06 level of significance.

[a, b] Means in same column bearing different superscripts are different ($P<.05$).

[y, z] ($P=.06$).

TABLE 6. CARCASS CHARACTERISTICS AND CHEMICAL COMPOSITION[1,2] OF STEERS AND HEIFERS FED TO A COMMON SERIES OF FOUR NEp EFFICIENCY ENDPOINTS

Sex	Cold carcass wt, kg	Percent		Adjusted fat thickness, cm	Loin eye area, cm^2	Yield grade	Quality grade[z]	Percent		
		Mesentery fat[3]	KHP fat[4]					Ether extract	Crude protein	Water
Steers	316.5 ± 7.7^a	$2.3 \pm .1^b$	$3.2 \pm .2^b$	$1.38 \pm .10$	76.0 ± 2.0^a	$3.5 \pm .1$	$8.4 \pm .4$	$35.79 \pm .76^b$	$14.71 \pm .16$	$49.02 \pm .59^a$
Heifers	275.3 ± 7.7^b	$2.7 \pm .1^a$	$3.7 \pm .2^a$	$1.36 \pm .10$	68.8 ± 2.0^b	$3.6 \pm .1$	$8.9 \pm .4$	$38.34 \pm .76^a$	$14.41 \pm .16$	$46.48 \pm .59^b$

[1] Least squares means ± standard error of the mean.

[2] Chemical composition of carcass edible portion (Hankins and Howe, 1946).

[3] Percentage of live weight.

[4] Percentage of cold carcass weight.

[a, b] Means in same column bearing different superscripts are different ($P<.05$).

[z] 7=Low good, 8=High good, 9=Low choice, etc.

Chemical composition data showed that steers had less (P<.05) ether extract (35.8% vs. 38.3%) and more (P<.01) water in the edible portion while no difference existed between sexes for estimated carcass crude protein.

When analysis of covariance was utilized to eliminate hot carcass weight effects on composition similar results for carcass ether extract and water were obtained as for analysis of variance. Slight advantages in yield grade and carcass crude protein found in the analysis of variance became significant differences (P<.05) when data were adjusted for hot carcass weight (table 7).

Taste panel analysis failed to disclose any differences in palatability of semitendinosus steaks from steers and heifers (table 4).

Differences Between Endpoint Groups

NEp efficiency, as a measure of performance, should show relationships similar to those that the more traditional measures of efficiency have shown with other performance variables. Separating endpoint groups by 1.0 Mcal NEp per kg of gain didn't cause animals to stay on feed significantly longer except in the case of EP4 which took longer (P<.05) to reach than any of the other endpoints (table 8). Furthermore, weight at slaughter was not significantly (P=.09) affected by endpoint, nor was total gain during the entire period in individual pens (P>.1).

ADG over the entire period was influenced (P<.05) by

TABLE 7. COMPOSITIONAL VARIABLES[1] OF STEERS AND HEIFERS CORRECTED FOR EFFECT OF HOT CARCASS WEIGHT[2]

Sex	Percent[3]			Yield grade
	Ether extract	Crude protein	Water	
Steers	34.94±.79[b]	14.95±.16[a]	49.60±.62[a]	3.3±.1[b]
Heifers	38.79±.75[a]	14.29±.15[b]	46.16±.59[b]	3.7±.1[a]

[1]Least squares means ± standard error of the mean.

[2]Analysis of covariance with hot carcass weight as covariate.

[3]Percentage of carcass edible portion (Hankins and Howe, 1946).

[a, b]Means in same column bearing different superscripts are different ($P<.05$)

TABLE 8. PERFORMANCE[1] OF CATTLE SLAUGHTERED AT FOUR NEp EFFICIENCY ENDPOINTS[2]

Endpoint	Data for entire individual feeding period							Last 70 days on feed		
	Age on test, kg	Weight on test, kg	Weight off test, kg	Days on feed	Average daily gain, kg	Total gain, kg	Gross efficiency	Average daily gain, kg	Total gain, kg	Gross efficiency
1	364 ± 4^{bc}	346.9 ± 8.9^{b}	463.0 ± 13.7^{b}	95 ± 9^{b}	$1.3 \pm .1^{a}$	116.0 ± 12.4	$5.8 \pm .2^{b}$	$1.3 \pm .1^{a}$	95.9 ± 4.5^{a}	$5.9 \pm .2^{d}$
2	358 ± 4^{c}	363.9 ± 9.3^{b}	469.9 ± 14.4^{ab}	94 ± 10^{b}	$1.1 \pm .1^{ab}$	106.0 ± 13.0	$6.0 \pm .2^{b}$	$1.2 \pm .1^{ab}$	85.3 ± 4.7^{a}	$7.0 \pm .2^{c}$
3	381 ± 4^{a}	398.8 ± 9.3^{a}	506.4 ± 14.4^{a}	105 ± 10^{b}	$1.0 \pm .1^{b}$	107.6 ± 13.0	$6.8 \pm .2^{a}$	$1.0 \pm .1^{b}$	68.3 ± 4.7^{b}	$8.8 \pm .2^{b}$
4	376 ± 6^{ab}	363.7 ± 12.6^{b}	507.1 ± 19.6^{a}	145 ± 13^{a}	$0.9 \pm .1^{b}$	143.5 ± 17.7	$7.4 \pm .3^{a}$	$0.8 \pm .1^{b}$	59.0 ± 6.4^{c}	$10.3 \pm .3^{a}$

[1]Least squares means ± standard error of the mean.

[2]Endpoint 1 = 4.0 Mcal NEp/kg gain, n=12.
Endpoint 2 = 5.0 Mcal NEp/kg gain, n=11.
Endpoint 3 = 6.0 Mcal NEp/kg gain, n=11.
Endpoint 4 = 7.0 Mcal NEp/kg gain, n=6.

[a, b, c, d]Means in same column bearing different superscripts are different ($P<.05$).

endpoint as was gross efficiency ($P<.01$). There were no significant interactions of endpoint with either sex or type for any of these variables.

Over the last 70 or 77 days on feed (the time NEp efficiency was measured) total gain decreased ($P<.01$) with each successive endpoint. This should be expected as decreased gain played a role in decreased NEp efficiency in most cases. F/G ratio is expected to be highly related to NEp efficiency, and was significantly ($P<.01$) higher for each successive endpoint.

Actual NEp efficiencies were 4.1, 5.0, 6.0 and 7.3 for endpoints one through four respectively. Calculating efficiencies on a weekly basis for animals within .1 Mcal NEp/kg gain of their assigned endpoints allowed us to prevent these animals from exceeding their designated efficiency, which is reflected in the actual NEp efficiencies.

ADG over the final 10 weeks on feed was higher ($P<.05$) for EP1 and EP2 than for the last two endpoints (table 8).

Cold carcass weight was not greatly affected by endpoint with the exception that EP4 carcasses were heavier ($P<.05$) than EP1 carcasses (table 9). Although this was the only significant difference, carcass weights tended to increase with each succeeding endpoint.

Endpoints did show significant differences in quality grade; however, no logical pattern existed as EP1 carcasses

TABLE 9. CARCASS CHARACTERISTICS AND CHEMICAL COMPOSITION[1,2] OF CATTLE SLAUGHTERED AT FOUR NEp EFFICIENCY ENDPOINTS[3]

Endpoint[2]	Cold carcass wt, kg	Percent Mesentery fat[4]	Percent KHP fat[5]	Adjusted fat thickness, cm	Loin eye area, cm^2	Yield grade	Quality grade[z]	Percent Ether extract	Percent Crude protein	Percent Water
1	280.2 ± 9.7^{b}	$2.4 \pm .1^{bc}$	$3.0 \pm .2^{b}$	$1.16 \pm .12^{b}$	78.6 ± 2.5^{a}	$2.8 \pm .2^{c}$	$7.5 \pm .5^{b}$	$33.36 \pm .92^{c}$	$15.38 \pm .19^{a}$	$50.58 \pm .71^{a}$
2	282.0 ± 10.2^{ab}	$2.6 \pm .1^{ab}$	$3.4 \pm .2^{b}$	$1.21 \pm .13^{b}$	70.5 ± 2.6^{b}	$3.3 \pm .2^{b}$	$9.4 \pm .5^{a}$	$36.84 \pm .97^{b}$	$14.60 \pm .20^{b}$	$48.02 \pm .75^{b}$
3	305.5 ± 10.2^{ab}	$2.2 \pm .1^{c}$	$3.4 \pm .2^{b}$	$1.45 \pm .13^{ab}$	70.1 ± 2.6^{b}	$3.8 \pm .2^{ab}$	$8.4 \pm .5^{ab}$	$37.35 \pm .97^{ab}$	$14.46 \pm .20^{bc}$	$47.58 \pm .75^{b}$
4	315.9 ± 13.9^{a}	$2.8 \pm .1^{a}$	$4.1 \pm .3^{a}$	$1.71 \pm .17^{a}$	71.2 ± 3.5^{ab}	$4.2 \pm .3^{a}$	$9.4 \pm .7^{a}$	40.73 ± 1.37^{a}	$13.78 \pm .28^{c}$	44.83 ± 1.06^{c}

[1]Least squares means ± standard error of the mean.

[2]Chemical composition of carcass edible portion (Hankins and Howe, 1946).

[3]Endpoint 1 = 4.0 Mcal NEp/kg gain, n=12.
Endpoint 2 = 5.0 Mcal NEp/kg gain, n=11.
Endpoint 3 = 6.0 Mcal NEp/kg gain, n=11.
Endpoint 4 = 7.0 Mcal NEp/kg gain, n=6.

[4]Percentage of live weight.

[5]Percentage of cold carcass weight.

[a, b, c]Means in same column bearing different superscripts are different ($P<.05$).

[z]7=Low good, 8=High good, 9-Low choice, etc.

graded lower ($P<.05$) than EP2 and EP4, and similar to EP3 carcasses. Results for percentage of mesentery fat were equally confusing as EP1 carcasses had a lower ($P<.05$) percentage than EP4 whereas EP3 carcasses had less mesentery fat than either EP2 or EP4.

Yield grades tended to increase with each endpoint. Although differences were not always significant, EP1 carcasses had lower ($P<.01$) yield grades than EP3 or EP4 with EP4 cracasses possessing higher yield grade numbers than all except EP3.

Loin eye area and percentage of kidney, heart and pelvic fat failed to show any consistent patterns although some differences did exist. Endpoint was not a significant ($P=.06$) source of variation in adjusted fat thickness; however, a trend existed for fat thickness to increase as endpoint increased.

Chemical composition of the edible portion (Hankins and Howe, 1946) was affected ($P<.01$) by endpoint. Correcting the compositional variables for the effect of hot carcass weight lessened these relationships; however, carcass ether extract tended to increase consistently while carcass crude protein and water tended to decrease with decreasing NEp efficiency (table 10). All three variables continued to be significantly affected by endpoint ($P<.01$).

Endpoint had no affect ($P>.1$) on the palatability of semitendinosus steaks evaluated by trained taste panelists (table 4).

TABLE 10. COMPOSITIONAL VARIABLES[1] OF CATTLE SLAUGHTERED AT FOUR NEp EFFICIENCY ENDPOINTS[2] CORRECTED FOR EFFECT OF HOT CARCASS WEIGHT[3]

Endpoint	Percent[4]			Yield grade
	Ether extract	Protein	Water	
1	$33.78 \pm .91^{b}$	$15.28 \pm .18^{a}$	$50.27 \pm .72^{a}$	$2.9 \pm .2^{b}$
2	$37.03 \pm .94^{a}$	$14.55 \pm .19^{b}$	$47.90 \pm .74^{b}$	$3.4 \pm .2^{a}$
3	$37.08 \pm .95^{a}$	$14.56 \pm .19^{b}$	$47.73 \pm .75^{b}$	$3.7 \pm .2^{a}$
4	39.60 ± 1.31^{a}	$14.09 \pm .26^{b}$	45.61 ± 1.03^{b}	$4.0 \pm .2^{a}$

[1] Least squares means ± standard error of the mean.

[2] Endpoint 1 = 4.0 Mcal NEp/kg gain, n=12.
Endpoint 2 = 5.0 Mcal NEp/kg gain, n=11.
Endpoint 3 = 6.0 Mcal NEp/kg gain, n=11.
Endpoint 4 = 7.0 Mcal NEp/kg gain, n=6.

[3] Hot carcass weight as covariate.

[4] Chemical composition of carcass edible portion (Hankins and Howe, 1946).

[a, b] Means in same column bearing different superscripts are different ($P<.05$).

Relationship of NEp Efficiency with Compositional Variables

In order to further clarify the affect of slaughtering cattle at designated endpoint efficiencies, covariance analysis with NEp efficiency as the covariate was performed. When the data was corrected for differences in NEp efficiency neither sex, type nor their interactions were significant (P>.1) sources of variation in composition.

Regression equations based on differences between sexes and types were developed which allow for prediction of chemical composition from NEp efficiency. R^2 values for these equations were .50 to .52 in predicting chemical composition and .44 for YG (table 11).

Slight improvements in R^2 values were achieved for composition and YG when covariance analysis was performed on the basis of all cattle in each endpoint being assigned the designated NEp efficiency rather than their actual efficiency.

A final covariance analysis divided the cattle into sex, type and endpoint groups with hot carcass weight as the covariate. This analysis accounted for the largest proportion of the variation in compositional variables with R^2 values ranging from .62 to .67 (appendix I). When data were corrected for differences in hot carcass weight, sex, type and endpoint were significant sources of variation in all compositional variables and YG (tables 3, 7 and 10).

The apparent relationship between hot carcass weight

TABLE 11. PREDICTION EQUATIONS FOR COMPOSITIONAL VARIABLES BASED ON LAST 70 DAYS ON FEED

	Data Using Actual NEp Efficiency				Data Using Designated NEp Endpoint Efficiency			
	Percent[1]				Percent			
	Ether extract (R^2=.50)[A]	Crude protein (R^2=.51)	Water (R^2=.52)	Yield grade (R^2=.44)	Ether extract (R^2=.55)	Crude protein (R^2=.57)	Water (R^2=.56)	Yield grade (R^2=.50)
Axd								
Steers	27.9+1.8(E)[B]	16.3-.4(E)	55.4-1.4(E)	1.6+.4(E)	26.1+2.2(E)	16.7-.5(E)	56.7-.17(E)	1.2+.5(E)
Heifers	30.4+1.8(E)	16.0-.4(E)	52.9-1.4(E)	1.7+.4(E)	28.4+2.2(E)	16.4-.5(E)	54.3-1.7(E)	1.3+.5(E)
Simm								
Steers	23.6+1.8(E)	17.4-.4(E)	58.6-1.4(E)	1.0+.4(E)	21.5+2.2(E)	17.8-.5(E)	60.1-1.7(E)	.5+.5(E)
Heifers	26.1+1.8(E)	17.1-.4(E)	56.1-1.4(E)	1.1+.4(E)	23.8+2.2(E)	17.6-.5(E)	57.7-1.7(E)	.6+.5(E)

[1] Percent of edible portion of carcass (Hanking and Howe, 1946).

A. R^2 for prediction equation accounting for differences between sexes and types, corrected for NEp efficiency.

B. E=NEp efficiency over last 10 weeks on feed.

and body composition in these data seem to agree with those who found empty body weight so strongly related with various measures of composition (Tulloh, 1963; Burton and Reid, 1969; Reid and Robb, 1971). Correction for hot carcass weight however, failed to negate the effects of sex, type and endpoint on the compositional variables. These results agree with Lipsey (1978), who found slight differences in composition between cattle types slaughtered at a common NEp efficiency endpoint, but disagree with Loveday (1977) who found no difference in composition between cattle slaughtered at two NEp efficiency endpoints. There is agreement with the differences Loveday (1977) found in composition between cattle types.

Performance of steers and heifers supports the contention that heifers fatten faster and earlier than steers (Hedrick, 1968; Berg and Butterfield, 1976) and have more kidney fat (Garrett and Hinman, 1971).

Summary

Summarizing the data over the last 70 days showed that large type cattle compared with small type cattle at the same NEp efficiency endpoint had lower YG numbers, less ether extract, more crude protein, slightly faster ADGs, with no differences in quality grade.

Steers had less carcass ether extract and more carcass water with no advantage in crude protein, yield grade or quality grade compared with heifers. ADGs were equal for steers and heifers while heifers were slightly superior in F/G

As the ratio of available NEp to gain increased, F/G ratio increased, ADG decreased, YG number and carcass ether extract increased, carcass crude protein and water decreased, and quality grade did not change.

Considerable variation in the performance and carcass composition of cattle approaching 7 Mcal NEp/kg gain agreed with Loveday (1977) and precluded several cattle from analysis. Below this point the relationship of NEp efficiency with physiological maturity as expressed by carcass composition was a strong one. Although differences in composition of steers and hiefers at the same NEp efficiency were somewhat inconsistent, definite differences in carcass composition were noted between biological types of cattle when slaughtered at the same NEp efficiency.

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APPENDIX I

PREDICTION EQUATIONS FOR COMPOSITIONAL VARIABLES BY SEX, TYPE AND ENDPOINT CORRECT FOR EFFECT OF HOT CARCASS WEIGHT[1]

	Percent[2]			
	Ether extract (R^2=.62)[A]	Crude protein (R^2=.67)	Water (R^2=.62)	Yield grade (R^2=.63)
AxH steers				
EP1	24.9+.03(HCW)[B]	17.4-.01(HCW)	56.8-.02(HCW)	.5+.009(HCW)
EP2	28.2+.03(HCW)	16.7-.01(HCW)	54.4-.02(HCW)	1.0+.009(HCW)
EP3	28.1+.03(HCW)	16.7-.01(HCW)	54.3-.02(HCW)	1.3+.009(HCW)
EP4	30.8+.03(HCW)	16.2-.01(HCW)	52.2-.02(HCW)	1.6+.009(HCW)
AxH heifers				
EP1	28.8+.03(HCW)	16.7-.01(HCW)	53.4-.02(HCW)	1.0+.009(HCW)
EP2	32.0+.03(HCW)	16.0-.01(HCW)	51.0-.02(HCW)	1.5+.009(HCW)
EP3	32.1+.03(HCW)	16.0-.01(HCW)	50.8-.02(HCW)	1.7+.009(HCW)
EP4	34.6+.03(HCW)	15.5-.01(HCW)	48.7-.02(HCW)	2.1+.009(HCW)
Simm steers				
EP1	18.5+.03(HCW)	19.0-.01(HCW)	61.6-.02(HCW)	.7+.009(HCW)
EP2	21.7+.03(HCW)	18.2-.01(HCW)	59.2-.02(HCW)	.2+.009(HCW)
EP3	21.8+.03(HCW)	18.2-.01(HCW)	59.1-.02(HCW)	0.0+.009(HCW)
EP4	24.3+.03(HCW)	17.8-.01(HCW)	56.9-.02(HCW)	.3+.009(HCW)
Simm heifers				
EP1	22.3+.03(HCW)	18.3-.01(HCW)	58.2-.02(HCW)	-.3+.009(HCW)
EP2	25.6+.03(HCW)	17.6-.01(HCW)	55.8-.02(HCW)	.2+.009(HCW)
EP3	25.6+.03(HCW)	17.6-.01(HCW)	55.6-.02(HCW)	.5+.009(HCW)
EP4	28.1+.03(HCW)	17.1-.01(HCW)	53.5-.02(HCW)	.8+.009(HCW)

[1] Hot carcass weight as covariate.

[2] Percent of edible portion of carcass (Hankins and Howe, 1946).

A. R^2 for prediction equation accounting for differences between sexes, types and endpoints, corrected for hot carcass weight.

B. HCW=Hot carcass weight.

THE RELATIONSHIP OF NET ENERGY FOR PRODUCTION EFFICIENCY AND PERFORMANCE AND COMPOSITION OF STEERS AND HEIFERS OF TWO BIOLOGICAL TYPES

by

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Our study was conducted to further clarify the relationship between the efficiency of feed energy used for production (NEp), after maintenance (NEm) has been accounted for, and carcass composition of the animal. Also of interest were any differences in this relationship due to sex or biological type, and the affect of slaughtering cattle at different NEp efficiency endpoints on meat palatability.

Twenty-six Angus x Hereford reciprocal crossbred cattle (13 steers and 13 heifers) comprised the traditional British type, whereas the large type cattle consisted of 26 Simmental sired calves (13 steers and 13 heifers) out of Maine-Anjou x Hereford, Maine-Anjou x Angus or Chianina x Angus dams. The cattle were randomly assigned to one of four endpoints with three head of each sex x type combination (e.g. steers-large type) assigned to each. Endpoints one through four represented NEp efficiencies of 4.0, 5.0, 6.0 and 7.0 Mcal of NEp/kg of gain measured over the last 70 or 77 days of the feeding period. Animals which were within .1 of their endpoint at 70 days were recalculated the following week.

During the trial 12 animals were removed due to illness or failure to reach their assigned endpoint. Least squares means for NEp efficiency endpoints one through four were 4.1, 5.0, 6.0 and 7.3, respectively, with a standard error of .1 for each value.

Energy required for maintenance was determined by the equation .077 ($Wt._{kg}{}^{.75}$), using the mid-weight of each animal over the feeding period. NEm requirements were then subtracted from the total dry matter available to determine NE left for production. NEp was then divided by the weight gain (as determined by quadratic regression) over the period to arrive at NEp efficiency.

Carcass chemical composition was estimated from the soft tissue of the 9-10-11th rib section and the resulting data, along with that for performance and carcass characteristics, were analyzed by least squares analysis of variance and analysis of covariance.

Significant statistical effects due to endpoint were noted for all compositional variables as well as for yield grade (YG), feed/gain (F/G) and average daily gain (ADG). As the ratio of available NEp/gain increased: carcass ether extract increased ($P<.01$), crude protein and water both decreased ($P<.01$), yield grade number increased ($P<.01$), F/G increased ($P<.01$), and ADG decreased ($P<.01$). Of the variables analyzed, only quality grade failed to show a solid trend due to endpoint ($P=.06$).

Performance and composition differences were noted between biological types of cattle. Large type cattle had slightly higher ADG's ($P<.05$), lower percentages of both protein ($P<.01$) and water ($P<.01$), and lower YG numbers ($P<.01$) when compared to British type cattle. Again, no difference in quality grade was evident ($P<.05$).