

EFFECTS OF ACCELERATED AND CONVENTIONAL FEEDING ON CATTLE PERFORMANCE,
CARCASS TRAITS AND PALATABILITY AND EFFECTS OF
ELECTRICAL STIMULATION ON MEAT QUALITY

by

STEVEN CLAIRE OLSEN

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Approved by

Michael E. Dikeman

Major Professor

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INTRODUCTION

High interest rates and high fixed costs have combined to make it economically advisable to shorten the feeding period for "fat" cattle. On this basis, an accelerated feeding system, one in which the growing phase is deleted, is favored in order to decrease the interest and fixed costs.

There is presently a void in published research concerning accelerated feeding's effects on performance, carcass and palatability traits. It is especially lacking in palatability traits however, most research does not even contain both performance and carcass data. Our research was designed to evaluate these three areas when comparing an accelerated feeding system to a conventional feeding system, which contained the growing phase.

REVIEW OF LITERATURE

Energetic Values of Feeds

Nutritive Value of a Diet. The value of a feed is determined by its chemical and nutrient composition: macro-nutrients (lipids, carbohydrates, protein, fatty and amino acids, calcium and phosphorus) and accessory nutrients (trace elements, vitamins and other metabolically active substances). In addition, the value of feeds depends on a number of influences independent of composition (Nehring et al., 1973). These influences include environment, intake and health.

Four categories of energy are used in estimating values of feeds or diets are: 1) gross energy (GE) which represents chemical composition and does not provide direct prediction of utilization and effects in animal production; 2) net energy (NE) which is the energy content in a animal tissue; 3) digestible energy (DE) which is used in the TDN system which has been shown by Schneider (1954) to have a number of uncertainties, but whose most important aspect is that it is based on the fact that energy can be provided by different nutrients (Nehring et al., 1973); and 4) metabolizable energy (ME) which represents the maximal amount of feed energy which can be utilized by animals for maintenance or production (Rubner, 1883).

Metabolizable energy was described by Nehring and Schiemann (1966) as depending on the utilization of nitrogen components for the process of protein synthesis.

Performance of animals cannot be predicted directly from contents of ME in feeds because utilization of ME is dependent upon performance and condition of the animal and contents of the different nutrients in the diet (Nehring et al., 1973).

Therefore, adjustments must be made for the transformation of ME into animal performance (Blaxter, 1965). Blaxter corrected ME for the total

quantity of feed depending on the energy concentration (ME per kg dry matter (DM)) and also for the nature and proportion of animal production (gain).

Metabolizable energy is utilized most efficiently in conversion of ME to NE for maintenance (67%) and least efficiently in converting ME to NE of live weight gain (47%) according to Burroughs et al. (1970). By using a 80% concentrate diet a 75% efficiency (ME per NE used in maintenance) for maintenance (NE_M) and a 45% efficiency (ME per NE in gain) for live weight gain (NE_p) was reported; however, a finishing diet of 40% concentrates was only 65% efficient for maintenance and 47% efficient for live weight gain.

Efficiency of Energy Deposition. The fattening process is more energetically efficient than structural growth according to Blaxter (1953) who reported that the amount of energy required to deposit 1000 kcal fat would only form 962 kcal of structural growth. Jesse et al. (1976b) also reported fattening as being more energetically efficient in a study they conducted using Hereford steers slaughtered at weight endpoints of 341, 454, and 545 kg which had been fed varying ratios of corn and corn silage. High energy diets have been reported to favor the efficiency of energy deposition (Jesse et al., 1976a) because of a greater intake of energy over maintenance requirements. At heavier weights, cattle are generally fatter and the daily energy deposition is increased. However, Lofgreen et al. (1963) reported an increased feed requirement at latter stages of fattening due to heat loss (increment).

NE_M and NE_p System. Lofgreen and Garrett (1968) developed this system due to earlier work in which they found from maintenance to ad libitum feeding, the partial NE of a feed used for weight gain does not deviate from linearity; therefore, partial NE for weight gain above maintenance is constant.

Since the partial efficiency of energy utilization for maintenance is higher than it is for production (Kleiber, 1961), NE_M should be higher than

NE_p in Lofgreen and Garrett's system.

The NE_M is defined to be the quantity of net energy necessary to keep the animal in energy equilibrium and is equal to the heat production of an animal at zero intake (Lofgreen and Garrett, 1968). Generally, NE_M is considered to be $70 W^{.75}$ where W is bodyweight in kilograms and heat production is expressed in kilocalories. However, Lofgreen and Garrett found with 208 feeder cattle at 230 to 300 kg that NE_M equals $77 W^{.75}$. Lofgreen and Garrett also reported that there was no difference between steers and heifers.

NE_p is the energy deposited in the gain. Lofgreen and Garrett (1968) found that energy concentrated in the weight gain (NE_p) increased as the rate of gain increased and that the increase is more rapid in heifers. This increase in NE_p could only be partially accounted for by body weight gains.

All roughage diets (100%) are only 72% as valuable as a 2% roughage diet (NE_M 1.20 and 1.67, respectively) and for production of weight gains the 100% roughage diet was only 41% as valuable as the 2% roughage diet (NE_p 0.5 and 1.22, respectively). (Lofgreen and Garrett, 1968)

NE_M according to Vance et al. (1972) is constant and independent of the proportion of the diet the feed itself makes up. Garrett (1979) also found NE_M to be constant for a feed when he noted a linear relationship between roughage level (90 to 24 percent alfalfa and sudan hay) and NE_M and NE_p . Vance et al. (1972) reported that NE_n values will vary dependent upon the proportion of the feed ingredient in the diet; as corn grain decreases and corn silage increases, the NE_p value of corn will decrease.

Both of these energy values have one very important fault that makes their application to actual feeding regimens questionable; both assume cattle are in the thermoneutral zone and no adjustment is made for environmental differences. Fox et al. (1977) and Knox and Handley (1973)

both found the need to adjust for environment.

Diet Effects on Feedlot Performance

Intake. The value of maximum energy and nutrient intake in feedlot performance cannot be understated. The more energy taken in above maintenance per day, the more energy available for production.

Hammes et al. (1964) remarked that intake variations have a positive effect on performance on high silage diets (increased intake results in increased performance). A positive correlation of .709 between feed conversion and feed consumption was found by Brown and Gifford (1962) using Hereford and Angus bulls.

Apparently animals have a chemical fill zone in addition to a physical fill level. It appears that high energy, all-concentrate diets pass the chemical fill threshold before a physical fill is attained.

Fontenot et al. (1967) found that intake was lower on a high energy (73% TDN) as compared to medium or low energy diets (67 or 62% TDN). In comparing varying ratios of corn to corn silage, Jesse et al. (1976b) reported the least DM intake as a percent of body weight occurred on the highest corn to corn silage ratio.

Thompson et al. (1965) noted a 2.3 kg lower daily consumption by steers receiving no hay compared to steers with long hay or ground hay added to a basal diet. An increased organic matter and dry matter intake was noted by Cole et al. (1976) on a low roughage level (21%) as compared to no roughage. However, Peterson et al. (1973) reported that with a high energy diet (100% high moisture corn), DM consumption was not reduced the first 56 days when compared to smaller ratios of high moisture corn to corn silage. However, intake was lower the third 56 days for the higher energy diet.

For the first 87 days, Harris et al. (1979) found a higher dry matter and corn grain intake on a high energy diet (60% shelled corn and 40% corn silage) compared to a moderate energy diet of 40% shelled corn and 60% corn silage. Ferrell et al. (1978a) reported that DM and ME intake on a high concentrate (3.17 Mcal ME/kg) diet was equal to a high corn silage diet (2.77 Mcal ME/kg) when fed to Red Poll, Chianina or Gelbvieh steers.

Various roughages can alter the palatability and therefore, consumption (White et al., 1971). They noted that sudangrass pellets or rice straw used as roughages when compared to alfalfa hay, polyethylene pellets, rice hulls or no roughage, gave a greater consumption. They noted that with this increase in consumption, more concentrate (energy) was consumed.

Vance et al. (1972) also reported that an all-concentrate diet improved digestion of dry matter, organic matter and protein. No effect by concentrate level was noted by Cole et al. (1976) when using various levels of roughage although they did note that more total digestion occurred on high roughage diets due to a greater intake. Thus, in the latter study more energy, protein and other nutrients were actually utilized by the animals on the high roughage diet.

If intake is decreased with all-concentrate diets, then starch and DM digestion should increase according to Galyean et al. (1979). By feeding from 1 to 2 times the 1976 NRC maintenance net energy requirements using a basal diet of 2.11 Mcal NE_M per kg DM, they found that starch digestion decreased as intake increased. They also noted that DM digestion was significantly lower at 2 and 1.67 times the NRC (1976) requirements.

In summary, DM intake tends to decrease with high levels of energy concentration in the diet. However, energy intake increases as dietary energy density increases. If a high roughage diet is fed, a physical fill limit

may control intake.

Digestibility. Digestibility, a measure of the amount of nutrients actually obtained by an animal for maintenance or productive use, by the breakdown of food products in the gastrointestinal tract, is an important factor in considering the actual feeding value of a diet.

Due to adaptation of rumen microbes, a diet component may be more or less digestible when fed in a mixed diet than when fed alone (Marion, 1979). Mixed diets decrease in digestibility with increased intake according to Anderson et al. (1959). Schneider and Flatt (1975) reported that as consumption increases, rate of passage also increases, resulting in decreased digestibility of the feedstuffs.

Angus and Santa Gertrudis steers fed five diets of 2.8 to 3.6 kcal DE per gram were not found to be different in digestibility (Dinius et al., 1976).

Vance et al. (1972), by feeding shelled or crimped corn with the addition of 0 to 11.3 kg corn silage per head per day to Hereford steers, found that digestibility was not altered by the form of the corn or by the addition of corn silage to the diet.

By using steam flaked corn (SFC) or dry rolled corn (DRC) in diets fed to 460 kg Hereford steers, Cole et al. (1976) found that SFC had 13% higher DM and 15% higher organic matter digestion in the rumen than DRC. DRC had higher intestinal organic matter and DM digestion, but this failed to overcome the SFC's advantage in the rumen. They also reported that a high concentrate diet had a higher digestion coefficient than a diet with more roughage.

In summary, research indicates a trend for digestibility to decrease with increasing intake. It also indicates a greater digestibility for high concentrate diets over high roughage diets. No trend prevails on how the

form of the corn influences digestibility.

Average Daily Gain. Average daily gain (ADG), the live weight gained per day during a feeding period by an individual animal, has important economic significance to the cattle feeder.

ADG has been correlated ($R = .4$) by researchers to feed efficiency. Dikeman (1973) stated that with cattle of similar size, faster gaining cattle tended to be more efficient and fatter because of the dilution of maintenance feed requirements when compared with slower gaining animals. Koch et al. (1963) found that 38% of the variation in gain was due to feed efficiency and 25% was due to variation in consumption.

Because of the significant correlations between efficiency, consumption, and ADG, a useful tool has been created for cattle selection. Since feed efficiency is seldom measured directly, ADG can be used as a selection criteria for improving efficiency.

ADG can be altered even before the feeding period begins according to Bond et al. (1972). By feeding steers a low level of nutrition prior to 180 days of age, the steers gained faster from 180 days to slaughter than steers fed a high level of nutrition prior to 180 days of age. He also noted that there was a breed effect on ADG from comparisons between dairy and beef steers.

ADG can decrease with age (Moody et al., 1970). These researchers finished Angus steers on a corn diet fed at 1.5% of body weight and corn silage fed ad libitum, and found that ADG decreased over the 28 to 112 days-on-feed endpoints. These endpoints corresponded to weights between 360 and 430 kg. Stringer et al. (1968) also noted a tendency for ADG to decline over time using Hereford and Hereford x Angus steers finished between 415 and 436 kg. However, Trenkle et al. (1978) found no significant effect on

ADG when Charolais and Angus cattle were fed to heavier weights (110 to 500 kg).

As weight increases, maintenance requirements also increase (Lofgreen and Garrett, 1968). As cattle weight increases during the finishing phase, fatness also increases. According to Dikeman (1973), this increase in fatness should reduce their efficiency when expressed on a kg of feed per kg of gain basis. However, ADG was reported to increase from 341 to 545 kg slaughter weight by Jesse et al. (1976b), who fed varying ratios of corn: corn silage to Hereford steers. They attributed some of the variation to the corn silage at the beginning of the feeding trial being higher in moisture than corn silage fed later.

Beardsley et al. (1959) studied concentrate:roughage ratios of 70:30, 55:45, and 40:60. They reported that gains of steers on unpelleted diets decreased as the proportions of roughage increased. This could be explained by the energy density dilution caused by the increased roughage levels.

By comparing moderate and high nutritional regimens, Callow (1961) reported various combinations of these regimens have a definite effect on ADG; in addition, he noted that carcass weights increase with live weight.

When finishing cattle on high silage diets, Hammes et al. (1964) found that by increasing the proportion of corn (energy) in the diet, performance increased. He also noted that using a more concentrated feed such as low moisture silage (high DM), that rate of gain is higher than with high moisture silage.

Ferrell et al. (1978a) also found that a high energy (3.17 Mcal ME/kg) diet fed to Red Poll, Chianina, or Gelbvieh steers increased ADG over that of a high corn silage, lower energy (2.77 Mcal ME/kg) diet. Many other re-

searchers have also reported the tendency for ADG to increase with increased energy in the diet (Miller et al., 1966; Wise et al., 1967; Oltjen et al., 1971; McCartor et al., 1972; Clemens et al., 1973; Smith et al., 1976; Dinius et al., 1978; and Garrett, 1979).

Type of cattle also has an effect on the influence of energy concentration on ADG. Prior et al. (1977) found that small type cattle (Angus and Hereford) increased in ADG .1 kg between low energy, moderate energy and high energy diets (2.9, 3.1, and 3.2 Mcal ME/kg DM). However, large type cattle (Charolais and Chianina) increased in ADG on the moderate energy diet when compared to the low energy diet; however, ADG was not different between high energy and moderate energy diets.

Kidwell and McCormick (1956) compared Holstein and Hereford cattle and concluded that at a given weight, or age, animals of larger mature size will gain more rapidly and are more efficient than animals with smaller mature sizes.

An effect of days-on-feed on ADG could also be present according to Peterson et al. (1973). They found by studying three consecutive 55 or 56 day feeding periods with Angus x Hereford calves, that for the first 55 days ADG increased with energy, protein, and an energy x protein interaction. During this period, an all-concentrate diet of 85.7% high moisture corn and 12.6% dry corn increased ADG 20% over that of a high silage diet of 85.7% corn silage and 10% dry corn. In the second 56 days, ADG increased linearly with energy concentration and ADG tended to increase with increasing protein levels although the effect was nonsignificant. During the third period of 56 days, only energy concentration increased ADG.

Significant increases in responses with 14% crude protein instead of 11% in an all-concentrate diet (82 gm per head per day increase in ADG) were

obtained by Haskins et al. (1967). They indicated that protein levels should possibly be increased over the recommended 11% level when using all-concentrate diets. Greathouse et al. (1974) also noticed a .2 kg ADG increase by using 11.8% instead of 9.5% crude protein in an all-concentrate diet.

Both Braman et al. (1973) and Fontenot et al. (1967) reported increased ADG with increased protein level, although Braman concluded that protein requirements of finishing steers may decrease with increasing physiological maturity or time-on-feed.

Several other researchers have found that adding roughage to an all-concentrate diet has had no effect on ADG: Anthony et al. (1960) by comparing diets containing 30, 10, and 0% bermudagrass hay; Wise et al. (1961) by adding 1.13 kg of ground or long hay to a ground shelled corn diet; Williamson et al. (1961) on 8 to 12% roughage levels using different roughage types; and Dinius et al. (1978) by comparing hay and concentrate diets after 3, 6, and 9 weeks of feeding.

Some researchers have even noted an increase in ADG with increased roughage level or by using high roughage diets. Anthony et al. (1961) fed a high roughage diet to steer and heifer calves which gained .96 kg per day on a 30% roughage diet, whereas a high energy diet containing no roughage resulted in a gain of only .93 kg per day. Vance et al. (1972) reported that ADG increased by adding 2.3 to 9.1 kg corn silage to whole shelled or crimped corn with 4.5 kg added corn silage being the best level for whole shelled corn, and 6.8 kg added corn silage being the best level for crimped corn. Thompson et al. (1965) found that for the first 56 days of feeding an all-concentrate diet, steers gained almost .5 kg per day less than steers receiving hay in their diet.

Wise et al. (1968) stated that the general pattern of results indicates

that rate of gain was essentially equal and feed consumption markedly lower on the all-concentrate diet. In addition, less feed per unit of gain was required when roughage was excluded.

In summary, ADG tends to be influenced heavily by the energy level of the diet. ADG is also highly related to efficiency. Others factors having influences over ADG include cattle type, days-on-feed (inverse), protein level (positive) and amount and type of roughage (inverse).

Feed Efficiency. Feed efficiency (feed per unit of gain or F/G) is a measure of the ability of animals to convert nutrients in the feedstuffs to carcass or live weight gain. Feed efficiency has been evaluated very extensively in research trials.

By expressing efficiency as weight of feed DM per unit of gain, fattening has a lower efficiency of gain as compared to skeletal and protein increases (VanStavern et al., 1970). However, expressing efficiency on a basis of energy intake per unit of energy deposited in the gain, the fattening process has been described by Jesse et al. (1976a) as being more efficient. Garrett (1979) fed Hereford and Angus steers over a range of 90:10 to 24:76 roughage (hay) to concentrate and found that retained energy increased as percent hay in the diet decreased.

Haskins et al. (1969) fed Hereford steer calves for 175 or 189 days on a basal diet and various roughages (hay, cottonseed hulls, ground corn cobs, oyster shells, sand, and ground polyethylene). He reported that F/G followed ADG since faster gaining steers ate more feed and were more efficient. Moody et al. (1970) also reported from a study feeding Angus steers for 28 to 112 days on ground shelled corn (1.5% body weight per day) and supplement (.63 kg soybean meal) that F/G decreased with increases in ADG.

By feeding Holstein, Shorthorn and beef-type steers to 60% of their mature weight, Bond et al. (1972) noted that a low plane of nutrition prior to 180 days of age increased efficiency from 180 days to slaughter because of compensatory growth which occurred when adequate nutrition levels are fed.

Since maintenance requirements are related to live weight, it is generally believed that higher energy feeds provide more energy for productive use above maintenance requirements. However, over a range of 8 to 16 percent roughages (ground corn cobs, cottonseed hulls, soybean hulls, rice hulls, ground rice hulls, ground peanut hulls, Bermuda screenings, oat mill feed, chopped alfalfa hay and dried beet pulp added to a diet), Williamson et al. (1961) noted that 12% roughage resulted in the best feed conversion. Over a range of 30, 10, and 0 percent bermudagrass hay added to a diet, Anthony et al. (1960) found no F/G difference. Bond et al. (1972) fed dairy, dual purpose and beef steers to slaughter weight and noted that the hay diet (ground mixture of alfalfa and timothy hay up to 5/6 of slaughter weight followed by concentrate) was more efficient than a finishing diet of 75% corn.

Oltjen et al. (1971) fed Hereford steers on all-concentrate or pelleted forage diets to similar slaughter weights and noted that the all-concentrate regimen was more efficient than the all-forage regimen or combinations of the two (5.71 vs 8.14, 10.06, and 7.98 respectively).

Jesse et al. (1976b) improved F/G ratios from 7.61 to 6.48 by increasing the ratio of corn to corn silage from 30:70 to 80:20. They also reported that efficiency was best for Hereford steers slaughtered at 341 kg as compared to Hereford steers slaughtered at 454 or 545 kg. This and other research indicates a trend toward increased efficiency with increased energy density (Williamson et al., 1961; Anthony et al., 1960; Hammes et al., 1964; Thompson et al., 1965; Wise et al., 1967; Fontenot et al., 1967; McCartor

et al., 1972; Vance et al., 1972; Peterson et al., 1973; Harvey et al., 1968; Ferrell et al., 1978a; and Garrett, 1979).

Prior et al (1977) reported a cattle type effect when cattle were fed to approximately equal carcass composition on three dietary energy levels (2.9, 3.1, and 3.2 Mcal ME/kg DM). They noted that for large type cattle, DM per kg of gain was best for the high energy diet. They also reported that the low energy diet was used more efficiently by small type steers than the medium or high energy diets. However, Smith et al. (1977) compared large type (at least $\frac{1}{2}$ Brown Swiss, Charolais, Chianina, Gelbvieh, Limousin, Maine Anjou or large dairy breeds) and small type (at least $\frac{5}{8}$ Hereford, Angus or Jersey) and found that feed efficiency did not differ due to dietary energy (2.18 to 3.11 Mcal ME/kg) or cattle type.

By feeding Angus x Hereford steers to 475 kg live weight, Peterson et al. (1973), reported that an all-concentrate diet of 85.7% high moisture corn silage, .2% soybean meal, and 12.6% dry corn as compared to a low roughage diet of 28.6% corn silage, 57.1% high moisture corn, .2% soybean meal and 12.4% dry corn required less DM per unit of gain.

Peterson et al. (1973) also reported that increasing protein levels from 9 to 15% crude protein will increase efficiency.

Fontenot et al. (1967) fed diets of 9.2, 12.9 and 17% protein to weanling steer calves and found that the lowest protein level had the lowest feed efficiency.

Brangus x Hereford x Shorthorn steer calves' efficiency increased linearly with increased protein (soybean meal) up to 56 days-on-feed according to Braman et al. (1973). This increase was found to be cubic at 140 days-on-feed.

Prior et al. (1977) noted that small type steers increased in efficiency

up to 325 kg on 11.5% protein instead of 10% protein; however, large type steers on 13% protein compared to 10% protein were more efficient up to 348 kg.

Comparisons of past research indicate that the higher the level of energy above maintenance, the more efficient the animal will be. Some research indicates an increase in efficiency by a addition of a small amount of roughage to the diet. Also there are indications that increasing protein to a degree will increase efficiency.

Diet Effects on Carcass Characteristics

Hot Carcass Weight (HCW). Total weight gain over the feeding period will increase HCW if dressing percent stays constant. Another way of increasing total weight gain and thus HCW is to extend the feeding period (Hedrick et al., 1969; Stringer et al., 1968; and Zinn et al., 1970).

Callow (1961) reported that at a constant dressing percent, a moderate level of nutrition over the entire feeding period produced the lightest animals compared to a high level of nutrition over the entire feeding period or combinations of high and moderate levels of nutrition. Therefore, the moderate level of nutrition produced carcasses where HCW was less.

Dressing Percent. Heavier steers have higher dressing percents according to Bowling et al. (1978) from work they conducted with Santa Gertrudis steers. Dinkel et al. (1969) also reported an effect of weight on dressing percent of Hereford and Angus steers because dressing percent changes have been highly correlated to changes in the amount of fat in a carcass. Forrest (1975) reported that as cattle approach a Prime quality grade (and percent fat increases) that dressing percent increases.

Many researchers found that time-on-feed, which is highly related to an

increase in carcass fatness, increased dressing percent (Stringer et al., 1968; Hedrick et al., 1969; Zinn et al., 1970; and Moody et al., 1970).

Dietary energy intake is also highly associated with the amount of fat in a carcass. Wellington et al. (1954), Callow (1961), Thompson et al. (1964), Henrickson et al. (1965), Klosterman et al. (1965), Vance et al. (1972), Kappel et al. (1972), Dinius et al. (1976), and Dinius et al. (1978) all found increases in dressing percent by increasing dietary energy uptake per day.

There is no effect of type of roughage on dressing percent according to McCartor et al. (1972) who used cottonseed hulls, cottonwood sawdust, and raw rice hulls in a finishing diet fed to Hereford steers. Harris et al. (1979) reported no effect of level of protein supplementation (7.9 to 11.9%) on dressing percent. From a study of Hereford steers fed four ratios of corn to corn silage with slaughter at three weight endpoints, Jesse et al. (1976b) noted that the fastest gaining cattle had the highest dressing percents. Dikeman (1973) also reported that the fastest gaining cattle tend to be fatter from trials involving cattle of similar mature size.

Fat Thickness. Fat thickness at the 12th rib has been found by many researchers to be highly influenced by energy density of the diet (Matthews et al., 1962; Guenther et al., 1965; Klosterman et al., 1965; Waldman et al., 1971; Rumsey et al., 1972; Sumida et al., 1972; Prior et al., 1977; Bowling et al., 1978; Ferrell et al., 1978b; Crouse et al., 1978; and Lipsey et al., 1978). However, Skelly et al. (1973) fed Hereford and Angus steers corn silage for 140 days and found that no effect was caused by diet on fat thickness.

There is a slight effect by protein source x protein level interaction on fat thickness per 100 kg of carcass weight according to work conducted by Braman et al. (1973). They studied Brangus x Hereford x Shorthorn steers

with urea or SBM for a protein source and feeding 10.7 to 18.4% crude protein. Protein level had no effect on carcass parameters but protein source had an effect on fat thickness.

Assuming adequate nutrition, another variable highly correlated with fat thickness is days-on-feed. Guenther et al. (1965), Stringer et al. (1968), Hedrick et al. (1969), Moody et al. (1970), Dinius et al. (1978) and Harrison et al. (1978) all found that increased time-on-feed increased fat thickness. This is associated with findings of Dinkel et al. (1969) and Lipsey et al. (1978) who found that fat thickness increases with increasing live and carcass weights.

Henrickson et al. (1959) concluded that moderately gaining calves had less external fat than high gaining calves (.69 and .87 kg ADG respectively). Dikeman (1973) agreed with this by stating that faster gaining cattle tend to be fatter.

Conflicting reports have been given concerning fat deposition. Dinkel et al. (1969) reported that there was no tendency to increase fat deposition rate on a weight constant basis from 363 to 590 kg from a study with Angus steers. However, from work with Hereford steer calves, Guenther et al. (1965) reported an increase in fat deposition as calves mature, irrespective of high or moderate planes of nutrition.

Interestingly, Waldman et al. (1971) found that a difference in fat thickness of Holstein calves occurred after 227 kg live weight when comparing a medium and high level of nutrition (where the moderate level of feeding was equal to 60 to 70% of the weight gains of the high level). This would support a difference between groups for rate of fattening. A difference would have occurred in the rate of fattening prior to 227 kg.

Researchers have also reported that cattle type has an influence on the effect of dietary energy density on fat thickness. Lipsey et al. (1978) found that small type steers (Hereford x Angus or Angus x Hereford) slaughtered at a NE_p of 8 Mcal NE_p per kg of gain had more fat over the 12th rib than large type steers (Gelbvieh or Maine-Anjou x Hereford or Angus).

It is apparent from research that fat thickness increases with increasing energy density or increasing time-on-feed. Research is still incomplete concerning cattle type or rate of fattening on fat thickness.

Longissimus Area. Most researchers, including Henrickson et al. (1965), Stringer et al. (1968), Hedrick et al. (1969), and Moody et al. (1970), found that longissimus area (LEA) increased with length of feeding.

Stringer et al. (1968), from work with Hereford and Angus x Hereford steers slaughtered at 28 day intervals, also noted LEA increases with mean live or carcass weight increases over a 416 to 487 kg live weight endpoint range. Other researchers finding similar responses include Dinkel et al. (1969), Wanderstock et al. (1948), and Trenkle et al. (1978). However, Moody et al. (1970) reported that LEA increased over time but not proportionately with live weight.

Peterson et al. (1973) found by feeding Angus x Hereford steers four ratios of corn silage to high moisture corn that a slight increase in LEA per unit of carcass weight occurred as dietary energy increased. LEA per kg carcass weight varied with the level of energy intake in a study conducted by Bowling et al. (1978).

Jesse et al. (1976b) using four ratios of corn to corn silage fed to slaughter endpoints between 227 and 545 kg found no effect of level of nutrition on LEA in cattle. Trenkle et al. (1978) by comparing full fed and limited fed (2/3 gain of full fed steers) over 110 to 590 kg live weight, and

Henrickson et al. (1965) feeding steers combinations of high and moderate nutritional levels for 400 kg feedlot gain, also found no effect of nutrition on LEA. Crouse et al. (1978) using high, moderate and low energy levels (2.7, 2.9, and 3.3 Mcal DE/kg) found no nutritional effect on LEA in lambs slaughtered at four weight endpoints.

A slight nitrogen x protein level interaction on LEA per 100 kg of carcass was found by Braman et al. (1973) using Brangus x Hereford x Shorthorn cattle fed over a range of 10.5 to 18% crude protein. However, Harris et al. (1979) and Peterson et al. (1973) found no dietary protein effects on LEA.

An increase in LEA for cattle on a pelleted forage diet for the first half of the feeding period (77 days) and concentrate feeding the last half of the feeding period (BA) was noticed by Oltjen et al. (1971), as compared to all-pelleted forage feeding, all-concentrate feeding, or a concentrate-pelleted forage feeding system. Days-on-feed were less for the BA system than two of three of the other systems (189 as compared to 203, 168, and 196 days-on-feed respectively).

Type of roughage had no effect on LEA according to McCartor et al. (1978) from a study conducted with Brahman x Hereford steers fed control or protected lipid diets for 56 days after a 145 day grazing period.

Research indicates that LEA increases with time-on-feed with little evidence of nutritional effects on longissimus growth. Protein level has also been studied and most research has found no effect on longissimus growth. Carcass Quality. USDA quality grade is very highly determined by marbling score. Marbling score is determined by estimating the amount of visible intramuscular fat in the Longissimus dorsi muscle (LD) at the 12th rib in a beef carcass. Therefore, any treatment which increases the amount of visible

intramuscular fat will increase the marbling score and quality grade. Marbling score is also highly correlated with ether extract (EE) in the LD muscle.

From a study of Holstein calves on two levels of nutrition, Waldman et al. (1971) reported no increase in LD lipid until after 227 kg live weight. Therefore, marbling may not increase until after 227 kg live weight.

The treatment which most highly influenced marbling score (and quality grade) was dietary energy concentration. Almost all researchers reported an increase in quality grade with increasing dietary energy (Matthews et al., 1962; Henrickson et al., 1965; Klosterman et al., 1965, Greathouse et al., 1974; Jesse et al., 1976b; Arthaud et al., 1977; Prior et al., 1977; Bowling et al., 1978; Harrison et al., 1978; and Harris et al., 1979).

When comparing different diets (85 to 90% corn with either cottonseed meal or raw soybeans, and Bermudagrass hay or corn silage), Skelly et al. (1973) found no effect on marbling score on a time constant basis (140 days-on-feed).

Vance et al. (1972), when working with Hereford steer calves, found that by adding corn silage (0 to 11.3 kg per day) to a diet of ground corn, that 4.5 kg per day increased marbling score and quality grade to their highest levels in that study.

Steers fed for moderate gains (.69 kg ADG) were lower in marbling and quality grade than those with high gains (.87 kg ADG) in a study conducted by Henrickson et al. (1959). Thompson et al. (1964) found when feeding Hereford steer calves to a constant weight gain (251 kg) on either a full-feed of high moisture shelled corn plus 5.5 kg corn silage, or 2.3 kg high moisture corn plus a full-feed of corn silage, that cattle full-fed high moisture corn graded higher. These results tend to verify the statement by Dikeman (1973) that faster gaining cattle fatten faster.

By feeding Holstein male calves two nutrition levels to five slaughter endpoints, Suess et al. (1969) reported an effect of dietary energy level for the last half of the feeding period on marbling score and quality. Henrickson et al. (1965) also reported this when feeding Hereford steer calves to 182 kg total feedlot gain. They also reported that high (H) and moderate (M) energy levels fed H-H and H-M were better than M-H and M-M for increasing marbling score and quality grade.

Another important factor for quality grade is time-on-feed. Stringer et al. (1968), Hedrick et al. (1969), Moody et al. (1970), Peterson et al. (1973), Zinn et al. (1970) and Dinius et al. (1978) all noted increased marbling with increased time-on-feed. However, Moody et al. (1970) found no significant increase in marbling after 84 days-on-feed. Interestingly, Stringer et al. (1968) conducted research on five lots of Angus x Hereford and Hereford steers slaughtered every 28 days after the first lot graded high Good, and reported that increases in quality grade occur faster towards the start of the feeding period.

Associated with a longer feeding period would be heavier live weights. Dinkel et al. (1969) at three slaughter weights of 408, 499 and 590 kg found a positive correlation of marbling with increasing weight. Trenkle et al. (1978) also reported this when feeding Charolais x Angus x Hereford and Angus x Angus x Hereford steers which were slaughtered over a range of 110 to 500 kg live weight. Lipsey et al. (1978) also correlated marbling score increases with weight gains.

Rumsey et al. (1972) and Dinius et al. (1978) both reported that percentage of EE was influenced by diet. Hedrick et al. (1969) found that percentage EE increased with an extended feeding period when feeding steers and heifers from 96 to 294 days.

Contrary to a faster gaining, faster fattening theory, Trenkle et al. (1978) reported that limited fed (after 220 kg live weight for 2/3 growth of full-fed animals) Charolais x Angus x Hereford and Angus x Angus x Hereford steers had significantly more LD EE at 500 kg live weight than animals fed the diet ad libitum throughout the feeding trial.

No effect on quality grade was noted by adding low levels of roughages (ground polyethylene, ground corn cobs, cottonseed hulls, hay, oyster shells, or sand) to a high energy basal diet for Hereford steers (Haskins et al., 1969). McCartor et al. (1972) reported no effect of type of roughage (10% cottonseed hulls, cottonwood sawdust or raw rice hulls) on quality grade of Hereford steers.

Prior et al. (1977) and Harris et al. (1979) both reported no effect of level of protein supplementation on marbling score or quality grade. Prior et al. (1977) studied 10, 11.5 and 13% protein levels; Harris studied 7.9 to 11% crude protein.

Marbling tended to become coarser with increased time-on-feed (Moody et al., 1970) when they fed Angus steers from 28 to 112 days and slaughtered them at 28 day intervals. No other researcher has noted this response.

Harrison et al. (1978) reported that crossbred calves fed 98 days had significantly whiter fat than those fed only 49 days. They also reported that lean maturity was unaffected by time-on-feed.

In summary, many researchers have found that increased dietary energy or increased time-on-feed increases marbling scores. There is also evidence that indicates a tendency for marbling score to increase with faster gaining cattle. Roughage level and protein level have been shown to have no effect on marbling score. Several researchers have reported that marbling score increases faster at the beginning of the feeding period than later.

Yield Grade and Cutability. Boggs (1979) stated that yield grade is much more highly related to the amount of fat in the carcass than muscle. Therefore, yield grades are not good indicators of muscle mass. However, they were designed (and are used for) predicting the yield of trimmed retail cuts from the round, loin, rib and chuck (Murphy et al., 1960). Yield grades range from 1, with an estimated 53.5% yield, to a 5 with an estimated 44.3% yield of trimmed retail cuts from the round, loin, rib and chuck.

Since yield grade is greatly influenced by fat, it is no surprise that any treatment which increases the proportion of fat in the carcass (specifically round, loin, rib and chuck) will increase yield grade number. Factors which increase yield grade number include: time-on-feed (Stringer et al., 1968; Hedrick et al., 1969; and Dinius et al., 1978); energy density of the diet (Wellington et al., 1954; Henrickson et al., 1959; Thompson et al., 1964; Henrickson et al., 1965; and Ferrell et al., 1978b); weight at slaughter (Henrickson et al., 1959; Dinkel et al., 1969; and Lipsey et al., 1978) and breed effects (Gregory et al., 1966; and Koch et al., 1976).

Harris et al. (1979) reported that high energy diets fed to Hereford steer calves increased marbling score (intramuscular fat) but had no significant effect on yield grade compared with moderate energy diets. Garcia-de-Siles et al. (1977) reported that marbling had no effect on percentage of cutability or on edible portion of steer and heifer carcasses.

Kauffman et al. (1975) reported that heavier carcasses possessed greater fat thicknesses, more marbling, larger longissimus muscles and consequently smaller proportions of fat free muscle. They reported from this work that adjusted fat thickness, marbling score and longissimus area are the three most important factors for predicting carcass composition. By using these

three factors alone they were able to account for 73% of the variation in percent fat free muscle. This surpasses the present yield grade equation.

Prior et al. (1977) noted that small type cattle (Angus x Hereford) had a higher yield grade number (4.3 vs 3.6) with increasing energy density from low to medium (2.9 to 3.1 Mcal ME/kg DM). They did not report this effect for large type cattle (Charolais and Chianina) at the same carcass weights of the small type cattle. Koch et al. (1976) reported that Limousin, Charolais and Simmental crosses had significantly lower yield grades than Hereford x Angus, Jersey or South Devon crosses. Prior et al. (1977) also reported that large type steers (Charolais and Chianina) had lower yield grades on high protein as compared to a low protein diet (13 vs 10% crude protein) while no significant effect existed for small type steers (Hereford x Angus).

Small type steers (Hereford x Angus or Angus x Hereford) at the same NE_p efficiency endpoint of 8 Mcal NE_p per kg of gain had poorer yield grades than large type steers (Gelbvieh and Maine-Anjou). (Lipsey et al., 1978)

From work with Hereford steers, Harris et al. (1979) reported no effect of dietary protein levels of 7.6 to 11.9%, or type of protein supplement on yield grade. However, Ferrell et al. (1978b) using two energy levels noted that Hereford, Angus, Charolais crosses, dairy crosses, and Limousin crosses increased yield of trimmed retail cuts on a high protein level as compared to a low protein level (high energy 13.4 vs 11.5% and low energy 12.4 vs 10.6%).

Several researchers have reported increasing weights of retail cuts with live weight increases (Stringer et al., 1968 and Dinkel et al., 1969). However, Stringer et al. (1968) reported that retail cut weight gains were not proportional to increases in live weight for Hereford and Angus x Hereford steers.

Moody et al. (1970) reported correlations of LEA, carcass weight, and dressing percent with weight of edible portion (.64, .94, and .59 respectively) and weight of total fat of the primal cuts (.09, .43, and .18 respectively) when he fed Angus steers at five initial weight groups with four different lengths of time-on-feed.

Bowling et al. (1978) reported that yearling Santa Gertrudis steers on grass for 139 days or 139 days on grass plus 60 days of supplemental grain had higher percentages of trimmed primal cuts than drylot finished Santa Gertrudis steers fed a fattening diet for 130 days after grass (75.4 and 74.2 vs 73.7%). However, Harrison et al. (1978) reported no differences in cutability between grass-fed crossbred steers (133 days), short-fed crossbred steers (drylot feeding of 20% alfalfa haylage and 75.2% cracked corn for 49 days after weaning), forage-fed crossbred steers (98 days of 40% corn silage, 20% alfalfa haylage, and 36% cracked corn) or long-fed (98 days drylot feeding of 20% alfalfa haylage, and 75.2% cracked corn after weaning).

McCartor et al. (1972) noted that type of roughage (cottonseed hulls, cottonwood sawdust, and raw rice hulls) had no effect on yield grade of Hereford steers.

Diet Effects on Carcass Composition.

Bone. Percentage fat varies inversely with bone according to Bowling et al (1978) from a study involving Santa Gertrudis steers fed a combination of grass and/or grain.

Waldman et al. (1971) fed Holstein steers up to 590 kg live weight under high and medium (60 to 70% ADG of high level) nutritional planes and reported that bone growth is associated with body size and is influenced very little by dietary energy levels during all phases of development. No effect of plane of nutrition on bone growth of pigs and lambs was reported by Elsley

et al. (1964).

Mild feed restriction has no effect on separable bone over a 110 to 500 kg live weight range according to Trenkle et al. (1978) from work with Charolais x Angus x Hereford and Angus x Angus x Hereford steers.

Stringer et al. (1968), Hedrick et al. (1969), and Trenkle et al. (1978) all reported that percent bone generally decreases with time-on-feed.

At less than 227 kg live weight, bone grows at a slower rate than muscle. However, after 227 kg, bone growth decreases more than muscle but retains a relatively constant rate of growth to 590 kg live weight (Waldman et al., 1971).

Callow (1961) reported that leaner carcasses have a higher percentage of bone (due to less fat).

Muscle. Boggs (1979) reported that muscle is intermediate in maturation between bone and fat. Forrest (1975) stated that as the proportion of fat increases, the proportion of bone and muscle decreases.

Zinn et al. (1963) reported that steers and heifers fed to 270 days and slaughtered at 30 day intervals declined in ratio of edible carcass lean to fat with increased days-on-feed. The 9-10-11th rib section has been used as a good predictor of lean, fat and bone in the carcass (Kelly et al., 1968).

Since dietary energy level has been associated with carcass fat, it is not surprising to find that high energy levels decrease the proportion of lean in the carcass (Wanderstock et al., 1948; Henrickson et al., 1965; and Arthaud et al., 1977). Trenkle et al. (1978) studied Charolais x Angus x Hereford and Angus x Angus x Hereford steers and reported that fat increased and lean decreased as a proportion of carcass weight over time but was only significant after 360 kg live weight. However, Guenther et al. (1965) reported that a high energy diet deposited lean faster than a moderate energy

diet. They also noted that the energy level of a diet had no effect on the weight of carcass lean on a constant carcass weight basis.

Arthaud et al. (1977) noted no significant dietary energy effect on separable lean of the 9-10-11th rib section when high and medium levels of dietary energy were compared. Feed restriction from 220 kg live weight up to 590 kg had no significant effect on separable muscle at constant slaughter weights (Trenkle et al., 1978).

Fat. Fat is reported by Boggs (1979) to be the latest developing of all tissues. Boggs stated that there are four sites that fat is deposited in the body: subcutaneous, internal (KHP), intermuscular, and intramuscular (marbling). He states that internal fat is the earliest developing and that intramuscular fat is the latest developing.

Many researchers including Wanderstock et al. (1948), Zinn et al. (1963), Henrickson et al. (1965), Waldman et al. (1971), Prior et al. (1977) and Ferrell et al. (1976b) have reported an inverse relationship between fat and water.

Arthaud et al. (1977) fed Angus calves on high and low energy levels and reported no significant separable fat differences in the 9-10-11th rib section due to nutritional treatment. Jesse et al. (1976b) fed four ratios of corn to corn silage from 227 to 545 kg live weight. They noted no empty body or carcass fat differences due to diet energy level when slaughtered at constant weight. Trenkle et al. (1978) reported no significant effect of feed restriction on carcass fat of Angus x Angus x Hereford and Charolais x Angus x Hereford steers at constant weight after 220 kg. Also, Callow (1961) reported that nutritional treatments had no effect on subcutaneous fat at constant weight. However, Utley et al. (1975) and Bidner et al. (1978) both found an increase in separable fat over the rib eye for steers on high energy or high grain diets compared to all-forage diets.

Callow (1961) claimed that nutritional treatments had no effect on the distribution of fat into the four depot areas. However, Skelly et al. (1973) reported that vitamin A supplementation increased the internal fat (KHP) of Angus and Hereford steers after 140 days-on-feed.

Protein. Forrest (1975) reported that as a percent of body weight, total protein declines about 7.5% on full feed, but changes very little when animals receive a restricted diet.

Guenther et al. (1965) fed Hereford calves and noted that protein deposition followed the muscle deposition curve but was smaller in magnitude over a 0 to 205 kg postweaning gain.

Over a feeding period of 0 to 270 days with slaughter at 30 day intervals, Zinn et al. (1963) reported a decrease in percentage of protein with time-on-feed. However, Waldman et al. (1971) reported an increase in percentage of carcass protein until 227 kg live weight, then it started to decline. The latter authors studied Holstein steers slaughtered from 91 to 590 kg live weight.

Ferrell et al. (1978b) also noted from feeding British breeds of cattle that lighter beef carcasses have higher protein levels as compared to heavier carcasses (due to less fat and less time-on-feed).

High dietary energy has been reported to decrease protein as a percentage of the beef carcass (Waldman et al., 1971; Ferrell et al., 1978b; and Prior et al., 1977). This is due to an increase in percentage of carcass fat. Crouse et al. (1978) reported that a high energy diet for lambs slaughtered at four weight endpoints significantly reduced protein levels as a percentage of body weight. However, Jesse et al. (1976a) and Arthaud et al. (1977) reported nonsignificant effects of nutrition on the protein percentage in the beef carcass. Henrickson et al. (1965) reported that protein deposition efficiency (unit of feed protein per unit of carcass protein) was

reduced on a high energy diet involving Hereford steers slaughtered after 400 kg feedlot gain. They theorized that protein deposition tends to favor the slower gaining animals.

Research tends to indicate that bone increases very slowly, muscle intermediately and fat very rapidly in weight as animals are fed a finishing diet. A high dietary energy content tends to increase fat but adequate nutritional regimens otherwise have little effect on bone or muscle. Protein deposition as a percent of body weight follows the lean deposition curve, on a smaller magnitude.

Diet Effects on Palatability

Tenderness. Tenderness is described by Webster (1975) as having a soft or yielding texture; easily broken or cut; easily chewed. Methods of estimating tenderness in the meat industry have mainly been by the Warner-Bratzler shear (WB shear) or by trained taste panels.

Bowling et al. (1977) reported, from comparing forage and grain finished steers slaughtered at equal maturity, that 8.9 mm was the minimum fat thickness to prevent cold shortening. They also noted that beyond 10.2 mm, no increase in tenderness occurred. Bowling et al. (1978) reported that 7 mm of fat thickness increased taste panel tenderness and decreased WB shear force values over lesser fat thicknesses in a study he conducted using combinations of grass and grain on Santa Gertrudis steer calves.

By varying the energy intake to study the effect of full feeding versus slow feeding (1.3 kg vs .89 kg ADG), Matthews et al. (1962) found that for cattle less than 18 months of age, preslaughter rates of gain and feed treatments have little, if any, effect on WB shear force.

No effect of nutrition on WB shear force was found by Hendrickson et al. (1959) when feeding weanling steers rapidly (.89 kg ADG), moderately (.69 kg

ADG), or combinations of the two for 182 kg of feedlot gain.

Prior et al. (1977) fed three dietary energy levels (2.9, 3.1, or 3.2 Mcal ME/kg DM) and three dietary protein levels (10, 11.5, and 13%) to small type and large type steers and slaughtered them at approximately equal carcass compositions. They found that dietary energy and dietary protein had minimal effects on WB shear forces. Cover et al. (1956) worked with Hereford and Hereford x Brahman steers fed on either 35 or 70% concentrate (and hay) and slaughtered on a time constant basis. They found no effect of diet on tenderness (WB shear or taste panel) for loin steaks or bottom round steaks. Henrickson et al. (1965) fed combinations of high and medium dietary energy for constant weight gains in Hereford steers and reported no differences in taste panel tenderness.

By studying the effect of increased age and three nutrient intake levels in young cattle, Wellington et al. (1954) found no nutrient effect on tenderness.

Bond et al. (1972) found that a high level of nutrition (75% concentrate) prior to 180 days of age increased tenderness over a low level of nutrition (hay to 5/6 slaughter weight followed by high concentrates) when fed to cattle slaughtered at 50 to 60% of their mature weight.

By decreasing time on pasture (133 days to 0) and increasing time on a higher energy finishing diet (98 to 266 days on a 60% forage diet), Smith et al. (1977) increased taste panel tenderness and decreased WB shear force values. These authors also found that if adjusted to constant 4% LD lipid or constant LD weight that no taste panel differences in tenderness were present but that WB shear force differences remained significant.

McCartor et al. (1978) noted that steers fed grain for 56 days after 145 days grazing on wheat, oats, and ryegrass pasture were more tender as com-

pared to steers slaughtered immediately after 145 days grazing.

Harrison et al. (1978) and Bowling et al. (1978) also found that grass-fed cattle were less tender than grain-fed cattle.

A significant increase in LD taste panel tenderness after 150 days-on-feed that was not present at 270 days on feed was reported by Zinn et al. (1963). The cause of this effect was not explained.

Hedrick et al. (1969) compared feedlot performance of steers and heifers and reported a slight increase in taste panel tenderness with feeding 148 days as compared to 87 days. However, he also noted no WB shear force differences.

By feeding Angus and Hereford cattle from 139 to 251 days, Epley et al. (1968) reported that taste panel tenderness and WB shear values were unaffected by time-on-feed. And Reagan et al. (1976) found by studying cattle of three age groups (305 to 1033, 1332 to 2927, and 3635 to 9828 days), that there were no differences in shear force or taste panel tenderness between groups. However, for individual animals, increasing actual age increased WB shear force values and decreased percentage of moisture and soluble collagen. They reported that actual age and total collagen are the most important variables affecting LD tenderness. In addition, they found no relationship between sarcomere length and tenderness.

Arthaud et al. (1977) fed Angus bulls and steers a high or low energy diet and slaughtered them at four age endpoints (12, 15, 18 and 24 months). They found a decrease in WB shear values for the high energy diet and that slaughter age had no effect on tenderness. Moody et al. (1970) also found no differences in WB shear and taste panel tenderness at 28, 84 and 112 days-on-feed for Angus yearling steers.

Skelley et al. (1973), from work with Angus and Hereford steers fed six

diets of varying energy and vitamin A supplementation, reported little relationship between diet and measurements of tenderness (WB shear).

In summary most researchers have reported minimal effects by diet on taste panel tenderness. Any differences that have been reported have been from work comparing grain feeding and all-forage diets.

Juiciness. Webster (1975) defines juiciness as having much juice; the liquid or moisture contained in something.

By studying cattle of 305 to 9828 days of age, Reagan et al. (1976) reported that no significant taste panel differences for juiciness were present by group. However, they found that higher quantities of total collagen had a significant association with higher taste panel ratings for juiciness. They also reported that sarcomere length was negatively correlated with juiciness.

Hedrick et al. (1969) fed steers and heifers for 49 or 98 days and time-on-feed had no effect on juiciness.

Harrison et al. (1978) and Bowling et al. (1978) found that all grass-fed cattle were higher in taste panel juiciness scores than all or partial-fed grain cattle.

By decreasing time on pasture and increasing time on a higher energy finishing diet, Smith et al. (1977) noted that juiciness increased.

Research still appears inconclusive as to the role of the diet on juiciness as evaluated by trained taste panels.

Flavor. Flavor is described by Webster (1975) as being the blend of taste and smell sensations evoked by a substance in the mouth.

Various combinations of grass and grain were studied by Harrison et al. (1978) with crossbred steers, and they found that flavor of fat increased with time on grain.

Comparing feeding periods of 28 to 112 days, Moody et al. (1970) found that there was significantly less flavor for 28 days-on-feed by taste panel scores than other days-on-feed endpoints. Smith et al. (1977) also found, by decreasing time on pasture and increasing the feeding period on a high energy diet, that taste panel flavor scores increased. On the other hand, extending the feeding period from 87 to 148 days, Hedrick et al. (1969) found no effect on flavor.

Epley et al. (1968) noted from cattle fed 139 to 251 days that feeding beyond 139 days didn't result in consistent increases or decreases in flavor intensity or desirability or in overall desirability.

Harrison et al. (1978), Bowling et al. (1978), and Brown et al. (1979) all reported that grass-fed cattle were lower in flavor. However, Harrison et al. (1978) found that forage-fed (40% corn silage) and long-fed (98 days) cattle were higher in taste panel flavor scores than short-fed (49 days) or grass-fed.

In summary, flavor tends to increase with time-on-feed. The point where increases cease to be of statistical and economical importance has not been precisely determined yet.

Effects of Accelerated Cattle Production on Feedlot Performance

Introduction. Accelerated feeding systems have generally been used to decrease the time from birth to slaughter. Accelerated feeding systems research has generally been done to study effects on ADG, F/G, quality and yield grades, and palatability traits. Accelerated feeding has been compared to conventional backgrounding followed by concentrate feeding in a drylot until slaughter.

Accelerated feeding systems research has consisted of two types; reducing or eliminating the backgrounding phase as compared to a conventional

system, or comparing high and medium energy levels for cattle on an accelerated feeding system.

Effect of Elimination of Backgrounding Phase. Guenther et al. (1965) found by feeding steer calves under two planes of nutrition with three slaughter weight endpoints, that 87% of skeletal growth had occurred before weaning. They also found no difference in skeletal development postweaning when comparing a high and medium level of nutrition (.91 and .77 kg gain per day). This disagrees with Lancaster et al. (1973) who found greater structural growth (by measurements of height at the withers) in the first 76 days-on-feed by accelerated cattle which were gaining .24 kg per day. The first 76 days corresponded to the backgrounding period for the conventional cattle. They reported no differences in structural growth by the end of the finishing feeding period.

Several researchers have found that certain weight gains are of significance when studying carcass composition. The majority of lean was produced by the end of a 205 kg postweaning weight gain (86% for accelerated cattle on a high nutritional regimen and 78% for a medium level of nutrition) according to Guenther et al. (1965) in a study using Hereford steer calves.

A mild nutritional restriction from 227 to 509 kg live weight did not influence muscle growth according to Suess et al. (1969). They did find a nutritional effect on the LD muscle, however.

Lancaster et al. (1973) found that accelerated cattle gained .24 kg per day faster for the first 76 days than cattle backgrounded for 76 days. However, over an entire feeding period of 152 days there was no difference in ADG, primarily because of better feedlot performance for the conventional cattle the second 76 day period when they consumed 1.36 kg more feed per day than the accelerated cattle.

Harris et al. (1979) also found that accelerated cattle (Hereford steer calves) gained faster on a high energy diet the first 87 days than those on a moderate energy diet (60:40 and 40:60 corn to corn silage respectively); Marchello et al. (1979) reported an increase in ADG for accelerated calves over yearlings when both were fed three levels of concentrate (45, 57 and 75%). However, Zimmerman et al. (1966) found no difference in ADG between accelerated and conventionally fed Hereford steers when adjusted to a constant yield grade.

Carcasses of Santa Gertrudis calves from regimens of greater concentration of energy (fattening diet in drylot vs sorghum silage in drylot or combinations of backgrounding with grass and/or grain) were heavier, fatter and had a greater muscle mass (Bowling et al., 1978). This agrees with the conclusion of White et al. (1969) who stated that postweaning ADG of accelerated steers increased with increased dietary energy. However, Lasley et al. (1973) found that accelerated feeding increased ADG over the entire feeding period when comparing long-fed (backgrounded on pasture for 134 days and fed concentrate for 139 and 195 days) and short-fed (full-fed for 180 and 257 days after weaning).

No difference in ADG over an entire feeding period was found by Ferrell et al. (1978b) when he compared accelerated cattle on a high compared to a medium nutritional regimen. Stringer et al. (1968), when comparing accelerated cattle at different times (Hereford steer calves slaughtered at 139 to 251 days-on-feed), noted that ADG tended to decline and dressing percent tended to increase with time-on-feed.

Smith et al. (1976) explained this decrease in gain by stating that on an age constant basis, more rapid gaining animals are more efficient, but this is tempered somewhat by increasing maintenance requirements.

ADG is influenced by a number of variables according to Koch et al. (1963) who explained that differences in ADG are influenced 38% by genetic differences in feed efficiency, 35% by genetic differences in feed consumption and 37% by environmental factors.

Feed Efficiency. Accelerated cattle gained significantly faster and were more efficient due to the increased maintenance requirements of the backgrounded conventional steers (Myers et al., 1979). Lancaster et al. (1973) found that accelerated steers were more efficient over the entire 152 day feeding period as compared to conventionally fed steers (.52 kg of feed per kg of live weight gain more efficient).

Koch et al. (1963) explained that once maintenance requirements are met, increasing increments of feed consumption would be expected to result in proportionate increases in gain, provided that there are no changes in composition of gain and/or efficiency of feed use.

Smith et al. (1976) also found that composition of gain can influence efficiency. They reported that the number of days to reach 5% LD fat (low Choice equivalent) accounted for 74% of the variation in efficiency.

Interestingly, Myers et al. (1979) found that traditional type cattle were more efficient on a conventional feeding system while a later maturing type of cattle were favored on the accelerated feeding system.

Accelerated Cattle Production Effects on Carcass Characteristics

Hot Carcass Weight. Carcasses from steers on an accelerated feeding system were slightly heavier (55 kg), and had significantly more fat over the 12th rib (.30 cm), and were higher in quality grade and marbling score compared to conventionally fed cattle when fed on a time constant basis (Lancaster et al., 1973). However, Marchello et al. (1979) reported that conventional cattle

tended to be heavier than accelerated calves when both were finished at 1.02 cm fat thickness.

Hot carcass weights increased with increased dietary energy intake on an accelerated feeding system according to Ferrell et al. (1978b). Stringer et al. (1968) correlated an increase in slaughter weight and hot carcass weight for accelerated cattle with length of feeding.

A high level of nutrition will increase ADG over the feeding period (and thus hot carcass weight) according to Guenther et al. (1965).

Marchello et al. (1979) found a tendency for dressing percent to increase with higher concentrate intake. They also found that accelerated cattle at similar slaughter weights tended to be about 1% higher in dressing percent than conventional cattle.

Fat Thickness. An increase in fat thickness will occur at the 12th rib with increased energy concentration and increasing time-on-feed. However, Zimmerman et al. (1966) noticed a .51 cm decrease in fat thickness for accelerated as compared to conventionally fed cattle.

Longissimus Area. Most researchers have found that LEA increased with time and was not influenced by adequate nutritional regimens. However, Zimmerman et al. (1966) noted a three cm² increase for accelerated cattle when compared to conventionally fed cattle slaughtered at an equal quality grade.

Suess et al. (1969) found that accelerated cattle on a medium level of nutrition had larger LEA's than those on high nutritional levels when fed to a constant live weight. However, the LD was the only muscle affected by the increased length of feeding on the medium level of nutrition.

Carcass Composition. No differences occurred in carcass composition or specific gravity between accelerated and conventionally fed cattle (Lancaster et al., 1973).

Dinkel et al. (1969) reported that the rib, loin, round, chuck, and other parts of the carcass grew at the same relative rate (trimmed weights as compared to carcass weight) from 216 to 307 kg. Therefore, up to 307 kg we should find no variation in proportions of these wholesale cuts on an accelerated feeding regimen. It's also possible that this influence extends to carcasses of greater weights. However, Marchello et al. (1979) found that accelerated calves generally had 3% more lipid, less moisture and bone, and about the same amount of protein when fed to 1.02 cm fat thickness.

Carcass Yield and Cutability. Accelerated cattle that graded high Choice averaged 5.5% lower in retail yield (% of carcass weight) than cattle on a conventional system that graded average Choice and averaged .51 cm greater fat thickness (Zimmerman et al., 1966). However, when comparing accelerated and conventionally fed cattle at constant fat thickness, Marchello et al. (1979) found a tendency for accelerated cattle to yield slightly higher percentages of retail cuts.

Almost no difference in percent yield of primal cuts occurred when dressing percent is considered when comparing accelerated and conventionally fed cattle (Bowling et al., 1978). Dikeman et al. (1979) reported a higher percentage retail product with accelerated steers when compared to conventionally fed steers.

Accelerated cattle had heavier trimmed retail cuts on a weight constant basis according to Dinkel et al. (1969), when he compared them to conventionally fed cattle, regardless of the rate of gain from 300 to 600 kg. Lancaster et al. (1973) reported a cutability value of .72% higher for conventionally fed Angus cattle (76 days on a grower diet) when both conventional and accelerated cattle were fed for 194 days.

Accelerated Cattle Production Effects on Palatability Traits

Lancaster et al. (1973) reported no differences between accelerated and conventionally fed cattle as measured by the Armour tenderometer. No differences between accelerated and conventionally fed cattle were found by Myers et al. (1979) when comparing palatability by taste panel or tenderness by use of the Warner-Bratzler shear. However, Dikeman et al. (1979) reported lower LD and SM shear values, higher taste panel overall tenderness, less detectable connective tissue, and higher flavor scores for accelerated when compared to conventionally fed crossbred steers.

Bowling et al. (1978) noted an increase in shear force for conventionally fed steers (backgrounded on rice straw and prairie hay until yearlings, then fed grain in drylot for 225 days) as compared to accelerated cattle (fed in drylot for 125 or 225 days).

Marchello et al. (1979) found no difference between accelerated and conventionally fed steers when fed on three levels of concentrate and slaughtered at 1.02 cm fat thickness. There was no difference by concentrate level for taste, tenderness, moisture or lipid content of the carcass. However, they did find a 23 to 25% increase in ratings of tenderness for rib steaks on a low (45% concentrate) as compared to high (75% concentrate) diet. This was reversed on rump or chuck roasts.

Effects of Electrical Stimulation on Carcass and Palatability Traits

Effects of ES on Palatability Traits. Chrystall and Hagyard (1975) reported that electrical stimulation (ES) reduces cold shortening. Carse (1973) found that ES before early freezing causes a significant reduction in toughening as measured by a tenderometer in lamb carcasses.

By studying two groups of cattle ranging from 52 to 107 kg and from 148

to 206 kg, Grusby et al. (1976) found a significant increase in tenderness (taste panel and WB shear) from ES when comparing paired ES and nonelectrically stimulated (NES) LD and semitendinosus (ST) muscles. Davey et al. (1976) found a tendency for stimulated fast chilled (2 C) sides from Angus x Hereford steers to be more tender in LD and SM taste panel scores than NES slow chilled (10 C) sides. The latter also found no differences in juiciness between ES and NES samples.

Low voltage stimulation (110 V, 90 sec) of Hereford steers reduced WB shear values from the SM, ST, deep pectoral, and triceps brachii muscles in a study by Bouton et al. (1978). However, they reported a decrease in juiciness by ES. Savell et al. (1977), Davey et al. (1976) and Gilbert and Davey (1976) found no differences between ES and NES treatments in taste panel tenderness for the SM muscle.

Effect of ES on Grading. Savell et al. (1978) stimulated carcasses for .5 to 1 sec duration at 1 sec intervals for 25, 50 or 75 impulses (100 V, 5 amp, 50-60 cycles). Carcasses were ribbed at 24 hr and little or no effect on marbling or quality grade was reported for 25 or 50 impulses. However, at 75 impulses there was a slight improvement in quality grade over control sides.

ES had no significant effect on grade in a study by Cross et al. (1980) comparing Good or Choice paired sides that had been ribbed at 48 hr. These sides had been stimulated four times per minute for three minutes (150-400V, 1.5 amp, 60 Hz). Cross et al. (1979) also reported ES had no effect (1.5 amp, 60 Hz) on quality grade.

Effect of ES on Lean Maturity. Savell et al. (1978) stated that the greatest positive effect of ES was in improving lean maturity score. An improvement in lean maturity by ES was also reported by Cross et al. (1980). How-

ever, Cross et al. (1979) reported that lean maturity was unaffected by ES.

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MATERIALS AND METHODS

Sixty-four large type crossbred steers, from 7/8 Simmental x 1/8 Hereford or 1/8 Angus sires mated to crossbred dams, were purchased from the R. L. Hruska US Meat Animal Research Center at Clay Center, Nebraska and delivered to the Kansas State University Beef Research Unit. At the date of delivery the spring dropped steers were approximately eight months of age and averaged 265 kg.

The steers were randomly allotted to 12 pens at the time of arrival. Nine pens containing 48 cattle were assigned to the Accelerated (Acc) feeding regimen which did not include a growing period, and the remaining three pens containing 16 cattle were assigned to the Conventional (Conv) feeding regimen which included a growing period followed by a finishing period.

Weights were recorded individually for cattle at 28 day intervals before the morning feeding throughout the trial with the exception that the first two weight periods were of 14 day intervals, and the last weight period varied slightly from 28 days due to scheduling of slaughter in the Kansas State University meats laboratory.

During the trial, cattle were fed twice daily and their consumption by pen monitored to maintain ad libitum feeding. Feed samples of forage sorghum silage (FSS) were taken frequently to determine the amount of dry matter present. For corn and soybean meal (SBM), an NRC (1976) book dry matter values was used (89% for both); for the protein and mineral supplement (Suppl.) a constant dry matter value was used throughout the feeding period. The diet was balanced to meet NRC (1976) requirements.

Upon arrival the Acc cattle were placed on a 13 day adjustment diet (Period 1, table 1). On day 14 cattle were placed on the Period 2 diet. The first two feeding periods had diets which varied greatly from their initial and final period diets due to a continuous change to a higher concentrate

TABLE 1. DIET COMPOSITIONS FOR ACCELERATED-FINISHING,
CONVENTIONAL-GROWING, AND CONVENTIONAL-FINISHING PERIODS

Ingredients	Int. Ref. No.	Acc- Finishing, Period 1	Acc- Finishing, Period 2	Acc and Conv Finishing, Period 3	Conv- Growing, Period 4	Conv-Pre- Finishing Adjustment, Period 5
Diet Composition ^a		%	%	%	%	%
corn, dent yellow, grain, gr 2 US	4-02-931	12.8→52.6 ^b	52.6	73.8	12.8→26.3 ^b	24.0→39.5 ^b
sorghum, grain variety, aerial part, w heads insiled	3-07-962	85.0→41.5 ^b	41.5	21.0	85.0→67.5 ^b	70.0→35.0 ^b
soybean, seeds meal solv-extd.	5-04-604	2.2→1.4 ^b	1.4	0.0	2.3→4.7 ^b	4.5→1.8 ^b
Supplement						
A ^c		0.0→4.5 ^b	4.5		0.0→1.5 ^b	1.5→3.6 ^b
B ^d				5.2		
Days within a period		13	45	—	110	23
NE _M ^e		1.4→1.7 ^b	1.7	1.9	1.4→1.5 ^b	1.5→1.8 ^b
NE _P ^f		.7→1.0 ^b	1.0	1.2	.7→.8 ^b	.8→1.1 ^b

^a Ingredients are listed on a percent dry matter basis

^b Within a period, the percentage of roughage was decreasing and percentage of concentrate was increasing.

^c Contained 42.8% crude protein, 1.9% calcium, 1.4% phosphorous, and supplied 200 mg of Rumensin per steer daily

^d Contained 40.4% crude protein, 1.8% calcium, 1.2% phosphorous, and supplied 200 mg of Rumensin per steer daily

^e Mcal NE_M per kg

^f Mcal NE_P per kg

diet. Cattle were fed on the Period 2 diet until they were placed on a higher concentrate, Period 3 diet. The SBM portion of the diet was decreased because of decreasing protein requirements as the feeding period progressed.

For evaluation of energetic efficiency ($\text{Mcal NE}_p/\text{kg}$), actual weights were quadratically regressed to a best fit curve (Lipsey *et al.*, 1978). The feed was assigned a NE_M and NE_p value by use of NRC (1976) book values for ingredients. Energetic efficiency was accumulated over time by use of the regressed weights and NE_M and NE_p book values of the feed.

The first of the three slaughter endpoints for Acc cattle was designated as 449 kg. The remaining two endpoints were planned at 57 kg intervals from the first endpoint. Slaughter for the Conv fed cattle was planned to be at a comparable final slaughter weight of the last Acc group of cattle and occurred at 591 kg.

Acc-III and Conv weights were chosen to simulate weights in which this type of cattle would be slaughtered by the industry, and would grade a high percentage of choice. Acc-I steers were to be slaughtered at a weight to simulate the "hamburger steer" and/or at a quality grade of low Good. Acc-II cattle were to be slaughtered at a weight midway between Acc-I and Acc-III cattle.

Two cattle which became ill and showed severe performance reduction were removed from the study.

At slaughter, after carcasses were split into sides, one side was randomly assigned to an electrical stimulation (ES) treatment and the other side served as a unstimulated control (C). ES sides were pulse stimulated (1.6 sec on, .8 sec off) for 2 min at 45 min after bleeding using 400 V, 60 Hz AC current with 6 to 8 amps delivered to the carcass with approximately 1 amp going thru the carcass. A Cervin hog stunner model no. SSR was modified for the electrical stimulation.

Core (1.27 cm samples for pH determinations were excised from the LD (opposite the 5th lumbar vertebrae) and SM (2.5 cm above the aitch bone) muscles at 45 min (prior to stimulation), at 4 hr postmortem. One to 2 g of muscle were blended with 10 ml of 5mM NaIAC in 150 mM KCl (Bendall, 1973). The pH of the meat slurry was read on a Corning digital pH meter equipped with an Orion gel filled combination electrode.

USDA yield grade (YG) and quality grade (QG) data were collected after chilling at 5 C for 24 hr. Quality grade was evaluated at 24 hr and 48 hr postmortem and the higher marbling score was used for statistical analysis. In addition, soft tissue of the 9-10-11th rib section was used to estimate carcass chemical composition (Hankins and Howe, 1946). The inside round and strip loin were removed at 48 hr, cut into 2.5 cm thick semimembranosis (SM) and longissimus (LD) steaks and vacuum packaged. These steaks were aged six days at 2 C before being frozen and stored at -26 C until subsequent sensory evaluation. Maximum frozen storage time for the shear steaks obtained from sides in the four slaughter groups was 50 days. Random selections of taste panel steaks from the four slaughter groups and two treatments were made prior to cooking. Random selection of the steaks was designed to eliminate any storage period differences between the slaughter groups since the maximum amount of storage time was 10 months.

Both sensory panel and shear steaks for C and ES treatments were thawed for 18 hr at 2 C prior to cooking. Steaks were trimmed to .25 cm subcutaneous fat thickness and modified oven broiled in a 163 C oven to an internal temperature of 70 C monitored by thermocouples. Taste panel and shear samples were taken perpendicular to the steak surface by use of a drill press equipped with a 1.27 cm diameter coring device and kept warm in small double broiler pans filled with warm water. Six cores were taken from each shear steak and sheared once using the Warner-Bratzler shear apparatus. Shear force

readings were recorded as peak force values. An eight member trained taste panel was used to evaluate steaks for flavor, myofibrillar tenderness, connective tissue amount, juiciness, and overall tenderness according to AMSA Guidelines for Cookery and Sensory Evaluation of Meat (1978).

Data were analyzed by least squares analysis of variance and corresponding F tests. Means were separated with least squares (Snedecor and Cochran, 1978). The analysis was performed by using the General Linear Models procedure on the Statistical Analysis System (SAS User's Guide, 1979).

RESULTS AND DISCUSSION

Our study was designed to evaluate the effect of Accelerated (Acc, finishing diet only) and Conventional (Conv, growing-finishing) feeding on cattle performance, carcass and palatability characteristics. We also evaluated electrical stimulation (ES) and its effects on meat quality of Acc or Conv cattle. In addition, we evaluated cumulative partial efficiency on a weigh-period basis to consider its relationship to carcass composition.

Acc and Conv feeding effects on production. The Acc cattle were on feed for 139, 178 and 242 days, respectively. The Conv cattle were on feed 284 days of which 110 days were the growing phase, 23 days the adjustment phase and 151 days the finishing phase diet. (figure 1).

It is not surprising that Acc slaughter weights and total gains were different ($P < .05$) between slaughter groups because our study was designed such that Acc-III and Conv cattle were to be slaughtered at 568 kg and the other two Acc slaughter groups at designated weights. However, due to unavoidable scheduling conflicts in the Kansas State University meats laboratory, Acc-III and Conv cattle could not be slaughtered at the same weight endpoints as designed.

There were no differences ($P > .05$) between the Acc-I, Acc-II or Acc-III cattle and the Conv cattle in overall ADG (table 2). However, the Acc cattle tended ($P > .05$) to increase in overall ADG between Acc-I and Acc-II (1.15 to 1.23 kg per day) but not between Acc-II and Acc-III (1.28 and 1.24 kg per day). Conv cattle had the same overall ADG as Acc-I cattle (1.15 and 1.15 kg per day). Lancaster et al. (1973) reported no difference in ADG between Acc and Conv cattle over a feeding period of 156 days due to an increased intake and performance by Conv cattle over the second half of the feeding period. Harris et al. (1979) also reported no difference in ADG be-

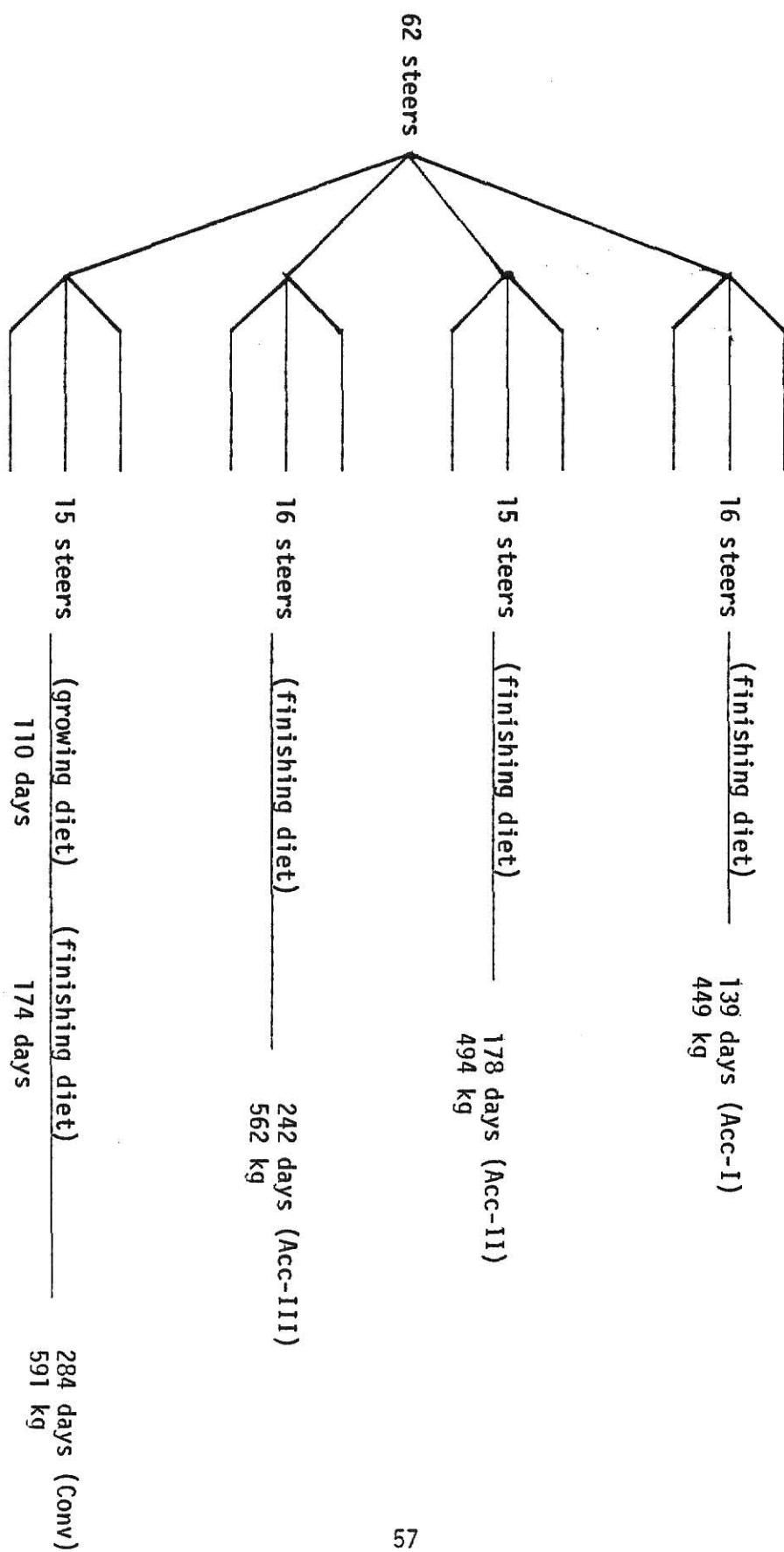


FIGURE 1. Accelerated and Conventional Feeding Regimens

TABLE 2. EFFECTS OF ACCELERATED AND CONVENTIONAL
FEEDING ON CATTLE PERFORMANCE

	Accelerated			Conventional- Overall	Conventional- Finishing
	I.	II.	III.		
N	16	15	16	15	15
Starting weight, kg	266.1	266.0	262.7	266.1	360.8
Final weight, kg	449.0 ^c	494.4 ^d	562.3 ^e	591.3 ^f	591.3
Total gain, kg	182.9 ^c	228.4 ^d	299.6 ^e	325.2 ^f	230.5
Days on feed	139 ^c	178 ^d	242 ^e	284 ^f	174
Total DM intake, kg	1033 ^c	1473 ^d	1946 ^e	2324 ^f	1618
F/G, DM basis					
Overall	5.7	6.5	6.5	7.1	
Overall ^b	5.7	6.5	6.5		7.0
139 days to slaughter		6.8	7.4	6.8	
ADG, kg/day					
Overall	1.15	1.28	1.24	1.15	
Overall ^b	1.15	1.28	1.24		1.34
139 days to slaughter		1.43 ^b	1.16 ^a	1.36 ^b	
cumulative ^a partial efficiency	6.35 ^{cd}	6.23 ^c	6.88 ^d	5.75 ^c	
cumulative ^{ab} partial efficiency	6.35 ^{cd}	6.23 ^c	6.88 ^d		7.00 ^d

^a Mcal NE_p per kg of gain

^b comparisons of Acc cattle with Conv-finishing cattle

^{cdef} means in same row with different superscripts are different (P<.05)

tween Acc and Conv Hereford steers over a 174 day feeding trial. In our study, the Acc-II steers tended ($P>.05$) to be higher in ADG when compared to to Conv and Acc-III cattle in ADG from 139 days until they were slaughtered. Both Lancaster et al. (1973) and Harris et al. (1979) reported that Acc steers had higher ADG's than Conv steers when compared over the first half of the feeding trial. An ADG decrease over a 139 to 251 day feeding period was also reported by Stringer et al. (1968) for Acc steers but not for Conv steers. Smith et al. (1976) stated that rapidly gaining cattle were more efficient, but gains and efficiency were tempered by increasing maintenance requirements as cattle got heavier.

When we compared Conv cattle over the finishing phase only (Conv-finishing) to Acc cattle there were no differences in ADG ($P>.05$). However, Conv-finishing cattle tended ($P>.05$) to be higher in ADG than the Acc-III cattle. Lancaster et al. (1973) reported that Conv-finishing steers outperformed Acc steers over the last 76 days of a 152 day feeding period.

Overall pen dry matter feed efficiency (total pen DM intake/total pen gain), expressed as F/G, was also not different ($P>.05$) between slaughter groups. This is possibly explained by Koch et al. (1976) who reported that feed efficiency and ADG are highly related. In our study pen overall F/G tended to increase from Acc-I to Acc-II (5.7 and 6.5, respectively) and Conv cattle tended to have a higher pen overall F/G than Acc-III cattle (7.1 vs 6.5, respectively). Myers et al. (1979) and Lancaster et al. (1973) both reported that Acc steers were more efficient than Conv steers. Smith et al. (1976) stated that differences in F/G may be due to fewer days for maintenance and this could possibly account for differences in our data as they found that 88% of the variation was due to days-on-feed when fed to a constant weight. Since Acc-II cattle were depositing more fat than Acc-I cattle, one would expect Acc-II to have higher F/G values since

Smith et al. (1977) reported that composition of gain influences efficiency.

In comparing cattle from 139 days to slaughter, Acc-II and Conv tended ($P>.05$) to have a lower F/G than Acc-III cattle. Smith et al. (1976) explained this as due to days-on-feed.

F/G was not different ($P=.08$) over the entire Conv feeding period compared to the finishing phase only (Conv-finishing). Lancaster et al. (1973) reported that Conv cattle increased dramatically in consumption (2.6 kg per day, in the finishing phase) compared to Acc cattle. However, they did report a slight increase in F/G (.19) by Conv-finishing cattle over Acc cattle. From our data we conclude that F/G did not change appreciably over the Conv feeding period. Smith et al. (1977) reported that F/G didn't vary when diet energy increased from 2.18 to 3.11 Mcal ME/kg. Haskins et al. (1969) noted a tendency for F/G to follow ADG variations. In our study there was no difference between Conv-overall and Conv-finishing in ADG (1.15 and 1.34 kg per day, respectively).

Cumulative partial energetic efficiency, Mcal NE_p per kg of gain. Partial energetic efficiency, Mcal NE_p per kg gain, has been used to estimate carcass composition in previous studies (Lipsey et al., 1977 and Loveday et al., 1980). We studied NE_p efficiency on a cumulative basis over the entire feeding period by subtracting the DM required for maintenance, based on .077 (kg live weight)^{.75}, (Lofgreen and Garrett, 1968), from the DM in the diet and multiplying this times the calculated NE_p (NRC, 1976) table values. This was then divided by the animals' weight gains.

By considering partial energetic efficiency on a cumulative basis we hoped to offset animal or environmental variances between weight periods.

Lipsey et al. (1977) proposed that physiological maturity, as expressed by carcass composition, is highly related to utilization of energy available for growth. They also theorized that carcass composition of steers of differing maturing rates would be similar if fed to the same NE_p efficiency endpoint. We hoped that NE_p efficiency would be an accurate indicator of carcass composition.

Figure 2 shows Acc-I, Acc-II and Acc-III cumulative NE_p efficiency curves. Acc-I follows a curve that generally would be considered a normal NE_p efficiency curve because it tends to increase curvilinearly with time-on-feed. Since the steers were increasing in fatness, and fat requires a higher caloric value per gram produced than muscle (Nehring et al., 1973), it is expected that cumulative NE_p /kg gain would increase over time. However, as Acc-II and Acc-III are considered, we found a rather large amount of initial variance in the curves. In addition, we observed a decrease in cumulative NE_p /kg gain at the end of Acc-II. Normally cattle of similar size and genetic background would be expected to have similar NE_p efficiencies when under similar conditions (Lipsey et al., 1977). By looking at the average Acc cumulative NE_p efficiency curve (figure 3), we observed a slight dip in the curve for points of 139 and 167 days-on-feed. There could have been an underestimation of maintenance requirements due to environmental changes during this time.

The Conv cumulative NE_p efficiency curve (figure 4) was a rather predictable curve. Over the backgrounding phase the steers were being fed relatively low levels of energy above maintenance. Due to a high proportion of muscle growth compared to lipid deposition, it was expected that the lower energy requirement for muscle deposition would decrease NE_p requirements per kg of gain. In addition, Knox and Handley (1973) reviewed the net energy system and reported that under a lowered production level it is possible that

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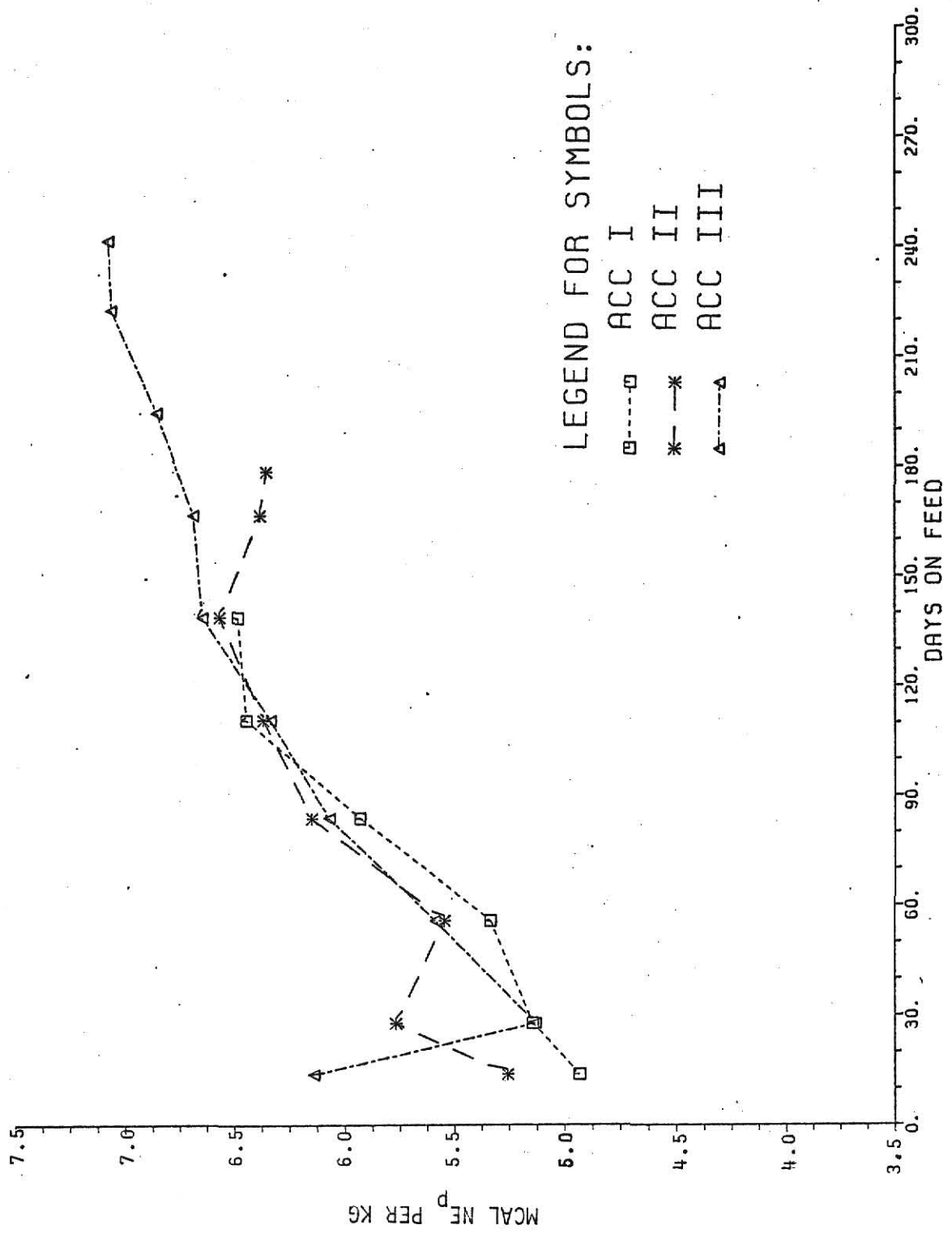


FIGURE 2. Cumulative NE_p Efficiency: Acc-I, Acc-II, Acc-III

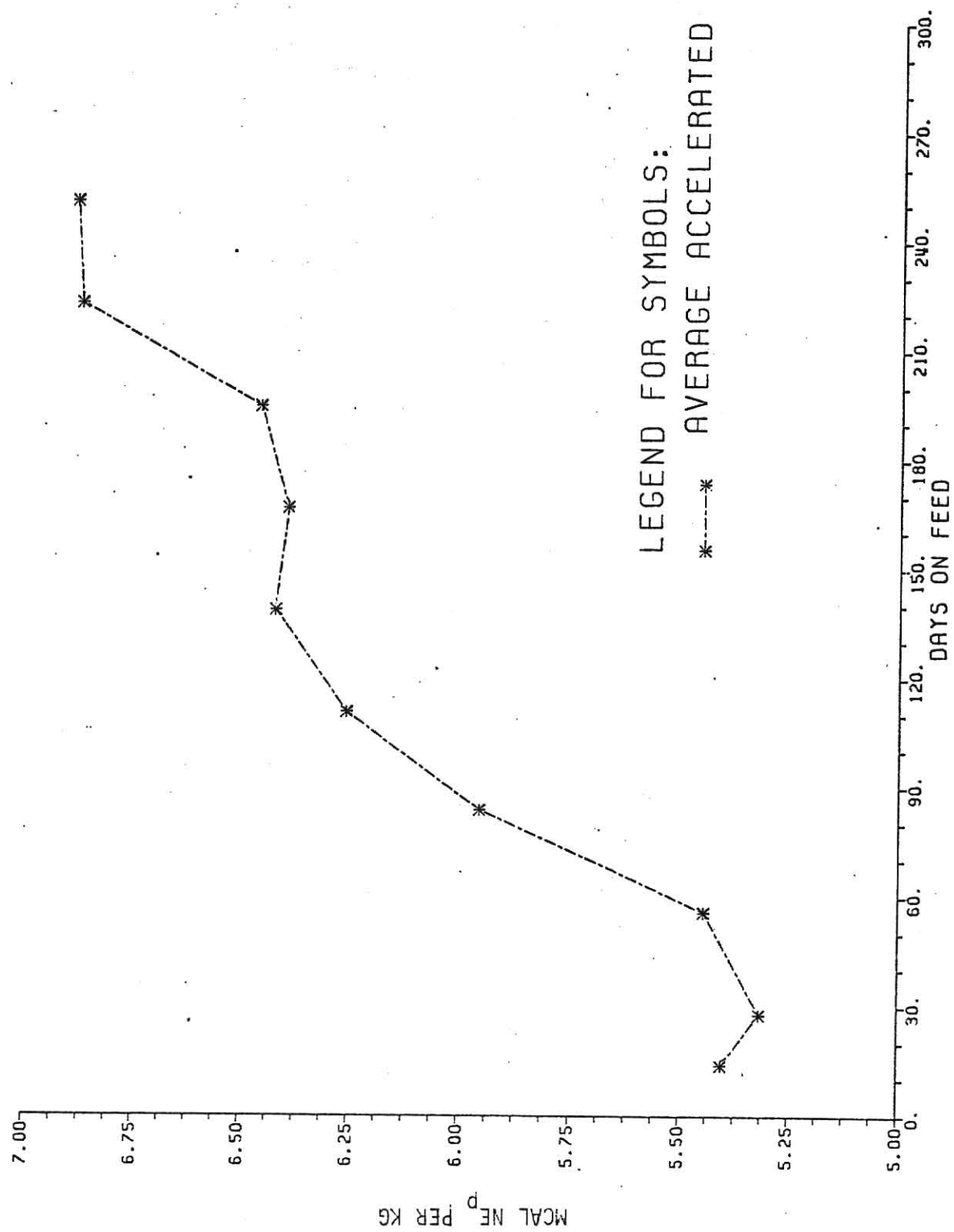


FIGURE 3. Cumulative NE_p Efficiency: Average Accelerated

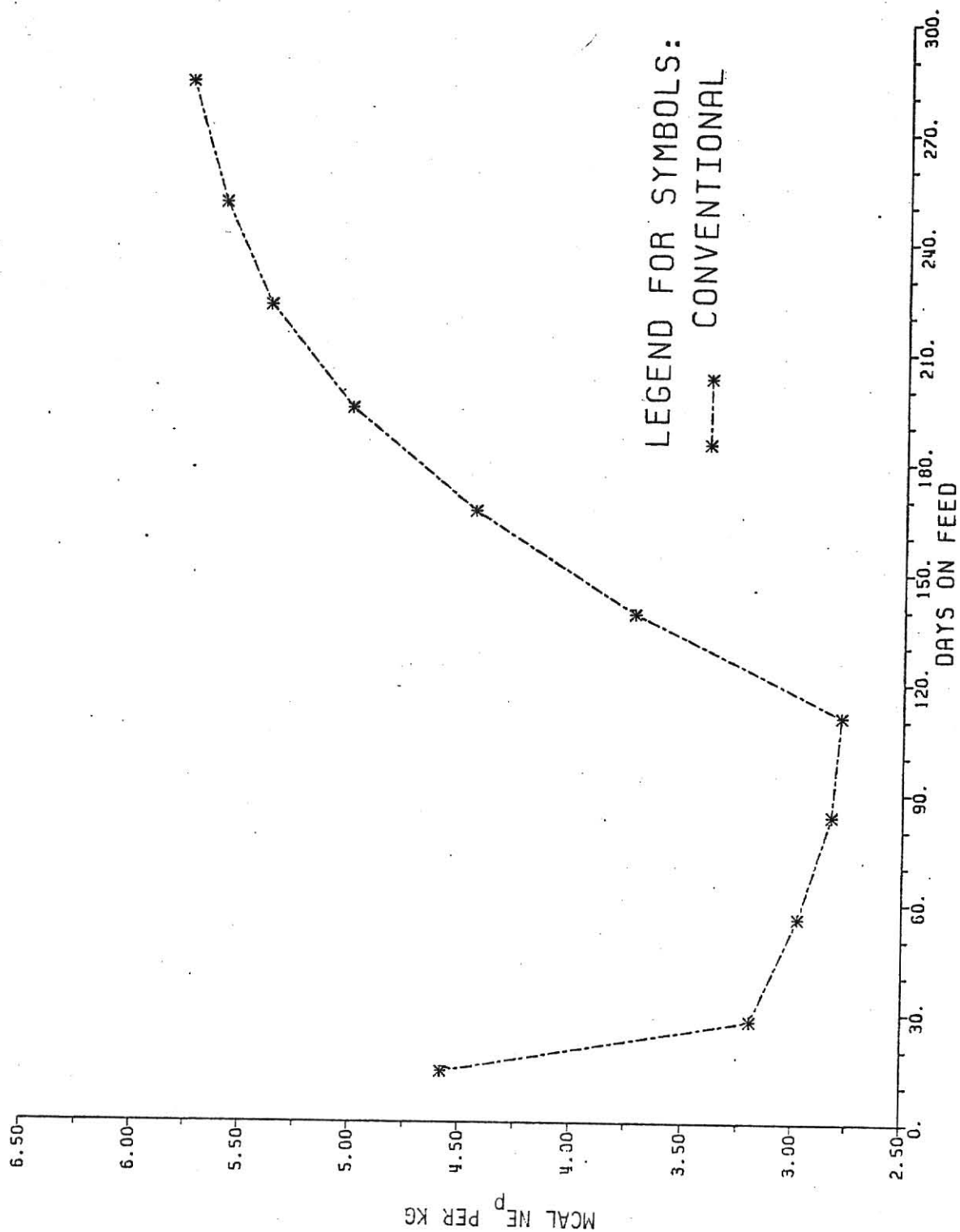


FIGURE 4. Cumulative NE_p Efficiency: Conventional

maintenance requirements are lower than on a high production level. Therefore, it is possible that we understated cumulative available NE_p during the backgrounding phase.

Lipsey et al. (1977) theorized that cumulative NE_p efficiency could be used to predict carcass composition. The major carcass characteristic we wanted to predict was fat (ether extract, yield grade, marbling score, and quality grade). By use of a correlation analysis over all slaughter endpoints, we found that cumulative NE_p efficiency by pen was very poor for predicting carcass composition. Cumulative pen NE_p efficiency correlated very weakly to ether extract in the 9-10-11th rib ($r = .01$), YG ($r = .10$), 24 and 48 hr marbling scores ($r = .01$ and $.05$, respectively), and quality grade ($r = .04$). However, it did show some high relationships to palatability traits such as LD flavor ($r = -.87$), LD myofibrillar tenderness ($r = -.54$), SM juiciness ($r = .88$), SM myofibrillar tenderness ($r = .57$) and SM overall tenderness ($r = .46$). However, these correlations cannot be explained.

Acc and Conv feeding effects on carcass traits. Since average live weight was used to determine slaughter endpoints, and since hot carcass weight (HCW) is highly related to live weight, it was not surprising that HCW was different ($P < .05$) between Acc slaughter groups (table 3). Since live weights between Acc-III and Conv were different ($P < .05$), it was surprising that HCW between them was not different ($P > .05$); however, dressing percents were higher ($P .05$) for Acc-III than for Conv cattle. Jesse et al. (1976) reported that the fastest gaining cattle had the highest dressing percents, which over the entire feeding period in our study tended to be Acc-III when compared to Conv-overall steers. Stringer et al. (1968), Hedrick et al. (1969) and Zinn et al. (1970) all reported that increased fatness increased dressing percent. On that basis, our Conv cattle should have had higher dressing percents be-

TABLE 3. ACCELERATED AND CONVENTIONAL
FEEDING EFFECTS ON CARCASS CHARACTERISTICS

	Accelerated			Conventional
	I.	II.	III.	
HCW, kg	263.0 ^d	310.0 ^e	358.0 ^f	365.0 ^f
dressing percent	59.6 ^d	61.4 ^d	63.5 ^e	60.8 ^d
adjusted fat thickness, cm	.64 ^d	.87 ^e	1.09 ^f	1.24 ^g
KPH, %	2.1	2.2	2.4	2.6
LEA, cm ²	69.94 ^d	75.16 ^e	83.30 ^f	83.55 ^f
YG	2.2 ^d	2.6 ^e	3.0 ^{ef}	3.1 ^f
24 hr marbling ^a	7.1 ^d	7.5 ^d	8.9 ^e	9.2 ^e
48 hr marbling ^a	6.9 ^d	7.5 ^d	9.5 ^e	9.5 ^e
bone maturity ^c	31.2 ^d	37.3 ^e	46.9 ^f	53.8 ^g
lean maturity ^c	31.5 ^d	32.5 ^d	41.9 ^e	45.3 ^e
overall ^c maturity	30.7 ^d	36.4 ^e	44.8 ^f	50.3 ^f
9-10-11 th rib section				
rib wt, kg	4.4 ^d	5.1 ^e	6.7 ^f	6.7 ^f
bone wt, kg	.8 ^d	.9 ^e	1.0 ^f	1.1 ^g
soft tissue wt, kg	3.6	4.2	5.7	5.6
percent water	53.4 ^e	51.8 ^e	47.2 ^d	46.3 ^d
percent ether extract	30.5 ^d	32.0 ^d	37.0 ^e	40.3 ^e
percent protein	16.1 ^e	15.1 ^e	14.0 ^d	13.6 ^d

^a 7= S1-, 8= S1⁰, 9= S1+, 10= Sm-, etcetera

^b 7= St+, 8= G-, 9= G+, 10= Ch-, etcetera

^c percentage within A maturity

^{defg} means in same row with different superscripts are different (P<.05)

cause they were fatter (highest 24 hr marbling; kidney, heart and pelvic fat (KPH); and adjusted fat thickness). No explanation can be offered for the difference in dressing percents between Acc-III and Conv cattle.

Adjusted fat thickness increased ($P < .01$) from Acc-I to Acc-III, and Conv cattle had a larger fat thickness than Acc-III (1.24 vs 1.09, respectively). KPH fat percentage also tended ($P > .05$) to increase from Acc-I to Conv slaughter groups. Many researchers have found an increase in fat thickness and KPH with an increase in time-on-feed.

LEA also increased ($P < .01$) over slaughter groups. Henrickson et al. (1965), Stringer et al. (1968), Moody et al. (1970), and others have found positive relationships between LEA and days-on-feed. Stringer et al. (1968), Dinkel et al. (1969) and Trenkle et al. (1978) have reported a positive effect of increasing weight on LEA. However, Moody et al. (1970) reported that the increase in LEA was not proportional to live weight.

Since YG is highly influenced by LEA, adjusted fat thickness and KPH, (all of which were significantly effected ($P < .05$) by slaughter group), it is not surprising that YG was effected ($P < .05$) by slaughter group.

Marbling scores were evaluated at 24 and 48 hr. There was an increase in 24 and 48 hr marbling ($P < .01$) by increasing time-on-feed ($r = .55$ and $.65$, respectively). Acc cattle increased in 24 hr marbling over the three slaughter endpoints with Conv cattle tending ($P > .05$) to have higher marbling scores than Acc-III cattle. Acc-I cattle tended to decrease in marbling score between 24 and 48 hrs; Acc-II stayed about the same, and Acc-III and Conv tended to increase between the 24 and 48 hr evaluations. Interestingly, Acc-III cattle increased enough that they were equal to Conv cattle at 48 hr. Stringer et al. (1968), Hedrick et al. (1969), Moody et al. (1970) and others have found a positive relationship between time-on-feed and marbling score, while

Lipsey et al. (1978) and Dinkel et al. (1969) reported a positive effect for weight. Our steers with the highest marbling scores were both heavier and had been on feed longer than steers with lower marbling scores. QG was increased ($P < .01$) by increasing time-on-feed and since QG is highly related to marbling score, it tends to follow marbling score trends. In addition, percentage of Choice carcasses increased with time-on-feed (0, 6, 56, and 61% respectively).

Bone maturity, lean maturity and overall maturity increased ($P < .05$) with slaughter group. Even though Conv cattle were on feed 42 more days than Acc-III cattle, only bone maturity was different ($P < .05$) between them. However, there was a tendency for lean maturity and overall maturity to increase for Conv compared to Acc-III cattle. Since maturity increased with age ($r = .82$) it was not surprising that all maturity values tended to increase over slaughter groups.

9-10-11th rib weight, bone weight, and soft tissue weight were effected ($P < .01$) by slaughter group. Hankins and Howe (1946) reported that the 9-10-11th rib section soft tissue composition can be used to accurately predict carcass composition.

In our study the 9-10-11th rib percentages of water and EE were the same ($P > .05$) between Acc-I and Acc-II and also between Acc-III and Conv cattle (table 3). Percentages of protein decreased ($P < .05$) between Acc-I, Acc-II and Acc-III cattle; however, Acc-III and Conv percentages of protein were not different ($P > .05$). Bowling et al. (1978) reported an increase in EE of Acc cattle by grain feeding. Forrest et al. (1975) stated that as the percentage of lipid in adipose tissue increases, the percentages of water, protein, and other constituents decrease. In our study EE and water were highly related inversely ($r = -.99$) compared to protein and water ($r = .69$) or protein and EE ($r = -.65$).

ES effects on carcass traits. In the LD muscle, ES decreased ($P < .05$) 4 hr pH readings. However, in the SM muscle, ES tended ($P > .05$) to decrease pH. Davey et al. (1976) and many other researchers have reported a more rapid pH decline with ES than nonelectrically stimulated (NES) sides.

Both 24 and 48 hr marbling were enhanced ($P < .01$) by ES (table 4) when all slaughter groups were combined. Since QG is highly related to marbling, QG also was higher ($P < .01$) for ES than for C. Savell et al. (1978b) reported an increase ($P = .15$) in quality grade by ES over NES by using 75 impulses (100 V, 5 amp, 50-60 Hz). Using 25 or 50 impulses they found no improvement from ES on QG. Cross et al. (1979) and Cross et al. (1980) both reported no effect of ES on QG (150 to 400 V, 1.5 amp, 60 Hz).

Bone maturity was not affected ($P > .05$) by ES. However, ES improved ($P < .05$) lean maturity except that Acc-II cattle did not show a strong tendency for improvement in lean maturity by ES. Savell et al. (1978b) and Cross et al. (1980) reported improvements in lean maturity from ES compared to controls. Considering the dramatic improvement in lean maturity from ES it is not surprising that overall maturity, which is related to lean maturity and bone maturity, was improved ($P < .01$).

Overall lean color score was improved ($P < .01$) by ES over C, while lean texture and lean firmness were unchanged ($P > .05$). Lean color has been improved by ES in studies conducted by Smith et al. (1977) and Savell et al. (1978b). Davey et al. (1976) reported no influence of ES on texture of strip loins or SM steaks. Since collagen is the major connective tissue in muscle, if it is affected it could alter texture or firmness. Pierson and Fox (1976) reported no effect on collagen by ES.

Acc and Conv feeding effects on palatability traits. Slaughter group had no effect ($P > .05$) on LD shear force, LD flavor, LD juiciness, LD myofibrillar

TABLE 4. ELECTRICAL STIMULATION EFFECTS ON CARCASS TRAITS

	Accelerated				Conventional			
	I.		II.		III.		Overall	
	C	ES	C	ES	C	ES	C	ES
4 hr LD pH	5.9 ^h	5.4 ^g	6.0 ^h	5.4 ^g	6.0 ^h	5.6 ^g	5.9 ^o	5.5 ⁿ
4 hr SM pH	6.0	5.7	6.0	5.7	6.2	5.9	6.0	5.8
24 hr ^a marbling	6.1 ^g	7.9 ^h	6.2 ^g	8.4 ^{hi}	8.7 ^{hij}	9.7 ^{ij}	7.6 ⁿ	9.1 ^o
48 hr ^a marbling	6.0 ^g	7.8 ^h	6.4 ^g	8.3 ^{hi}	9.0 ⁱ	10.2 ^j	7.6 ⁿ	9.3 ^o
QG ^b	7.6 ^{gh}	8.5 ^{hi}	7.3 ^g	8.8 ⁱ	9.1 ^{ij}	10.4 ^l	8.3 ⁿ	9.4 ^o
bone ^c maturity	32.6	29.7	40.0	34.5	47.9	45.9	56.0	44.1
lean ^c maturity	37.8 ^{hij}	25.1 ^g	32.9 ^{ghi}	32.2 ^{gh}	45.9 ^{jk}	37.9 ^{hij}	50.0 ^k	40.6 ^{hijk}
overall ^c maturity	34.2 ^h	27.2 ^g	38.8 ^h	34.0 ^h	47.8 ^{ij}	41.8 ^{hi}	52.7 ^j	47.9 ^{ij}
lean color ^d	3.1 ^m	1.7 ^g	2.5 ^{hijkl}	1.7 ^{gh}	2.2 ^{ghij}	2.0 ^{ghi}	2.2 ^{ghijk}	1.9 ^{gh}
lean ^e firmness	2.6	2.4	2.2	2.3	2.4	2.8	2.3	3.1
lean ^f texture	3.3	2.9	3.3	2.3	2.7	3.3	3.3	3.0

a 7= S1-, 8= S1^o, 9= S1+, 10= Sm-, etcetera

b 7= St+, 8= G-, 9= G+, 10= Ch-, etcetera

c percentage within A maturity

d 1= very light cherry red,, 7= black

e 1= very firm,, 7= extremely soft

f 1= very fine,, 7= very coarse

ghijklm means in the same row across all four slaughter groups with different superscripts are different (P<.05)
no means in the same row on an overall basis with different superscripts are different (P<.05)

tenderness or LD overall tenderness (table 5). LD myofibrillar tenderness did, however, tend ($P > .05$) to decline with Acc slaughter groups. However, management system did effect ($P < .05$) LD detectable connective tissue amount (LD CT) in that LD CT was more detectable ($P < .05$) for Acc-III cattle than any other group. Conv cattle also tended ($P > .05$) to have more detectable CT than Acc-I and Acc-II cattle. Generally one expects an increase in detectable CT with age due to an increase in chemical cross linkages. An increase in detectable CT should tend to decrease taste panel overall tenderness values and in our study, overall tenderness scores tended to be lower for Acc-III cattle. Myers et al. (1979) reported no difference in Warner-Bratzler shear value or taste panel flavor between rib steaks from Acc and Conv cattle. Marchello et al. (1979) found no difference in flavor or tenderness by an untrained taste panel, when comparing Acc and Conv cattle fed three levels of concentrate and slaughtered at 1.02 cm fat thickness.

SM traits were not affected ($P > .05$) by feeding system. However, there was a tendency for SM myofibrillar tenderness to be lower for Conv cattle. This differs somewhat with Nagele et al. (1979) who reported less SM detectable connective tissue, higher SM flavor and higher overall SM tenderness ratings for Acc steers over Conv steers. SM overall tenderness tended to be more highly related to SM CT ($r = .84$) than to SM myofibrillar tenderness ($r = .60$) or SM juiciness ($r = .53$). However, in the LD, overall tenderness was more highly related to myofibrillar tenderness ($r = .94$) than to LD CT ($r = .52$).

ES effects on palatability traits. ES decreased ($P < .05$) LD shear values (table 6); however, differences in LD shear values between ES and C tended to decline with increasing time-on-feed. Grusby et al. (1976) reported increased tenderness from ES over C for LD and semitendinosus steaks when eval-

TABLE 5. ACCELERATED AND CONVENTIONAL FEEDING EFFECTS
ON LONGISSIMUS AND SEMIMEMBRANOSUS PALATABILITY

	Accelerated			Conventional
	I.	II.	III.	
LD shear, kg	3.5	3.5	3.3	3.6
LD flavor ^a	6.2	6.3	6.2	6.5
LD juiciness ^b	5.9	6.1	6.1	6.3
LD ^c myofibrillar tenderness	6.9	6.6	6.1	6.7
LD CT ^d	7.1 ^f	7.1 ^f	6.5 ^e	6.9 ^f
LD overall ^c tenderness	6.7	6.7	6.3	6.6
SM shear, kg	4.9	4.2	4.5	4.6
SM flavor ^a	6.0	6.3	6.0	6.0
SM juiciness ^b	5.8	5.9	5.9	5.6
SM ^c myofibrillar tenderness	6.4	5.9	5.9	5.5
SM CT ^d	5.4	5.5	5.5	5.2
SM overall ^c tenderness	5.6	5.7	5.6	5.2

^a 1= extremely bland,, 8= extremely intense

^b 1= extremely dry,, 8= extremely juicy

^c 1= extremely tough,, 8= extremely tender

^d 1= abundant,, 8= none

^{ef} means in same row with different superscripts are different (P<.05)

TABLE 6. ELECTRICAL STIMULATION EFFECTS ON LONGISSIMUS AND SEMIMEMBRANOSUS PALATABILITY

	Accelerated						Conventional						Overall
	I.			II.			III.			I.			
	C	ES	C	ES	C	ES	C	ES	C	ES	C	ES	
LD shear, kg	4.6 ^g	2.4 ^e	3.8 ^{fg}	3.3 ^{ef}	3.5 ^f	2.7 ^{ef}	3.6 ^f	3.6 ^f	3.9 ^y	3.1 ^x			
LD flavor ^a	6.2	6.2	6.3	6.3	6.2	6.1	6.6	6.4	6.3	6.3			
LD juiciness ^b	5.8	5.9	6.4	5.9	6.1	6.2	6.2	6.4	6.1	6.1			
LD ^c	6.4	7.0	6.8	6.5	6.5	5.8	6.9	6.5	6.6	6.4			
myofibrillar tenderness													
LD CT ^d	7.0 ^{fg}	7.2 ^{gh}	7.4 ^h	6.7 ^f	6.8 ^f	6.2 ^e	7.1 ^{fgh}	6.8 ^f	7.1 ^y	6.7 ^x			
amount													
LD ^c	6.4	7.0	6.8	6.5	6.5	6.1	6.7	6.5	6.6	6.5			
overall tenderness													
SM shear, kg	4.5	4.8	4.3	4.2	4.5	4.5	3.9	5.4	4.4	4.7			
SM flavor ^a	6.0	6.0	6.2	6.3	6.0	6.0	6.3	5.8	6.1	6.0			
SM juiciness ^b	6.0 ^{fg}	5.6 ^{ef}	5.9 ^{fg}	6.2 ^g	5.7 ^{efg}	5.7 ^{efg}	5.8 ^{efg}	5.4 ^e	6.0 ^y	5.6 ^x			
SM ^c	5.9	6.8	5.9	5.9	6.0	5.9	5.7	5.3	5.9	6.0			
myofibrillar tenderness													
SM CT ^d	5.4	5.5	5.4	5.6	5.5	5.4	5.4	5.0	5.4	5.4			
amount													
SM ^c	5.6	5.6	5.6	5.8	5.7	5.5	5.5	5.0	5.6	5.5			
overall tenderness													

a 1= extremely bland,, 8= extremely intense

b 1= extremely dry,, 8= extremely juicy

c 1= extremely tough,, 8= extremely tender

d 1= abundant,, 8= none

efgh means in same row with different superscripts are different (P<.05)

xy means in same row with different superscripts are different (P<.05)

uated by Warner-Bratzler shear and taste panel scores. Davey et al. (1976) and Bouton et al. (1978) also reported increased taste panel tenderness from ES over C steaks.

ES increased ($P < .05$) taste panel detectable LD CT for all slaughter groups except Acc-I and Conv. However, Savell et al. (1978a and 1978b) and Savell et al. (1979) all reported a decrease in LD CT from ES as determined by taste panel. No explanation can be given for our findings.

LD flavor, LD juiciness, LD myofibrillar tenderness and LD overall tenderness were not affected ($P > .05$) by ES in our study. In fact, there was a tendency ($P > .05$) for LD myofibrillar tenderness and LD overall tenderness to be more desirable for C than for ES, except for the Acc-I cattle. This tends to indicate that ES had more of an effect with the lighter weight or thinner cattle. Grusby et al. (1976) studied cattle over two carcass weight ranges, 148 to 206 and 52 to 107 kg, and found increased LD tenderness (taste panel and Warner-Bratzler shear) from ES.

SM shear values, SM flavor, SM myofibrillar tenderness, SM CT, and SM overall tenderness were not influenced ($P > .05$) by ES, but SM myofibrillar tenderness did tend ($P > .05$) to increase in Acc-I cattle due to ES (6.8 vs 5.9, respectively). However, this trend was reversed with Conv cattle (5.7 and 5.3, respectively). A slight advantage for ES steaks in overall tenderness was seen in Acc-I and Acc-II, but Acc-III and Conv C steaks tended ($P > .05$) to be more tender than ES steaks. Savell et al. (1977), Davey et al. (1976) and Gilbert and Davey (1976) all reported no taste panel tenderness differences between ES and C for the SM muscle. SM juiciness tended to decrease ($P > .05$) with time-on-feed and was decreased ($P < .05$) by ES. Savell et al. (1978a) reported that ES LD steaks were less juicy than C LD steaks; and perhaps this same effect could occur in the SM muscle. However, most research-

ers, including Savell et al. (1977) and Davey et al. (1976) reported no significant differences in juiciness between ES and C.

Summary. These results suggest that cattle fed a minimum of 139 days on a concentrate diet were not different in palatability traits from cattle fed on a concentrate diet for 242 days. Therefore, it appears from our study, that feeding Acc cattle 139 days on concentrate will provide a very acceptable product and that feeding beyond 139 days does not improve the palatability of the product. However, increasing time-on-feed increased percentage of Choice carcasses and dressing percent and thus, economic value per unit of live weight.

Acc-I cattle tended to respond more to ES than other cattle, likely because they were lighter and had less fat. It has been shown that thinner carcasses have less fat cover to insulate against rapid chilling. Therefore with thinner cattle the effect of ES could have been due to the prevention of cold toughening.

By estimating that cattle initially would have a dressing percent of 55% and a retail yield of 82%, and by use of Dikeman's (1976) values for predicting the yield of retail cuts by yield grade, the Acc-I steers tended to be lower in unit of feed per unit of retail cuts (7.2, 7.8, 8.1 and 9.5, respectively for Acc-I, Acc-II, Acc-III and Conv). However, this data was not statistically analyzed.

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EFFECTS OF ACCELERATED AND CONVENTIONAL FEEDING ON CATTLE PERFORMANCE,
CARCASS TRAITS AND PALATABILITY AND EFFECTS OF
ELECTRICAL STIMULATION ON MEAT QUALITY

by

STEVEN CLAIRE OLSEN

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Four groups of 8 month old steers from 7/8 Simmental x 1/8 Hereford or 1/8 Angus sires mated to crossbred dams were utilized in this study. Steers averaged 265 kg when purchased from the R.L. Hruska US Meat Animal Research Center at Clay Center, Nebraska. Nine pens containing 48 steers were assigned to an Accelerated (Acc) feeding system while three pens containing 16 steers were assigned to a Conventional (Conv) feeding system.

Cattle on the Acc system were fed a 74% concentrate diet; cattle on the Conv system were backgrounded for 110 days on a high silage diet and then finished on a 74% concentrate diet. Acc cattle were slaughtered in three slaughter groups at average weights of 449, 494, and 562 kg; the Conv cattle were slaughtered at 591 kg. Days-on-feed were 139, 174, 242 and 284 respectively. Energetic efficiency (Mcal NE_p per kg of gain) was measured for all slaughter groups.

At slaughter, after steers were split into sides, one side was randomly selected for electrical stimulation (ES) and the other side served as a nonelectrically stimulated control (C). ES sides were pulse stimulated (1.6 sec on, .8 sec off) for 2 min at 45 min postmortem with 400 V, 6 amps and 60 Hz AC current. Carcass yield grade, quality grade and 9-10-11th rib section chemical composition were determined. Semimembranosis (SM) and longissimus (LD) steaks were removed at 48 hr postmortem, vacuum packaged, aged six days at 2 C, frozen and later thawed for trained taste panel and Warner-Bratzler shear evaluations. Steaks were trimmed to .25 cm subcutaneous fat thickness and modified-oven broiled in a 163 C oven to an internal temperature of 70 C.

Data were analyzed by least squares analysis of variance and means were separated with least squares.

Overall ADG and feed efficiency were not different between slaughter groups. Conv-finishing cattle (Conv cattle during the finishing phase only)

were not different ($P > .05$) in ADG and feed efficiency from Acc cattle. Pen NE_p energetic efficiency was demonstrated to be poor in predicting carcass composition. Acc-III cattle had higher dressing percents ($P < .05$) than Conv cattle, but equal ($P > .05$) hot carcass weights. Fat thickness, LD area and quality grade increased ($P < .05$) with successive Acc slaughter groups whereas Conv cattle were equal ($P > .05$) to Acc-III cattle except for having a larger fat thickness ($P < .05$). Ether extractable lipid of the 9-10-11th rib section was higher ($P > .05$) and protein and water lower ($P < .05$) for Acc-III than for Acc-I and Acc-II cattle, but not different ($P > .05$) from the Conv cattle. ES decreased ($P < .05$) 4 hr pH readings, enhanced ($P < .05$) 24 and 48 hr marbling scores, increased ($P < .05$) quality grade and lean color, and decreased ($P < .05$) lean maturity and overall maturity.

Acc-III steaks were higher ($P < .05$) in LD detectable connective tissue than Acc-I, Acc-II, and Conv steaks. LD myofibrillar tenderness tended ($P > .05$) to decline over the Acc groups and overall tenderness tended to be lower for the Acc-III group than any other group. SM palatability traits were unaffected ($P > .05$) by feeding system but SM myofibrillar tenderness tended ($P > .05$) to decrease with time-on-feed. ES increased ($P < .05$) LD detectable connective tissue and decreased ($P < .05$) SM juiciness but no other SM or LD palatability trait was affected ($P > .05$) by ES. However, there was a tendency ($p > .05$) for ES to improve LD and SM shear force values, myofibrillar tenderness and overall tenderness in Acc-I cattle which was not present in later slaughter groups. This could indicate more of an ES effect on lighter or thinner cattle.

By estimating that cattle initially would have a dressing percent of 55% and a retail yield of 82%, and by use of Dikeman's (1976) values for predicting the yield of retail cuts by yield grade, the Acc-I steers tend-

ed to be lower in unit of feed per unit of retail cuts (7.2, 7.8, 8.1 and 9.5, respectively for Acc-I, Acc-II, Acc-III and Conv). However, this data was not statistically analyzed.