CONCENTRATE LEVEL, FEEDER GRADE, AND BREED TYPE, THEIR RELATIONSHIP TO PRODUCTION FACTORS AND CARCASS CHARACTERISTICS IN FATTENING CALVES

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ABSTRACT

CONCENTRATE LEVEL, FEEDER GRADE, AND BREED TYPE, THEIR RELATIONSHIP TO PRODUCTION FACTORS AND CARCASS CHARACTERISTICS IN FATTENING CALVES

by Gary Lee Minish

Two experiments, involving 272 steer calves, were conducted to investigate the effects of four concentrate levels; I, 0.0; II, 0.5; III, 1.0; and IV, 1.5 pounds of total concentrate (shelled corn and 64% protein supplement) added per 100 pounds of body weight to high corn silage rations, upon feedlot performance and carcass characteristics of various feeder grades and beef-types of steer calves. Feeder grades (Choice, Good, and Standard) and breed-types (Angus, Hereford, Shorthorn, and Charolaise x Hereford) were compared for performance and carcass merit. Interrelationships between concentrate level and feeder grade were also studied. One separate experiment involving 30 steer calves was conducted to compare Angus, Hereford, and Shorthorn steers for performance and carcass traits when fed a high roughage ration for the entire feeding period.

When the four concentrate levels were compared in Experiment II and III for all feeder grades, it was impossible to designate a specific concentrate level which was optimum to add to a full-feed of corn silage. From the

standpoint of daily gains and carcass desirability, the 1.0 percent level of added concentrates appeared most optimum. However, in terms of higher net return per steer and pounds of beef produced per acre of corn the lower levels appeared more adequate.

In Experiment II and III, concentrate levels were also compared within feeder grades. One pound of total concentrate (shelled corn and protein supplement) was the most optimum level to add to a full feed of corn silage for the Choice and Good grade feeders from the stand point of the most ideal combination of feedlot performance (daily gain) carcass cut-out, and highest net return per steer. For the Standard feeders, it appeared that a full-feed of corn silage without added concentrate was adequate for performance, carcass characteristics, and pounds of beef produced per acre of corn; however, average net return per steer favored 0.5 pound of added concentrate per 100 pounds of body weight. This was primarily a result of a very low dressing percent for the 0.0 percent level.

In Experiment II and III, feeder grades were compared for feedlot performance and carcass traits. Standard grade feeders (Holsteins) had significantly higher daily gains, less fat thickness over the rib-eye and a greater percentage of boneless, closely trimmed round, rib, loin and chuck than the Choice or Good grade feeders. Choice grade feeders had significantly larger rib-eye areas, higher dressing percents and higher carcass grades than

Good grade calves. Choice and Good grade feeders both exhibited significantly larger rib-eye areas, higher dressing percents, higher carcass grades, and superior carcass prices than the Standard feeders. The Standards (Holsteins) consumed significantly more feed daily (85% D.M.) on a total basis and when compared per 100 pounds of body weight than the Choice feeders.

In Experiment II and III four breed types; Angus, Hereford, Shorthorn and Charolaise x Hereford steers were compared for feed lot performance and carcass characteristics when fed four different rations, varying in amount of concentrate added. There was no interaction between concentrate level and breed-type. Shorthorn and Charolaise x Hereford steers were significantly superior to Angus steers in average daily gain. Angus steers had the highest marbling score and carcass grade, the crossbreds the lowest, with the Shorthorns and Herefords intermediate. The Charolaise x Hereford steers had significantly less fat at the 12th rib and a higher estimated percent of boneless closely trimmed lean cuts (round, rib, loin and chuck) than the other three breed types. Herefords had significantly lower percent of kidney knob than the other breeds.

In Experiment I, 10 Angus, 10 Herefords, and 10 Shorthorns were compared on a high roughage ration for performance and carcass traits. The Herefords and Shorthorns significantly outgained the Angus. Herefords dress significantly lower and had significantly higher percent of hide than the other breeds. Herefords had significantly less fat thickness over the rib-eye than Angus or Shorthorns. Shorthorns had significantly the smallest rib-eye. Angus steers were rated higher for carcass conformation, marbling, and carcass grade then Herefords or Shorthorns. Herefords had a significantly higher percent of lean and preferred cuts on a trimmed wholesale cut basis and as a percent of boneless closely trimmed cuts of the left side of the carcass.

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I. INTRODUCTION

Recent years have seen expanding interest by the consumer for trimmer lean cuts of beef, with acceptable flavor tenderness and juiciness. Thus, feeding systems which will result in more lean beef (of acceptable palatability) at lower cost need to be developed.

Many experiments have been conducted to study the effects of low and high planes of nutrition on feedlot performance and carcass merit of beef cattle. However, there is still a lack of data regarding the effect of different feeding treatments on performance and carcasses of beef, especially where various breed types and feeder grades are represented. Trials comparing various concentrate levels most frequently involve a specific feeder grade of cattle, primarily Choice.

Recent years have seen feeds such as corn silage become very popular in cattle rations, but there is little uniformity of opinion on what level of concentrate should be added to corn silage rations for efficient beef production.

In many trials, increasing the concentrate level resulted in higher average daily gains, reduced feed efficiency, and higher feed cost per pound of gain (Perry, _et al_., 1964 and Burroughs _et al_., 1965). In contrast to these studies, Deans _et al_. (1962) reported no relationship between daily gains and concentrate level, and Newland et al. (1962) found that TDN per pound of gain was not related to concentrate level. Pope et al. (1963) reported calves gained faster and required less feed per pound of gain on a 92 percent concentrate ration than those receiving a 62 percent concentrate diet. Furthermore, Branaman et al. (1959) and Hammes et al. (1964) found no significant relationship between concentrate level and carcass grade or backfat thickness. Willey et al. (1952) and Brethour et al. (1961) found no significant relationship between concentrate levels and dressing percent. In contrast to this, Pope et al. (1958), Hendrickson et al. (1959, 1960) and Neumann et al. (1962) all reported increased carcass grade, marbling and outside fat, with a reduction in the yield of lean cuts as the concentrate level was increased. Thus, it can be said that the effect of various concentrate levels and their relationship to performance and carcass merit has had wide study, but it would be very difficult to recommend the optimum concentrate level.

As mentioned previously, it is possible that there is some interaction between concentrate level and breed type, feeder grade or sex that is causing the inconsistent results that are presented. This is definitely an unexplored area.

Despite market differentials and ideas of desirable beef conformation, the differences among feeder grades and/or breed types, have received inadequate study. Previous studies

reveal that the lower feeder grades tend to upgrade themselves at slaughter and on the rail and also show very similar, if not superior, feedlot performance compared to higher grading calves (Burroughs et al., 1963, 1964). However, there is a need for more trials to further elucidate this. Many questions arise as to which breed type within the Choice grade is superior in the feedlot and on the rail. Significant differences between breeds have been found (Butler et al., 1962; Ramsey et al., 1963; and Cole et al., 1963, 1964) and are reviewed in the literature that follows; however, this is an area that also required more investigation before definite conclusions can be drawn.

The work presented in this dissertation was initiated to: (1) determine the optimum level of concentrate added to high corn silage rations for superior feedlot preformance and carcass merit when fed to steer calves of various feeder grade and breed type, and to examine the interaction, if present, of concentrate level with either feeder grade or breed type, and (2) to elucidate differences between various feeder grades in feedlot performance and carcass traits and to further compare breed types within the Choice grade for the same traits.

II. REVIEW OF LITERATURE

Effect of Various Energy Levels on Protein and Energy Digestibilities

Much of the early work on energy utilization by livestock was performed in the respiration calorimeter. Armsby (1915) discussed the calorimeter and some of its uses. Gross energy in the ingested feed was determined by use of the bomb calorimeter. In the respiration calorimeter, it was possible to determine all the various classes of energy loss, including energy lost by ruminants in the formation of methane and the energy of the heat increment.

Forbes *et al.* (1928) related five planes of nutrition--(1) fast, (2) half of maintenance requirement, (3) maintenance (energy equilibrium), (4) half more than maintenance, and (5) twice maintenance--to the energy metabolism of cattle. He reported that from the plane of half of maintenance to that of twice maintenance, digestible energy first rose slightly, because of increased digestion of crude fiber, and then decreased, at an increasing rate, as a result of lowered digestion of carbohydrate and protein. The total net energy (for maintenance and growth) decreased almost linearly as the plane of nutrition rose. In further studies of the energy metabolism of cattle in relation to the plane of nutrition, Forbes *et al.* (1930) reported that from the lowest to the highest plane of nutrition there was a general and decided decrease in the net energy value of the ration. When a 2-year-old grade Shorthorn steer was fed six levels of nutrition, ranging from fasting to full-feed, Mitchell et al. (1932) reported a progressive decrease in digestibility only in the case of nitrogen-free-extract, ether extract, and dry matter. Watson et al. (1939) reported that increasing the intake of corn silage and decreasing the total concentrates resulted in increasingly lower energy digestibility. Haynes et al. (1955) and Pahnish et al. (1956) reported a linear increase in TDN as the amount of concentrate in the ration of cattle increased to 66 percent. This was in agreement with Phillips et al. (1951) who reported that the apparent digestibilities of the nutrients, as well as intake energy, usually increased as the grain percent of the ration rose. Dome et al. (1955) observed a linear increase in TDN as roughage-concentrate ratio increased from 1:1 to 1:4, but not from 1:4 to 1:5. Putman and Loosli (1959) stated that digestibility coefficients (except crude fiber) increase as the proportion of concentrates increase, and within the range investigated (0 to 60 percent) no change in nutrient digestibilities was found that could not be explained by the additive digestibilities of roughages and concentrates. Nicholson et al. (1956) found the relationship between percent roughage and percent digestible dry matter was almost perfectly linear from 100 percent roughage to 50 percent roughage and 50 percent concentrates. However, when the roughage percentage was further reduced to 35 percent, digestibility tended to level off.

Hopson (1959) determined digestible energy at various concentrate-roughage ratios. When digestible energy values were compared according to the roughage-concentrate ratio, there was a sharp increase between 20 percent concentrate and 30 percent concentrate, but only a slight increase from 30 to 50 percent. Brent (1959) reported in a digestion study with lambs that the digestible energy in the rations increased as the percentage of roughage in the ration decreased, and the relationship between the two measures was principally linear.

Watson et al. (1947), after several well documented experiments, detected no effect on protein digestibilities from feeding different mixtures of hays and concentrates. Elliot and Loosli (1959) reported that neither protein nor crude fiber digestibility was affected by changes in hay-concentrate ratios. In 1951, Lofgreen et al., working with young dairy calves, found that the efficiency of utilization of protein in high protein rations, as measured by nitrogen balance was markedly affected by energy intake. Fontenot et al. (1955) found an increase in nitrogen retention in steers when Cerelose (corn sugar) was added to a 10 percent protein wintering ration. Jones et al. (1958) reported that protein requirements may be affected by the energy content of the ration; apparently, a low protein level was sufficient for the low energy ration but not for the high energy groups.

In experiments conducted by Joyce (1959) and Brent (1959), protein digestion coefficients decreased as percent of roughage in the ration decreased. Jones and Hogue (1960) evaluated the response of lambs fed different amounts of protein and energy with and without stilbestrol and showed that the lambs fed high energy rations required more protein than those fed low energy rations to maintain feed intake and growth rate. Kane *et al*. (1961) reported that ration digestibilities of dry matter, crude protein, ether extract, and nitrogen-free-extract were significantly higher for cows fed a 36 percent grain ration (dry matter basis) compared with cows fed 16.4 or 6.6 percent grain. In comparing 16.4 and 6.6 percent grain levels, crude protein, ether extract, nitrogen-free-extract digestibilities were significantly higher for the 16 percent grain ration. These results are in agreement with Dome *et al*. (1955), Elliot and Loosli (1959), Phillips *et al*. (1951), and Putman and Loosli (1959), who have shown higher nutrient digestibilities with increased grain levels.

Effect of Various Concentrate Levels on Gains and Feed Efficiency

Skinner and King (1916) reported that 2-year-old steers fed a limited amount of grain (5.80 pounds shelled corn per day) with corn silage, protein supplement, and hay, made more economical gains than full-fed steers (9.81 pounds shelled corn per day) plus corn silage, protein supplement, and hay.

Gerlaugh et al. (1938) fed yearling steers a basal ration of corn silage and protein supplement with varying levels of corn and cob meal at full-feed, three-fourths, and one-half of full feed. Daily gains and pounds of beef produced per acre were 1.91 and 361; 1.78 and 348; 1.69 and 351 for the respective three levels of corn. It was thus concluded that a reduction in the quantity of corn in the ration for yearling steers from a full-feed to three-fourths full-feed would require a slightly longer feeding period to obtain a similar degree of finish, but there would be little difference in economic returns. Reducing the corn to one-half full-feed appeared to be too severe for adequate rate of finishing or for satisfactory financial returns.

McCroskey et al. (1958) stated from two trials involving 236 long-aged steer and heifer calves, the effects of widely varying concentrate-roughage ratios of 35:65, 50:50, 65:35, and 80:20, resulted in no significant differences in average daily gains, or TDN required per 100 pounds of gain. Daily feed intake declined as the percentage of concentrate in the ration increased, thus, tending to equalize the TDN intake.

In studying the effect of rapid versus moderate rates of gain on feed efficiency of cattle fed rolled milo, cottonseed meal, dehydrated alfalfa, and cottonseed hulls, Pope et al. (1958) reported that cattle fed to gain rapidly

(2 pounds of milo per cwt per day) were less efficient and required the largest amount of total digestible nutrients per 100 pounds of gain, while those cattle fed to gain moderately (1 pound milo per cwt.per day) required the least amount of total digestible nutrients per 100 pounds gain.

Hendrickson et al. (1959) individually fed 64 weanling steer calves to make 400 pounds total feedlot gain in several ways: (a) rapidly, (b) moderately, (c) rapidly for 200 pounds and then moderately, or (d) moderately for 200 pounds and then rapidly. Calves fed to gain moderately required 60 days longer to reach final weight and were no more efficient than full-fed calves due to a longer feeding period. The rapid-moderate system appeared to be the least desirable, based on feed efficiency and rate of gain.

Branaman et al. (1959) compared steers and heifers receiving a "limited-fed" ration of ground shelled corn at the rate of 1.25 pounds per 100 pounds body weight plus corn silage full-fed, to "delayed full-fed" steers and heifers receiving a full-feed of corn silage for the first 98 days and thereafter a full-feed of ground shelled corn plus silage until slaughter. The limited-fed steers and heifers gained 2.21 and 2.08 pounds daily respectively, compared with 2.06 and 1.95, respectively, for the "delayed full-fed" steers and heifers. The limited-fed steers ate approximately 10 percent more total corn per day than the delayed full-fed steers.

Brethour et al. (1959) reported very little increase in rate of gain when the ratio of sorghum grain to Ellis sorgo silage was increased from 1:3 to 3:2. Klosterman et al. (1959) reported that the amount of energy required per pound of gain increased as the ratio of ground ear corn to silage increased. Cattle fed silage with ground ear corn gained as fast or faster than those full-fed ground ear corn. This occurred even though the amount of ground ear corn was reduced to one-half or even one-third full-feed. Lofgreen et al. (1960) observed that an energy supplement fed at the rate of 0.5 pound per 100 pounds of body weight daily to steers receiving alfalfa soilage would significantly increase daily gain, whereas a higher rate of supplementation (0.7 pound per 100 pounds body weight) did not significantly stimulate daily gain above the 0.5 pound level of supplementation. In studying the effect of length of heavy corn silage feeding upon feed requirements of beef steers, Neumann et al. (1960) compared four rations: (1) full-fed cracked shelled corn, corn silage, and supplemental hay until 1038 pound slaughter weight was reached; (2) full-fed corn silage and protein supplement for 140 days, then fed ration; (3) same as 2, except full-fed silage for 210 days; (4) same as 2, except full-fed silage for 280 days. Average daily gain decreased as the length of silage feeding period increased and as more total silage was fed. However, 17.0, 20.8, and 29.3 fewer bushels of corn, including that in the corn silage, were required for rations 2, 3, and 4, respectively, than ration 1. Furthermore, 43, 55, and 103 percent more steers could be finished from a given acreage of corn used as in rations 2, 3, and 4, respectively, than with ration 1.

Perry, et al. (1961) compared varicus ratios of corn and corn silage in the fattening ration of beef calves by full feeding silage and adding 1.5, 4.1, 8.2, and 12.3 pounds of shelled corn to the four respective raticns. The most economical gains were made by calves fed 1.5 pounds of corn; however, these cattle did not gain as rapidly as those fed higher levels. The authors concluded that the most rapid, efficient, and practical growing and fattening gains for beef calves fed corn silage and supplement could be obtained by feeding 4 to 8 pounds of corn per head daily. Deans et al. (1962) compared four levels of concentrate (corn and supplement) fed daily as a percent of animal body weight (0, 0.5, 0.75, and 1.5 percent) added to a full-fed basal ration of corn silage, and reported that daily gains during the 50 to 60 day finishing period were not directly related to energy levels. There was an inverse relationship between silage intake and concentrate level. However, Newland et al. (1962) reported that the higher concentrate levels (1.5 percent of body weight daily) produced significantly faster gains than the lower level of concentrate (0.5 percent of body weight daily). TDN per pound of gain was not related to energy level in this study.

In a study evaluating methods of feeding corn silage to cattle, Kolari et al. (1963) found the highest daily gains were made when a ration of ground ear corn was fed without silage. Less pounds of feed per 100 pounds of gain (average of three trials on a dry matter basis) were required with this ration. Pope et al. (1963) showed that calves fed an "all concentrate ration," (92 percent concentrate) gained slightly faster, consumed 2.1 pounds less feed per day, and required 87 percent less feed per 100 pounds gain than the calves fed a 68 percent concentrate ration. This observation is in agreement with studies reported by other workers. Brethour and Duitsman (1963) reported little difference in rate of gain resulting from different concentrate-to-silage ratios. Young et al. (1962) fed steers and heifers corn silage without corn for 98 days and then full-fed corn and compared these cattle to those fed a limited amount of corn with silage for the entire feeding period. No differences were found between these two methods of feeding with regard to total gain or feed efficiency. Shepard et al. (1965) reported that corn silage fed with a limited amount of corn (2 pounds of corn per head per day), compared with a full feed of corn, produced significantly higher gains than the limited-fed ration. However, the cattle on limited-fed corn and full-fed silage required 23.7 percent less TDN per pound of gain at a 20.7 percent lower feed cost per pound of gain than the cattle on full-fed corn plus silage.

Madamba et al. (1965) found that a high energy ration (73 percent TDN) fed to four breed types of cattle produced markedly increased weight gains per day compared to those fed the medium energy ration (60 percent TDN).

In a 3 year series of studies, Hughes et al. (1964) reported reduced feed and caloric intake on the high concentrate ration (95 percent concentrate) in comparison to the conventional ration (65 percent concentrate). An examination of the volatile fatty acid production in the rumen revealed a lower proportion of acetic to proprionic acid in cattle fed the high energy ration.

Burroughs et al. (1965) studied the comparative merits of finishing cattle on corn silage versus corn grain. Twenty-four steers were placed on finishing rations of: (1) ear corn and no silage; (2) half ear corn and half corn silage; and (3) corn silage. The high corn silage finishing ration excelled the others in lower cost of gain, greater profit per steer fed, higher retail cut-out values of the beef carcasses produced, and more beef produced per acre of corn. However, consistent with previous studies, the corn silage ration produced slower live weight gains and required a longer feedlot finishing period.

Perry et al. (1964) compared a high concentrate ration (full-fed cracked shelled corn) with a low concentrate ration (full-fed corn silage and 2 pounds of cracked shelled corn per head daily) fed to calves and yearlings. Calves and yearlings on the high concentrate rations gained 10 and

14 percent, respectively, more rapidly than those on high corn silage rations. Calves on the high corn rations required 12 percent more TDN per pound of gain and had a 10 percent higher feed cost per pound of gain than calves on high corn silage rations. The yearlings on the high concentrate ration required 20 percent more TDN per pound of gain and had a 20 percent higher feed cost per pound of gain than yearlings on the high corn silage ration.

Effect of Various Concentrate Levels on Carcass Evaluation

Current emphasis on lean meat production has led to investigations of lean to fat ratio and means of controlling or regulating it by varying the diet of animals. Ellis and Zeller (1931) full-fed pigs and restricted others to three-fourths or one-half of the intake of the full-fed pigs. They found that restricting feed intake greatly reduced the percentage of fat in the carcass. Similar results were found by Burroughs and Carroll (1939) who reported a decrease in carcass fat due to restriction of feed intake.

Convincing evidence of the influence of nutritional environment as a directive and controlling force in the development of the animal was reported by McMeeken (1940a, 1940b, 1940c, and 1941). Quantitatively controlling the plane of nutrition, closely inbred pigs were fed four rations in such a manner to permit four major variations in the shape of the growth curve from birth to 200 pounds live weight. The four variations included a high rate throughout (High-High), a high followed by a low rate (High-Low), a low followed by a high (Low-High), and a low rate throughout (Low-Low).

The amount of skeletal and muscle tissue increased, and fat (subcutaneous and intramuscular) decreased in the order of the following groups: Low-High, High-High, High-Low, and Low-Low. Pigs fed on a high plane of nutrition from birth to 16 weeks had considerably larger muscle fibers and more marbling in the longissimus dorsi muscle than pigs on a low plane of nutrition. The feeding of a low level of nutrition to pigs followed by a high level resulted in more fat, both subcutaneous and intramuscular, than pigs fed a high level throughout. When a high level of nutrition followed a low level as in the case of the "Low-High" group, the growth of fat in the late developing regions, as also with total fat, was increased markedly. This emphasizes the fact that skeletal and muscle tissue reach a peak of formation during the animal's early development (125 pounds maximum development for swine) and adipose tissue reaches its peak of development during a much later (approximately 175 pounds maximum development for swine) period of growth.

Guilbert et al. (1944) reported evidence in an experiment with cattle that high planes of nutrition speed up the development of thickness growth, especially in later maturing parts such as the loin and hindquarters. Thus, a high plane of nutrition early in life followed by a lower plane results in carcasses higher in lean and lower in fat than when the reverse occurs, even though the same final weight at the same age is obtained. Palsson and Verges (1952), studying the effect of plane of nutrition on the growth and development of carcass quality in lambs, reported that maximum lean and minimum fat were produced when these animals were fed liberal rations during early growth and somewhat restricted rations when growth rate declined and fattening occurred. They re-emphasized previous work which showed that limited nutritive supply at any age causes the greatest inhibiting effects on those tissues or parts of tissues, having the highest growth intensity at that particular age. Although there are many areas of agreement, there is nevertheless considerable controversy as to the effect of varying the diet (predominantly energy or concentrate levels) upon carcass characteristics. In work reported by Branaman et al. (1959), no significant differences were apparent in carcass grade or outside fat covering when steers and heifers limited-fed shelled corn at the rate of 1.25 pounds per 100 pounds body weight plus corn silage were compared with steers and heifers that were full-fed corn silage for the first 98 days and full-fed ground shelled corn thereafter.

Willey et al. (1952) studied the influence of energy in the ration on carcass composition of fattening steers and found no significant differences in dressing percent, carcass grade, percent carcass lean, percent carcass fat, or percent edible lean due to the effect of different energy levels. McCroskey et al. (1958) reported no apparent effect of concentrate-roughage ratios of 35:65, 50:50, 65:35, or 80:20 on marbling score or carcass grade of 96 steers. Brethour et al. (1961) compared steer fattening rations differing in the ratio of sorghum grain to sorgo silage and found no significant difference in carcass grade or yield. Hammes et al. (1964) found no significant difference in carcass grade, loin eye area, backfat, or marbling score between cattle fed a high corn silage ration (80 or 100 percent of dry matter fed as silage) versus a conventional high grain fattening ration.

Many investigations have demonstrated significant relationships between energy or concentrate levels and carcass characteristics. Pope et al. (1958) and Hendrickson et al. (1959, 1960) both compared the carcass characteristics of steer calves fed to gain as follows: (1) rapidly, (2) rapidly for first one-half of the feedlot period, then moderately for the remainder, (3) reverse of lot 2, and (4) moderately. Results indicated that steer calves fed to gain rapidly throughout the feedlot period produced slightly higher grading carcasses, with more marbling and a higher percentage of fat. There was also a tendency for faster gaining calves to produce a lower percentage of lean in the carcass.

Pope et al. (1961) reported a trial in which three groups of eight weanling Hereford steers were individually fed to gain as rapidly as possible for 350 pounds (lot 1), moderately for the same period (lot 2), and moderately for 350 pounds total feedlot gain (lot 3). Average daily gains for the three lots were 1.72, 1.31, and 1.29 pounds, respectively. Moderates slaughtered at the same time as the rapidly-gaining calves were the lowest grading lot, with less yield and less internal and external fat. Except for fatness, results indicated little difference in carcass composition of calves making different rates of gain when slaughtered at the same time, or at equal weights. Newland _et al_. (1962) compared two levels of added concentrates (.5 versus 1.5 pounds per 100 pounds body weight daily) fed to calves and yearlings. Each animal was individually removed from the experiment and slaughtered at 1000 pounds. The higher concentrate level resulted in significantly higher carcass grades in the calf experiment, but concentrate levels were not related to carcass grade in the yearling trial. This was in agreement with Lofgreen _et al_. (1960) who found that adding an energy supplement of shelled corn at the rate of a 0.7 pound per 100 pounds of body weight to alfalfa silage brought about a significant increase in carcass grade and dressing percent over cattle receiving either 0.5 or no energy supplement per 100 pounds of body weight.

Richardson _et al_. (1961) studied the effects of four roughage-concentrate ratios--1:1, 1:3, 1:5, and a changing ratio produced by increasing the concentrate each 28 days--on carcass characteristics of fattening cattle. The 1:3 and 1:5 ratios resulted in higher grading carcasses than either 1:1 or the changing ratio.

Neumann _et al_. (1962) reported the effect of reducing energy level by heavy feeding of corn silage on carcass grade and yield in fattening steers. Four rations were fed until the choice feeder calves reached a slaughter weight of 1050 pounds. The treatments were (1) full-fed cracked shelled corn, 15 pounds of silage, and 1.5 pounds of soybean meal; (2) full-fed only corn silage for 112 days and then plan 1 until slaughter; (3) same as 2, except heavy silage for 168 days; and (4) same as 2 except heavy silage for 224 days. Generally, as the heavy silage period increased, outside fat was reduced, marbling increased and yield of trimmed lean cuts improved. Returns per animal over feed costs, based on grade and yield and their current prices, favored the cattle on heavy silage, lots 3 and 4.

Henrickson et al. (1965) reported a study similar to McMeeken's design, mentioned earlier with swine, where 88, 8-month-old Hereford calves were allotted to four treatments based on two 200-pound phases of the feeding period: High-High, High-Moderate, Moderate-High, and Moderate-Moderate. Calves on the high treatment received 2 pounds of ground milo per 100 pounds of body weight, while those on the moderate ration received 1.0 pound of ground milo per 100 pounds of body weight. Both received a full-feed of roughage. Marbling scores improved with increased energy intake. The High-Moderate treatment produced significantly more marbling than the Moderate-High treatment. Differences in dressing percent were small and nonsignificant, with a tendency for increased yield of carcasses if steers were fattened on the high plane of nutrition. Carcasses from steers full-fed in phase II (High-High and Moderate-High) yielded a small but significantly lower percent of the high-priced cuts (round, loin, rib) and a higher percent of the low-priced cuts (chuck, flank, plate). Physical separation of the 9 - 10 - 11 rib cut revealed significant differences in lean, fat and bone percentages among treatments. The High-High and Moderate-High treatments produced carcasses containing 2.8 percent less lean, 4.0 percent more fat and 0.8 percent less bone than the cattle on the High-Moderate and Moderate-Moderate treatments. Calves fed to gain rapidly for 400 pounds in the feedlot (High-High) produced higher grading carcasses with more marbling and less lean than those fed to gain moderately throughout the entire feedlot period (Moderate-Moderate).

The Relationship of Feeder Cattle Grade to Performance in the Feedlot and Carcass Evaluation

Hultz (1927) found a correlation between feeder grade and carcass grade of 0.234, and a correlation between fat grade and carcass grade of 0.477. Stanley and McCall (1945), working with calves, found a low and nonsignificant correlation (0.02) between feeder grade and carcass grade. They also found a low and nonsignificant correlation between feeder grade and daily gain in the feedlot. This was in agreement with Durham and Knox (1953) who found correlations between grades at weaning and subsequent gains on 424

Hereford steers to be negatively (-0.021) associated or actually not associated at all. They reported the correlation between feeder grade at weaning and carcass grade to be virtually zero (0.022). Gain during the fattening period was associated with carcass grade.

Knox (1931) compared Choice, Good, Medium and Common feeder steers for rate of gain, feed required per 100 pounds of gain, dressing percent, and the quality of carcass produced. The feeder cattle selected were typical of their respective grades with respect to size, form, quality, breeding, and condition. Average daily gain for the 152-day feeding period showed little evidence to indicate the superiority of one feeder grade over the other for this trait. Feed consumed per unit of gain varied even less between feeder grades than rate of gain. Dressing percentage tended to decrease from the Choice feeder grade to the Common grade of feeder cattle. The carcasses tended to grade higher for the higher feeder grades and the value of the carcass followed the same trend. A slightly greater return for the Common feeders was realized, but this was explained by the narrow spread in price between the grades of fat steers in the spring of 1929. Peters (1932) reported two trials, where thin cattle of three grades of feeder steers--Good, Medium, and Common--were fattened. The steers of the Common feeder grade gained in weight a bit more rapidly and used their feed much more efficiently than the Good feeder cattle and thus, a significantly lower cost of gain resulted for steers of the lower feeder grade. Therefore, as feeder grade was lowered, feed required per pound of gain was likewise lowered.

Burroughs et al. (1963) reported on 72 yearling steers representing four feeder grades of cattle, Choice, Good, Medium, and Common that were fed ground ear corn (23.5 pounds daily) plus 2 pounds of protein supplement per head daily during a 160-day finishing period. Two-thirds of the total number of Common feeder steers were Holsteins and the remaining one-third were Brown Swiss. The Medium, Good, and Choice feeder grades were principally of Aberdeen Angus and Hereford breeding. Average daily gains were 2.98, 3.08, 2.82, and 2.55 pounds for the Choice, Common, Good, and Medium grade feeders, respectively. The spread in carcass grade of the finished cattle at the end of the feeding period was much less than the spread in feeder grade at the time the cattle were purchased. The Choice, Good, and Common feeder grade cattle averaged Low Choice, Average Good, and Average Good, respectively, as finished cattle. Thus, the initial feeder grades narrowed to less than one slaughter grade at termination. Average carcass grades were Low Choice, Average Choice, Average Choice, and High Good for the Choice, Good, Medium, and Common feeder grades, respectively. There was no apparent difference in rib-eye area or fat thickness between the various feeder grades. Burroughs et al. (1964), using the same design of the preceding trial, where four feeder grades were compared when fed a high energy ration during a 6-month finishing period, found the lowest feeder grade (Common Holsteins) consumed slightly more feed and gained slightly more weight than any of the other feeder groups. Excellent, and approximately similar feedlot performance, was obtained with all four groups of feeder cattle. Federal carcass grades were Low Choice for the Choice, Good, and Medium feeders, and Average Good for the Common feeder grade. Slaughter grades were again relatively similar for the four groups of cattle, averaging Low Choice for each of the higher feeder grades and Average Good for the lowest feeder grade. Dressing percents were higher for the higher feeder grades, averaging 61.8, 61.4, 60.2, and 60.7 for the Choice, Good, Medium, and Common feeders, respectively. This may have been due to overall fatness of the animals, since the fat thickness, measured over the 12th rib, was highest for the Choice feeder grade (0.7 inch) and lowest for the Common feeder (0.2 inch), with intermediate values for the intermediate feeder grades.

Retail cut-out value favored the two lower feeder grades (Common, 48.1, and Medium, 53.2 percent trimmed boneless round, rib, loin, and chuck) as compared to the two higher feeder grades (Good, 47.9, and Choice, 46.2 percent trimmed, boneless round, rib, loin, and chuck). Tenderness tests of cooked round steak indicated no significant difference between feeder grades of cattle when they were handled alike in the feedlot and given a high-concentrate ration for an extensive feeding period.

Feedlot Performance and Carcass Characteristics of Dairy-Bred Feeder Steers Versus Beef-Bred Feeder Steers

Fuller (1929) compared Holsteins, Angus, and Holstein x Angus crosses, where 6-month-old calves were full-fed for 217 days. The Holsteins made higher daily gains (2.37 pounds daily) than either the Angus (2.19 pounds daily) or the Holstein x Angus cross (2.17 pounds daily). Dressing percent was 3.1 percent lower for the Holsteins than either the Angus or Holstein x Angus crosses. There was no difference determined from simple cooking and taste tests between the breed types in either flavor or tenderness. Branaman and Brown (1936) and (1937) compared Herefords and Holsteins fed a similar ration of shelled corn, cottonseed meal, corn silage, and alfalfa hay. In both trials, the Holsteins had higher average daily gains (0.12 pound more daily) than the Hereford steers. Holstein steers averaged 3.2 percent lower in dressing percent than the Herefords, and the Holsteins graded lower (Medium) than the Herefords (Choice). Kidwell and McCormick (1956) compared the growth rate and carcass traits of 35 Hereford and 39 Holstein steers fed a fattening ration for 140 days. In agreement with other data, the Holsteins had significantly higher average daily gains (2.34 vs. 1.66 pounds), required significantly less grain per pound of gain (3.82 vs. 6.37 pounds), and graded significantly lower than Herefords. Holsteins had a significantly higher percent of bone (+4.1 percent), significantly higher percent of separable muscle (+5.5

percent), and significantly less fat (-9.4 percent) than Herefords when estimated by physical separation of the 9 - 10 - 11 rib.

Brookes and Hodges (1959) compared the effects of four levels of feeding--High-High, High-Moderate, Moderate-High, and moderate-Moderate--for growth rate, economy of feed conversion, and type of carcass produced, of three breeds of spring-born Hereford, Dairy Shorthorn, and Friesian steers. There was no interaction present between breed and level of feeding. The growth rate of the Friesians was higher than that of the Dairy Shorthorn or Hereford breeds, but the difference between the latter was negligible.

Callow (1961) compared steers of the beef-breed (Herefords), a dual purpose breed (Dairy Shorthorns), and a milk breed (Friesians) on four levels of nutrition. Friesians had a higher proportion of muscular tissue (33.6 percent liveweight), compared to Herefords (31.5 percent liveweight) or Dairy Shorthorns (30.9 percent liveweight). The percentage of fat was inversely proportional to that of muscular tissue. The leaner Friesians had a higher proportion of bone (8.6 percent) than the Dairy Shorthorns (8.1 percent) or the Herefords (7.9 percent). Taste tests on the 12th rib joint after boning failed to show any effect of breed or treatment. In this study, no significant difference in dressing percent was apparent between Holsteins and Herefords. In a study comparing the cutability and eatability of beef and dairy-type steers, Branaman (1962) reported that dairy-type steers dressed significantly less (-3 percent) than beef-type and graded significantly lower, Average Standard, compared to Average Choice for the beef-type cattle. There was no significant difference in tenderness when measured by taste panel or by the mechanical shear. The flavor of the lean and quality and quantity of juiciness were rated significantly superior for beef-type steers, although the meat from beef-type steers had greater shrinkage. Hanke et al. (1964), Carroll et al. (1964) and Madamba et al. (1965) were all in agreement when comparing a beef breed with a dairy breed. They reported that dairy breeds had higher daily gains, less carcass fat, more carcass lean, more bone, and lower grading carcasses.

Cole (1963) and (1964) reported a study employing six breeds and one breed cross, representing the British breeds, Zebu, and dairy cattle full-fed under similar conditions. Holstein carcasses demonstrated more separable lean, separable bone, moisture, protein, round, and foreshank than the Hereford, Angus, Brahman, Brahman x Santa Gertrudis, and Jersey breeds. Dairy steers showed more shrink in a 48-hour cooler chilling period, graded lower and had less external fat, but had the highest percentage of kidney fat. Ramsey et al. (1965) reported that Holsteins and Jerseys dressed significantly lower than Herefords, Angus, Brahman x British crosses, and Santa Gertrudis. It was also shown that the two dairy breeds (Holsteins and Jerseys) yielded significantly more gastrointestinal tract and viscera than the other breeds.

Dairy steers also had a significantly greater percent of rumen and reticulum + contents and esophagus than British or Zebu breeds, except Santa Gertrudis. This indicates greater capacity for fill and shrink of the dairy breeds, which helps to explain the approximately one percent higher shrink for dairy breeds than for the beef-type steers.

Burroughs et al. (1965) summarized three year's work comparing beef-bred steers with dairy type Holstein steers. The summary revealed that the Holsteins consumed 10 percent more feed daily and gained 10 percent faster per animal than the beef-bred animals. The Holsteins had lower dressing percentage (3.1 percent less) and graded one-half grade lower than beef-bred steers. As more grain was added to the finishing ration of Holstein steers, average daily gain, dressing percent and carcass grade all increased. Fewer pounds of feed per unit of gain was required as more grain was added.

Jersey and Guernsey steers are seldom used in a dairy beef program because of buyer discrimination due to the characteristic yellow color of the fat, which results in lower prices. This is primarily why most of the experiments used Holstein steers when comparing dairy cattle with other beef types.

Relationship of Breeds of Beef Cattle to Feedlot Performance and Carcass Characteristics

Hamond (1920) made the first attempt to study the relative qualities of the various British breeds of beef cattle. This investigation used data compiled from the years 1893 to 1913 at the Smithfield Fat Stock Shows, Islington, England. In comparing the size of 33-month-old steers, the South Devons were by far the heaviest breed, followed by the Shorthorn, Hereford, Sussex, and Aberdeen Angus in that order. Watson and Harrison (1910) compared the weights of the cattle at the 1907, 1908 and 1909 International Livestock Show held in Chicago, Illinois, and reported the average weights for 2-year-old steers as follows: Herefords, 1639 pounds; Shorthorns, 1617 pounds; Aberdeen Angus, 1571 pounds; and Galloways, 1437 pounds.

Black et al. (1934) compared the performance of the Brahman x Hereford cross and the Brahman x Shorthorn cross with straightbred Herefords and Shorthorns. This work indicated that the Brahman crosses were heavier at weaning and at the end of 120 days of feeding than were the British breeds. However, when the feeding period ranged from 150 to 179 days, there was a tendency for this to be reversed. During this feeding period, the British breeds gained somewhat faster and more efficiently and graded slightly higher than the Brahman x British crosses; however, dressing percent was 2 to 4 percent higher for the crossbreds. In studying the growth and fattening of Brahman x Hereford crossbreds versus straightbred Herefords, Hubert et al. (1955) found no advantage in favor of crossbreds over the Herefords. Carroll et al. (1955), in making the same comparison as Hubert, found that Herefords made significantly greater gains (+0.26 pound daily), used less feed per 100 pounds gain (-86 pounds), and graded higher than Brahman-Hereford crosses. Brahman x Hereford crossbreds yielded significantly more carcass (+2.2 percent) and had more bone and less fat.

Butler _et_ _al_. (1956), comparing the Hereford x Brahman cross with straightbred Herefords, fed a growing ration (35 percent concentrates) and a fattening ration (65 percent concentrates). The gain response and carcass grades showed that the Herefords made better utilization of the high-concentrate ration than did the crossbreds. The Herefords gained 2.24 pounds daily on the high-concentrate ration and 2.02 pounds daily on the low-concentrate. The crossbreds gained 2.02 pounds daily on the high concentrate and 2.13 pounds daily on the low concentrate; thus, the crossbreds performed about equally well with high and low concentrates.

Klosterman _et_ _al_. (1963) and (1964), in a study comparing the Hereford and Charolaise breeds and their crosses, found that Charolaise calves were heavier at weaning and gained somewhat faster (+0.24 pounds daily) following weaning than the Herefords. Charolaise carcasses graded lower (approximately one U.S.D.A. grade lower), had less fat trim (approximately 5 percent less) and a higher percentage of edible beef (approximately 3 percent more).

A very comprehensive carcass comparison of Angus, Hereford, and Shorthorn steers was carried out by Merkel and Bray (1957) in which 1013 steers were selected from within specified weight categories: 845-950, 950-1020, 1020-1085, 1085-1155, 1155-1225, 1225-1300, and 1300 and up, and compared within the Choice and Prime slaughter grades. Angus steers had significantly higher grading carcasses and more marbling at an equivalent weight or live grade than Herefords or Shorthorns. This is in agreement with Butler et al. (1962), Ramsey et al. (1963), Cole et al. (1963) and (1964), who compared the Angus and Herefords, and Gregory et al. (1966b) who compared the same three breeds. There was no significant difference reported for dressing percent. This was in agreement with Butler et al. (1962) and (1963). Powell et al. (1961) and Cole et al. (1963) reported, in a comparison of Angus and Hereford steers, that Angus had significantly higher dressing percents (+ 0.9 percent). In the latter two trials, Shorthorns were not compared. Merkel and Bray (1957) also reported a significantly higher percent of hide for the Herefords as compared to the Angus and Shorthorns within both the Choice and Prime grades. This was also found to be true by Powell et al. (1961) and Butler et al. (1962), comparing Angus and Hereford steers. Merkel and Bray further reported that Herefords had a significantly higher percent of untrimmed round, rib, loin, and chuck than Angus or Shorthorns. In this same study Angus steers had significantly less fat thickness at the 12th rib than Herefords or Shorthorns when compared within the Choice grade and significantly less fat thickness over the short loin, sirloin, and round than Herefords or Shorthorns. However, Herefords had significantly less percent kidney knob and less fat thickness over the rib than did Angus or Shorthorns when compared within both the Choice and Prime grades. Shorthorn steers had a significantly higher percent of brisket, seam fat, and percent chuck than Angus or Herefords within the Prime and Choice grades.

In a study comparing 53 Hereford and 51 Angus steer calves fed a standard fattening ration of cottonseed hulls, alfalfa hay, sorghum grain, and cottonseed meal, Butler et al. (1962) reported that on a wholesale cut basis, carcass yield of preferred cuts favored the Herefords. Herefords also showed a significant advantage in weight and percent of boneless round and sirloin and had a significantly higher percent hindquarter than Angus. Angus were significantly higher in percent of boneless chuck.

Gregory et al. (1966b) compared the Hereford, Angus, and Shorthorn breeds and all reciprocal crosses among them using an evaluation of the net merit, computed as the value of the boneless, closely trimmed cuts (retail product) minus feed costs from weaning to slaughter. Herefords ranked first in net merit, Shorthorns were the lowest, and Angus were intermediate. Herefords were superior in yield of retail product because of less fat trim. Gregory et al. (1966a), in the same study, compared growth rate and feed efficiency for the same three breeds. Breed effects revealed the Herefords to be superior in growth rate and feed efficiency. The Shorthorns were also superior to the Angus breed in growth rate and feed efficiency. Butler et al. (1962) reported that Herefords had a significantly higher daily gain than did the Angus (2.37 vs. 2.25 pounds).

Carpenter et al. (1955) found that as the percentage of Brahman breeding increased, tenderness of steaks and roasts decreased. Burns et al. (1958) found that Angus and Hereford steers were more tender than Brahman steers, while Brahman crossbreds were intermediate in tenderness. The British breeds were found to be significantly more tender than the Brahman x British crosses, with the dairy breeds intermediate.

Palmer et al. (1963), studying the effect of breeding on beef cattle tenderness, reported that breed of sire had a pronounced effect on tenderness. Angus, Hereford, and Shorthorn progeny were significantly more tender than the progeny of Brahman and Brahman x Shorthorn sires. In a study by Ramsey et al. (1963), loin steaks and round steaks of Brahman steers were scored least tender of all breeds. Hereford, Angus, Brahman x British, Santa Gertrudis, and Holstein steaks did not differ significantly in tenderness scores. Although Angus steer carcasses had the most marbling and graded highest, their steaks were generally rated lower on palatability than the steaks of Jerseys and Herefords by the taste panel. Kincaid (1962) showed that tenderness, as measured by shear force, decreased as the percent of Brahman blood increased in British x Brahman crosses.

Powell et al. (1961), Butler et al. (1962), and Ramsey et al. (1963) found no significant difference in tenderness by shear or panel between the Angus and Hereford breeds.

III. EXPERIMENTAL PROCEDURE

General

Steer calves, ranging from 350 to 700 pounds, were used in each of three experiments described in this thesis. All lots were distributed as evenly as possible for weight, breed and grade. The general procedure for lotting, management, and record keeping was essentially the same in every trial, except trial I.

Individual, two-day weights were taken at the start and end of the experiment. Feed and growth data were collected at 28-day intervals. All diets were adequately fortified with protein, vitamins, and minerals in accordance with N.R.C. (1958 and 1963) recommendations.

All data in trials I and III were treated statistically by analysis of variance (Snedecor, 1956). Data of trial II were analyzed by least-square analysis (Harvey, 1960). Treatment means were compared by the multiple range test of Duncan (1955).

Experiment I
Finishing Three Beef Breeds on a Low Concentrate--High Roughage Ration

The purpose of this work was to compare the Angus, Hereford, and Shorthorn breeds for performance and carcass value, when all three breeds were fed a high roughage-low concentrate ration.

Since it is difficult to adequately sample a breed in terms of numbers and representative bloodlines, the cattle in this experiment were chosen in a manner believed to be adequate for a single study. Thirty head of Michigan beef steer calves consisting of 10 Angus, 10 Herefords, and 10 Shorthorns were purchased in October, 1962. Each breed was represented by cattle from five different Michigan breeders.

These cattle were wintered on a 80-20 percent brome-alfalfa hay mixture and summer pastured on a brome-timothy mixture. During fall of 1963 they received a brome-alfalfa hay mixture until December 17, 1963, when they were officially started on test. Facilities dictated group feeding, and all steers were full-fed corn silage with free-choice timothy-brome hay, three-fourths pound of soybean meal per head daily and free-choice 50-50 mixture of iodized salt and dicalcium phosphate. This high roughage ration was maintained throughout the entire feeding period.

The steers were slaughtered at the Michigan State University Meats Laboratory, when they reached an individual weight of 950 pounds. Each steer was given a 24-hour pre-slaughter shrink without access to feed or water. The weight of the hide and the hot carcass weight were obtained from each steer at the time of slaughter. Chilled carcass weight was recorded after a 48-hour chill. Dressing percent was calculated using the chilled carcass weight and the slaughter weight. Percent hide was also calculated using slaughter weight.

After the 48-hour chill each carcass was ribbed at the 12th rib and grading information was obtained by an Animal Husbandry Meats Specialist from Michigan State University. The information obtained on each carcass as they were graded under the 1963 federal meat grading standards included: marbling score, maturity classification, overall conformation score, and the final grade of the carcass. The latter two grades were recorded to the nearest one-third of U.S.D.A. grade. A tracing of the rib eye (longissimus dorsi) was taken from the left ribbed side of each carcass at the 12th rib using an acetate tracing paper and a soft-leaded pencil. The area of the rib eye muscle was then determined by the use of a polar planimeter. Fat thickness over the 12th rib was traced at the same time the rib eye tracing was made. Average fat thickness (average of three measurements taken over the 12th rib as described by Naumann, 1952) was calculated.

The right side of each carcass was cut into conventional wholesale cuts as described by Wellington (1953), with the following two exceptions: (1) the brisket and foreshank were separated from the chuck at a point 1/2 inch above the joint of the humerus and ulna-radius junction, parallel with the dorsal side of the chuck. (2) The shortplate and the wholesale rib were separated 10 inches ventrally from the spinal column measuring from each end of the rib. The four major wholesale cuts from the right side (round, rib, loin, and chuck) were weighed and trimmed of external fat to approximately 3/8 inch. The weight of the trimmed cut and fat trim were recorded to the nearest 0.1 pound. All trimmed wholesale cuts were then reduced to closely trimmed, boneless retail cuts, and the weight of the edible portion, fat trim and bone from each cut were recorded. The remainder of the wholesale cuts were weighed to the nearest 0.1 pound and then cut into edible portion, fat trim, and bone.

The shortloin from the left side of each carcass was frozen for a subsequent taste panel and Warner-Bratzler shear test. The freezer storage period ranged from approximately 1 to 12 months. These shortloins were removed from the freezer 24 hours prior to test, and three 1.25-inch thick steaks were removed from the anterior end of the cut. Numbering from the anterior end of the shortloin, steak number 1 was used for the shear test and steaks 2 and 3 were designated for the taste panel. The three steaks were thawed overnight at 38^{o}F before testing. The steaks were then cooked in deep fat (lard) at 300 $\pm$ 2^{o}F to an internal temperature of 145^{o}F. The steaks were removed from the deep fat and allowed to cool for 20 minutes. Four 1.0 inch cores were cut parallel to the muscle fibers from each steak. Each of the four cores from steak number 1 were measured for tenderness with the Warner-Bratzler shear instrument, and an average of the four values was recorded for each respective steak. Cores from steaks 2 and 3 were cut in two equal pieces perpendicular to the direction of the muscle fibers. The steaks were scored on a nine-point hedonic scale (1 = dislike extremely; 9 = like extremely) for juiciness, flavor, and overall eatability by a laboratory panel composed of eight college staff members who had experience on beef taste panels. This panel also evaluated tenderness using the objective chew count evaluation on the core samples.

Experiment II
Various Concentrate Levels on a High Corn Silage Ration for Various Grades and Breed Types of Beef Cattle

The purpose of this experiment was to determine the effect of adding various levels of concentrate (shelled corn and protein supplement) to a basal ration of corn silage fed to three distinct feeder grades and four representative breed types, and to compare steers of various feeder grades and breed types for production factors and carcass merit.

One hundred forty-four steer calves, averaging 630 pounds, were purchased in the late fall of 1964 and allotted as evenly as possible for weight, breed, and grade. The cattle officially started on test February 11, 1965, after a long acclimation period. Individual two-day weights were taken at the start and end of the experiment. Each lot was removed for slaughter when a 1000 pound average weight was reached. Design of the ration treatments was as follows: 0.0, 0.5, 1.0, and 1.5 pounds of total concentrates daily (shelled corn and 64% protein supplement) per 100 pounds body weight. All lots received a full-feed of corn silage and the concentrates as specified above. All rations were completely mixed in a horizontal batch mixer and fed twice daily. The 64 percent protein specified as a component of the total concentrates was fed in equal amounts to the various ration treatments. Thus, the shelled corn was adjusted to provide the various added concentrate levels. The 64 percent protein contained urea (8.6% of the weight), stilbestrol and terramycin. Daily intake of the latter two were 10 mg. and 64 mg., respectively. A mineral mix containing 50 percent trace mineral salt and 50 percent dicalcium phosphate was fed free-choice to all lots. The added concentrates were adjusted for increasing lot weight every 28 days. Performance and feed data were also measured and recorded at the same 28-day intervals.

In this experiment there was one replication of the concentrate levels on high energy corn silage in addition to two replications of the concentrate levels on regular corn silage as shown in Appendix Table 1. Within each of the concentrate level pens there were cattle of three feeder grades: Standard, Good, and Choice. Furthermore, the Choice cattle were from four breed types. Thus, in each lot there were 4 Standards, 4 Good, and 4 Choice cattle. Of the Choice cattle, there were one of each of the breed types: Angus, Hereford, Shorthorn and Charolaise x Hereford cross. The Standard grade steers were of Holstein breeding and the Good primarily Herefords.

The steers were weighed off test twenty-four hours prior to being trucked 100 miles to the Peet Packing Company, Bay City, Michigan. The cattle were penned overnight and slaughtered early the next morning. The final weight was obtained on each steer just prior to slaughter and was used as the slaughter weight of the steer. The hot carcass weight was obtained at the time of slaughter. Chilled carcass weight was calculated from the hot carcass weight using a standard 2 percent cooler shrink. Dressing percent was calculated using the chilled carcass weight and the slaughter weight. Immediately after slaughter, carcasses were shrouded and hung in the coolers for a 48-hour chill. The right side of each carcass was divided between the 12th and 13th rib and the carcasses were graded to the nearest third U.S.D.A. grade by a federal meat grader, who evaluated each carcass with regard to (1) conformation grade, (2) marbling score, (3) maturity score, and (4) final overall carcass grade. A tracing of the rib eye muscle (longissimus dorsi) was taken from the ribbed side of each carcass at the 12th rib and rib eye area was determined by the use of a polar planimeter. Average fat thickness (average of three measurements taken over the 12th rib as described by Naumann, 1952) was calculated.

The kidney knob, heart, and pelvic fat were removed from the chilled carcass, weighed, and recorded. Using previously mentioned objective carcass measurements and weights, the percent of boneless retail cuts (cutability) from the round, loin, rib and chuck were estimated using the U.S.D.A. (1965) multiple regression formula. This formula is as follows: 2.5 + (2.50 x fat thickness over rib eye, inches) + (0.20 x percent kidney, pelvic and heart fat) + (0.0038 x hot carcass weight, pounds) - (0.32 x rib eye area, square inches).

Palmer et al. (1961) reported a highly significant correlation (0.76) between carcass retail yield estimates using the U.S.D.A. yield equation and actual percentage yield of boneless retail cuts from the round, loin, rib and chuck. Brungardt et al. (1963) reported a correlation of .82 between actual and estimated boneless retail cuts using the same four variables as used by the U.S.D.A.

Experiment III
Various Concentrate Levels on a High Corn Silage Ration for Different Feeder Grades and Breed Types

The purpose of this experiment was quite similar to Experiment II; however, the design was altered somewhat.

Experiment II and III were designed to determine the optimum level of concentrate (shelled corn and protein supplement) to add to a full-fed basal ration of corn silage, when fed to steer calves of various feeder grades and breed types. It was also the purpose to further elucidate differences in production factors and carcass characteristics between calves of different feeder grades and breed types.

One hundred and twenty-eight steer calves were purchased in September and October of 1965 and were acclimated on a ration of alfalfa hay and ground ear corn until November 18, 1965, when they were officially allotted for experiment. Individual two-day weights were taken at the start and end of the experiment. Each lot was removed for slaughter when a 1025 pound average weight was reached. Design of the ration treatments was as follows: 0.0, 0.5, 1.0, and 1.5 pounds of total concentrates daily (shelled corn and 64% protein supplement) per 100 pounds body weight. All lots received a full-feed of corn silage and concentrates as specified above. All rations were completely mixed in a horizontal batch mixer and fed twice daily. The 64 percent protein specified as a component of the total concentrates was fed in equal amounts to the various ration treatments. Thus, the shelled corn was adjusted to provide the various added concentrate levels. The 64 percent protein contained urea (8.6% of the weight), stilbestrol and terramycin. Daily intake of the latter two were 10 mg. and 64 mg., respectively. A mineral mix containing 50 percent trace mineral salt and 50 percent dicalcium phosphate was fed free-choice to all lots. The added concentrates were adjusted for increasing lot weight every 28 days. Performance and feed data were also measured and recorded at the same 28-day intervals.

In this experiment, a 2 x 2 x 4 x 8 factorial arrangement was used to compare: (1) four concentrate levels fed: 0.0, 0.5, 1.0, and 1.5 pounds of total concentrate (shelled corn and 64% protein supplement) per 100 pounds body weight with each treatment receiving a full-feed of corn silage, (2) two feeder grades, Standard and Choice; and (3) two replications, which were two types of housing. The effects of housing were removed from the analysis, and were considered as replication 1 and 2. There were eight animals per lot (concentrate level treatment).

Within replication 1 and 2, respectively, there were four concentrate treatments (0.0, 0.5, 1.0, and 1.5 pounds total concentrate per 100 pounds body weight daily) with a total of eight Choice steer calves per lot, and four other concentrate treatments (0.0, 0.5, 1.0, 1.5 pounds of total concentrate per 100 pounds of body weight daily) with a total of eight Standard steer calves per lot.

The Choice grade calves were of four breed types: Angus, Hereford, Shorthorn, and Charolaise x Hereford crossbreds, with two of each breed type per lot. The Standard grade calves were of Holstein breeding.

A comparison of breed types was determined within the lots containing Choice grade calves.

The steers were weighed off test 24 hours prior to being trucked 30 miles to Allen Packing Plant, Charlotte, Michigan. The procedures for obtaining carcass data were identical to those explained in Experiment II.

A standard digestion trial was designed in an attempt to obtain information on the digestibility of the four concentrate treatment levels fed in Experiment III.

Eight crossbred wether lambs of average mutton type were selected to be nearly alike as possible in age and weight.

Four rations of shelled corn, protein supplement (64%) and corn silage were full-fed during this study. The four respective rations expressed as a percent of the total weight fed were: Ration I, 2.2 percent protein supplement and 97.8 percent corn silage; Ration II, 10.7 percent shelled corn, 2.1 percent protein supplement, and 87.2 percent corn silage; Ration III, 12.4 percent shelled corn, 2.4 percent protein supplement, and 85.2 percent corn silage; Ration IV, 20.0 percent shelled corn, 2.4 percent protein supplement, and 77.6 percent corn silage. Each of the four rations were respectively identical in composition to the average of the four concentrate rations fed to the steer calves in Experiment III. These averages were calculated from the consumption of shelled corn, protein supplement, and corn silage consumed by the steers, in the first 82 days on experiment.

The wether lambs were fed in a modified digestion stall during both the eight-day preliminary and five-day collection periods. The lambs were free to move about for feed and water. The reason for this type of pen was to reduce confinement in order to have optimum intake of the silage rations. During the collection periods, fecal collections were made twice daily from plastic collection bags that were attached with rubber cement to the wether lambs. All of the feces collected were preserved in a refrigerator until the end of the collection period. The feces were then thoroughly mixed and placed in a forced draft oven at 100°C before being ground for laboratory analysis. Laboratory analysis of feeds and feces were carried out by methods approved by the A.O.A.C. (1966). Feed and fecal nitrogen was determined by the semi-micro Kjeldahl nitrogen determination. Gross energy values of feed and feces were determined by the use of an oxygen bomb adiabatic calorimeter. Apparent digestible energy of the rations was calculated by subtracting the total energy of the feces from the total gross energy of the feed. Dividing the apparent digestible energy by total gross energy of the feed resulted in the digestibility coefficient for energy. These same steps were followed in calculating the protein digestibility coefficients.

IV. RESULTS AND DISCUSSION

Experiment I

General

The results of experiment I are summarized in Tables 1, 2, 3, and 4. Analysis of variance and Duncan's multiple range test for growth rate and standard carcass measurements are reported in Table 1. All statistical analyses were compared at the 5 percent level of probability.

Steers were group fed and feed consumption data were not available. Therefore, it was not possible to test for feed efficiency between breeds.

Comparison of Angus, Hereford, and Shorthorn Steers for Performance and Carcass Merit When Fed a High Roughage Ration

Combining all three breeds, average daily gains for the entire 375 day feeding period were low (1.41 pounds daily); however, this was expected on a "high-roughage" ration. Hereford and Shorthorn steers had significantly higher average daily gains than Angus. Gregory *et al.* (1966a) likewise noted superior growth rate for the Herefords and Shorthorns with the same three breed comparison. Hereford steers yielded significantly lighter weight chilled carcasses and a significantly lower dressing percent than the other two breeds. This was in agreement with Powell *et al.*

(1961) and Cole et al. (1963). This may be partially explained by the significantly higher hide percent of the Herefords, which agrees with Butler et al. (1962), who reported significantly heavier hides for Herefords compared to Angus.

The official meat grader favored the carcass conformation of the Angus over the Herefords and estimated less marbling and a lower carcass grade for Herefords than the other two breeds. These comparisons were all statistically significant.

The steers in this trial were approximately 32 months old at slaughter, and consequently all breeds were scored low on maturity.

Shorthorns had the smallest rib-eye area of the three breeds ($P < .05$) while Herefords had significantly less fat thickness at the 12th rib than either the Angus or Shorthorns. The latter comparison was in agreement with Gregory et al. (1966b).

Table 2 shows the comparisons of trimmed wholesale cuts expressed by weight and percent of the left side of the carcass. The Angus had significantly heavier ribs than either the Herefords or Shorthorns, and the Angus had significantly lighter weight rounds than the Herefords. Herefords had a significantly higher percent of preferred cuts (loin, rib, and round) and lean cuts (loin, rib, round and chuck) and a significantly lower percent of belly cuts (plate, brisket, flank and shank) and kidney knob, than either the

Angus or Shorthorns. All three breeds were significantly different for percent round with the Herefords ranking first, the Angus lowest and Shorthorns intermediate. Percent rib significantly favored the Herefords and the Angus over the Shorthorns. These results compare favorably with Butler et al. (1962) who noted that on a wholesale cut basis, carcass yield of preferred cuts favored Hereford steers, when compared to Angus.

Table 1. Exp. I - Means of performance and carcass measurements by breed and test of significance between means. (Av. feeding period, Dec. 17, 1962 to Dec. 1, 1963, 375 days.)

Measurement	Angus	Hereford	Shorthorn	Std. error of means[4]
No. steer calves	10	10	10	--
Av. initial wt., lb.	414	461	437	--
Total gain, lb.	535.7	502.7	515.2	12.29
Av. daily gain, lb.	1.33[a]	1.48[b]	1.43[b]	0.027
Weight at slaughter	899.0	904.3	903.6	5.05
Chilled carcass wt., lb.	540.4[a]	515.4[b]	531.3[a]	3.83
Dressing percent	59.9[a]	57.0[b]	58.8[a]	0.44
Carcass conformation grade[1]	6.5[a]	5.2[b]	5.7[a,b]	0.30
Maturity score[2]	6.7	6.8	6.9	0.15
Marbling score[3]	14.6[a]	10.7[b]	13.4[a]	0.80
Carcass grade[1]	6.1[a]	4.4[b]	5.5[a]	0.37
Rib-eye area, sq. in.	9.46[a]	9.02[a]	8.09[b]	0.27
Fat thickness, 12th rib, in.	.77[a]	.47[b]	.63[a]	0.049
Hide percent	7.34[a]	9.27[b]	7.25[a]	0.16

[1]Coded: 2 = Standard; 5 = Good; 8 = Choice; 11 = Prime.

[2]Coded: 1 = A; 3 = A+; 5 = B; 7 = C-.

[3]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant

[4]Based on 18 degrees of freedom.

[a,b]Means on the same line having the same superscript do not differ significantly. All others differ significantly ($P < .05$).

The superiority of the Herefords in the comparison of trimmed wholesale cuts could partially be explained by less fat, which is indicated by a significantly lower fat thickness measurement at the 12th rib, and a lower percent of kidney knob.

A very reliable measure of cut-cut value of beef carcasses is the yield of boneless, closely trimmed retail cuts. Table 3 presents the results of the breed comparison for salable yield (boneless, closely trimmed wholesale cuts) expressed by weight and percent of the left side of the carcass.

Herefords had significantly more weight in the preferred and lean cuts, and the chuck respectively than did Shorthorns. Hereford steers also had more total pounds of loin, rib, round, chuck and belly cuts than either the Shorthorns or the Angus. This was significantly higher than the Shorthorns.

Based upon a percent of the left side, Herefords had a significantly higher percent of boned, closely trimmed round, chuck, preferred cuts, lean cuts, and lean cuts plus belly cuts, respectively, than did the Angus or Shorthorns. The ability to put on less fat when fed a high roughage diet compared to the other breeds, gave the Herefords a definite carcass cut-out advantage. Angus and Herefords had a significantly higher percent of boneless, closely trimmed rib than the Shorthorns.

Gregory <u>et al</u>. (1966b) likewise noted that Herefords had higher retail yield than either the Angus or Shorthorns

Table 2. Exp. I - Mean weights and percent of wholesale cuts[1] from the left side by breeds and test of significance between means.

Wholesale Cut	Weight, lb.				% of left side			
	Angus	Here-ford	Short-horn	Std. error of means[3]	Angus	Here-ford	Short-horn	Std. error of means[3]
Full loin	37.7	37.6	37.1	0.61	14.0	14.6	14.0	0.22
Rib	22.7[a]	21.3[b]	20.1[b]	0.47	8.4[a]	8.3[a]	7.6[b]	0.14
Round	56.0[a]	62.0[b]	59.1[a,b]	1.17	20.8[a]	24.1[b]	22.3[c]	0.40
Chuck	68.0	68.0	65.4	1.06	25.2[a,b]	26.3[a]	24.6[b]	0.37
Belly cuts[2]	69.0[a]	59.6[b]	69.2[a]	1.37	25.6[a]	23.1[b]	26.1[a]	0.50
Sum full loin, rib, round	116.4	120.9	116.2	1.59	43.2[a]	46.8[b]	43.8[a]	0.47
Sum full loin, rib, round, chuck	184.4	188.9	181.6	2.28	68.4[a]	73.6[b]	68.4[a]	0.71
Kidney knob	12.0[a]	7.7[b]	11.6[a]	0.69	4.5[a]	3.0[b]	4.4[a]	0.25

[1]The weights and percentages of the round, loin, rib, and chuck are of closely trimmed wholesale cuts with an external fat thickness of 3/8 inch. The belly cuts and kidney were not trimmed for these determinations.

[2]Belly cuts include the flank, plate, shank and brisket.

[3]Based on 18 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

Table 3. Exp. I - Mean weights and percents of boneless, closely trimmed wholesale cuts from the left side by breeds and test of significance between means.

Trimmed cut	Weight, lb.				% of left side			
	Angus	Hereford	Shorthorn	Std. error of means[4]	Angus	Hereford	Shorthorn	Std. error of means[3]
Full loin	30.3	30.70	29.5	0.71	11.22	11.92	11.11	0.26
Rib	22.7	21.3	20.1	0.40	6.50^{a}	6.36^{a}	5.78^{b}	0.13
Round	45.4	50.5	46.1	0.98	16.8^{a}	19.6^{b}	17.3^{a}	0.32
Chuck	$54.0^{a,b}$	55.6^{a}	51.9^{b}	0.87	20.0^{a}	21.6^{b}	19.5^{a}	0.32
Belly cuts[1]	42.9	40.5	40.6	0.92	15.9	15.7	15.3	0.18
Sum full loin, rib, round	$93.3^{a,b}$	97.5^{a}	90.9^{b}	1.50	34.6^{a}	37.8^{b}	34.2^{a}	0.44
Sum full loin, rib, round, chuck	$147.1^{a,b}$	153.1^{a}	142.8^{b}	2.12	54.5^{a}	59.4^{b}	53.7^{a}	0.64
Sum full loin, rib, round, chuck, belly cuts	$190.2^{a,b}$	193.8^{a}	183.4^{b}	2.41	70.5^{a}	75.2^{b}	69.0^{a}	0.76
Trimmed fat[2]	--	--	--	--	9.66^{a}	5.64^{b}	10.88^{a}	0.67

[1] Belly cuts include: plate, flank, shank and brisket.

[2] Fat trimmed from trimmed wholesale cuts.

[3] Based on 18 degrees of freedom.

[a,b] Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

and the author credited this to the fact that Herefords had less fat than the other two breeds. Butler et al. (1962) reported that Herefords showed a statistically significant advantage in the weight and percent of boneless round and sirloin and the Angus had a statistically significant advantage in percent of boneless chuck.

The superiority of Herefords for yield of boneless trimmed cuts appeared to be a result of a lower percent of fat which was shown to be significantly less than that of either the Angus or Shorthorns. Murphey et al. (1960) reported correlations of -.68, -.85, and -.85 between fat thickness over the rib eye and yield of wholesale, bone in retail, and boneless retail cuts. Herefords had a significantly smaller amount of fat over the rib eye.

The results of average shear force and panel scores for tenderness, juiciness, flavor, and overall cutability are shown in Table 4. There were no large or significant differences between breeds for these traits. This is in agreement with Powell et al. (1961), Butler et al. (1962) and Ramsey et al. (1963).

Table 4. Exp. I - Means for shear values and laboratory scores of loin steaks by breed and test of significance between means.

	Angus	Here-ford	Short-horn	Std. error of means[4]
Shear value (1/2 in.core)[1]	7.2	7.3	7.4	0.44
Taste panel scores:				
Tenderness[2]	24.8	26.1	27.3	1.87
Juiciness[3]	7.0	6.9	6.7	0.16
Flavor[3]	6.9	6.8	6.7	0.13
Overall eatability[3]	7.0	7.1	6.8	0.14

[1]Warner-Bratzler shear instrument was used to measure the force to shear a 1/2 inch core of loin steak at right angles to the fibers.

[2]Coded: Steaks were rated by chew-count.

[3]Coded: Steaks were scored on a nine-point scale; (1 = dislike extremely; 9 = like extremely).

[4]Based on 18 degrees of freedom.

Experiment II

General

Least square means and Duncan's multiple range test for performance and carcass traits are given in Tables 5, 6, 7, and 8 for concentrate level, concentrate level within feeder grades, feeder grade and breed type, respectively. Consumption, efficiency and cost of feed could not be reported or tested in this experiment because of unequal replications of concentrate levels within the two types of corn silage fed.

In order to increase treatment numbers and still analyze the various factors, least squares analysis was used to adjust the two types of corn silage to equal amounts of each type fed. Thus, types of silage were standardized and the direct effects of type of silage were removed from the statistical analysis of this experiment.

All statistical analyses were run at the ($P < .05$) level and will be reported at this level in the results and discussion that follows.

Comparison of Four Concentrate Levels Added to a High Corn Silage Ration

The results of performance and carcass measurements for the following concentrate levels: I, 0.0; II, 0.5; III, 1.0; IV, 1.5 pounds of total concentrate (shelled corn and 64% protein supplement) added daily per 100 pounds body weight to a basal ration of corn silage, are presented in Table 5.

Differences in average daily gain resulting from the addition of various concentrate levels to the basal corn silage diet were significantly higher as the concentrate was raised to level III, but increased only slightly from level III to IV.

Deans *et al.* (1962) found no relationship between concentrate level and daily gain during a 50 to 60 day final finishing period. However, Newland *et al.* (1962) reported significantly faster gains at the 1.5 percent concentrate level than at the 0.5 percent level, and further noted

Table 5. Exp. II - Least square means for performance and carcass characteristics by concentrate level and test of significance between means.

	Percent Concentrate Added				Std. error of means[5]
	0.0	0.5	1.0	1.5	
No. steer calves	36	36	36	36	--
Av. initial wt., lb.	630	631	630	631	--
Total gain, lb.	370.4[a]	386.4[a,c]	410.4[b]	403.9[b,c]	7.23
Av. daily gain, lb.	2.40[a]	2.59[b]	2.73[c]	2.78[c]	0.048
Live slaughter grade[1]	9.05	8.94	8.99	9.02	0.20
Carcass evaluation:					
Conformation grade[1]	8.58	8.44	8.49	9.10	0.32
Marbling score[2]	13.14[a,b]	12.06[a]	14.19[b]	14.11[b]	0.42
Carcass grade (final)[1]	7.41[a]	8.08[a]	9.08[b]	8.94[b]	0.27
Fat thickness, 12th rib, in.	.49	.54	.61	.52	0.001
Rib eye area, sq. in.	10.06	10.37	10.33	10.56	0.16
Dressing percent	58.5	58.3	58.0	58.5	0.53
Kidney knob, %	1.70	1.67	1.74	1.80	0.062
Cutability[3]	3.13	3.18	3.44	3.13	0.11
Selling price, per cwt.,live[4]	$25.22	$25.26	$25.36	$25.43	0.27

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

Table 5. <u>Footnotes Continued</u>.

[4]Selling Price: Actual return for each carcass divided by off experiment weight.

[5]Based on 130 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

higher carcass grades for cattle receiving the higher level, when compared on a 260-day feeding period.

Concentrate levels III and IV produced significantly higher grading carcasses than either level I or II. This was primarily a result of marbling, which followed the same increase as carcass grade with levels III and IV producing higher marbling scores than level I or II, but only significantly more than level II. Lofgreen *et al*. (1960) and Richardson *et al*. (1961) reported that increasing the concentrate level resulted in higher grading carcasses.

There were no large or significant differences appearing for dressing percent, rib-eye area, kidney knob percent, cutability, or selling price that were a direct result of the various concentrate levels.

From the data presented in Table 5, it appeared that the optimum level of concentrate to add to a full feed of corn silage was level III, 1.0 pound of concentrate added daily per 100 pounds of body weight. Carcass grade and daily gain appear to have reached an optimum at level III and increasing the concentrate level beyond this amount was of no appreciable benefit for any of the traits studied. It should be noted that the concentrate levels were compared with cattle of three feeder grades and four breed-types. Concentrate levels may not show the same response when compared within each respective feeder grade.

Comparison of Four Concentrate Levels Within Three Respective Feeder Grades

In Table 6, least square means of performance and carcass measurements for the various concentrate levels within Choice, Good, and Standard feeder grades are presented.

Within both the Choice and Good feeder grades there was a significant increase in performance (daily gain) from level I to level III with each increase in concentrate level (see Figure 1). Within the Choice feeder grade, carcass grade was significantly higher for levels III and IV than level II. Levels III and IV were significantly higher than level I for carcass grade within the Good grade feeders. Conformation grade followed the same pattern of significance as carcass grade for the Good grade feeders. Carcass grade dropped slightly from level III to level IV for both the Choice and Good feeder grades.

There were no large or significant differences observed for dressing percent, rib-eye area, kidney knob percent, cutability or selling price between the four concentrate levels for the Choice or Good grade calves. Levels III, 1.0 percent added concentrate daily to a full feed of corn silage appeared to be optimum for performance (daily

Table 6. Exp. II - Least square means for performance and carcass traits by concentrate level within the Choice and Good feeder grade and test of significance between means within feeder grades.

	Percent Concentrate Added				
			Choice		
	0.0	0.5	1.0	1.5	Std. error of means[5]
No. steer calves	12	12	12	12	--
Av. initial wt., lb.	642	644	641	639	--
Total gain, lb.	341.6[a]	369.3[a,b]	402.2[b]	375.5[b]	11.2
Av. daily gain, lb.	2.21[a]	2.48[b]	2.68[c]	2.51[c]	0.074
Live slaughter grade[1]	10.66	10.66	11.32	10.57	0.33
Carcass Evaluation:					
Conformation grade[1]	9.80	8.97	9.30	11.21	0.72
Marbling score[2]	15.02	12.11	15.11	14.69	1.29
Carcass grade, final[1]	9.46[a,b]	8.22[a]	10.39[b]	10.05[b]	0.48
Fat thickness, 12th rib, in.	.58	.60	.71	.67	0.064
Rib-eye area, sq. in.	10.22	10.82	10.90	10.81	0.32
Dressing percent	60.5	60.8	59.8	60.6	.74
Kidney knob percent	1.73	1.70	1.70	1.97	.12
Cutability[3]	3.36	3.28	3.57	3.52	.219
Selling price, per cwt., live[4]	$26.55	$26.47	$26.88	$26.63	0.40

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 42 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$). Means are analyzed within each respective grade.

Table 6. Continued.

	Percent Concentrate Added				
	Good				Std. error of means[5]
	0.0	0.5	1.0	1.5	
No. steer calves	12	12	12	12	--
Av. initial wt., lb.	617	617	617	621	--
Total gain, lb.	342.4[a]	380.5[b]	411.0[b]	411.1[b]	11.0
Av. daily gain, lb.	2.22[a]	2.54[b]	2.74[c]	2.70[c]	0.071
Live slaughter grade[1]	9.82	9.58	9.83	9.74	0.082
Carcass Evaluation:					
Conformation grade[1]	8.05[a]	9.05[a,b]	10.05[b]	9.88[b]	0.45
Marbling score[2]	12.44	12.44	14.44	14.11	0.87
Carcass grade, final[1]	7.97[a]	8.64[a,b]	9.64[b]	9.39[b]	0.39
Fat thickness, 12th rib, in.	.49	.65	.68	.57	0.055
Rib-eye area, sq. in.	9.96	10.10	10.50	10.58	0.081
Dressing percent	57.7	58.8	58.0	58.5	0.93
Kidney knob percent	1.71	1.66	1.71	1.63	0.10
Cutability[3]	3.05	3.30	3.54	3.24	0.062
Selling price, per cwt. live[4]	$24.66	$25.71	$25.56	$25.64	0.47

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 42 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$). Means are analyzed within each respective grade.

Table 6. Continued.

	Percent Concentrate Added				
	Standard				
	0.0	0.5	1.0	1.5	Std. error of means[5]
No. steer calves	12	12	12	12	--
Av. initial wt., lb.	630	631	634	633	--
Total gain, lb.	427.3	409.3	418.1	425.1	15.1
Av. daily gain, lb.	2.76	2.74	2.78	2.92	0.11
Live slaughter grade[1]	6.66	6.70	5.84	6.74	0.45
Carcass Evaluation:					
Conformation grade[1]	7.88	7.30	6.13	6.13	0.49
Marbling score[2]	11.94	11.61	13.03	13.53	1.07
Carcass grade, final[1]	7.63	7.39	7.22	7.39	0.50
Fat thickness, 12th rib, in.	.41	.38	.43	.32	0.050
Rib-eye area, sq. in.	10.00	10.17	9.61	10.25	0.25
Dressing percent	57.3	55.3	56.0	56.5	0.99
Kidney knob percent	1.66	1.64	1.80	1.80	0.11
Cutability[3]	3.01	2.76	3.17	2.53	0.16
Selling price, per cwt., live[4]	$24.45	$23.60	$23.74	$23.92	0.50

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 42 degrees of freedom.

Figure 1: Expt. II - Comparison of concentrate levels within feeder grades for daily gain and carcass grade

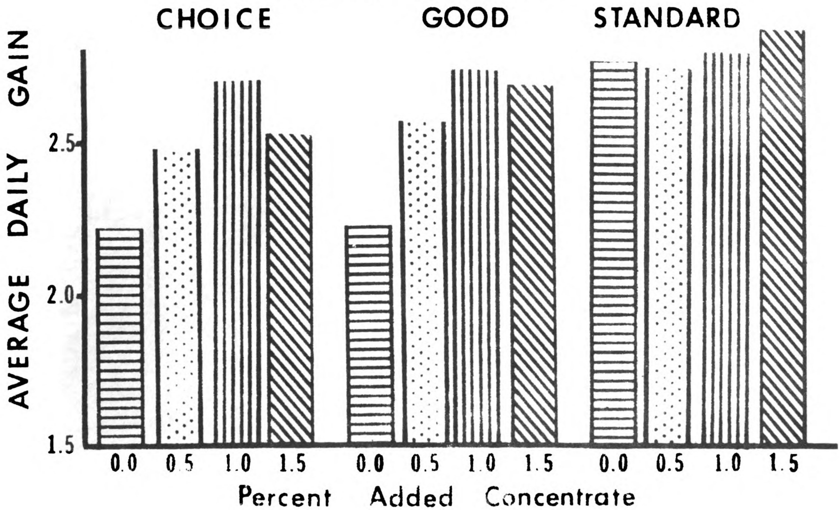
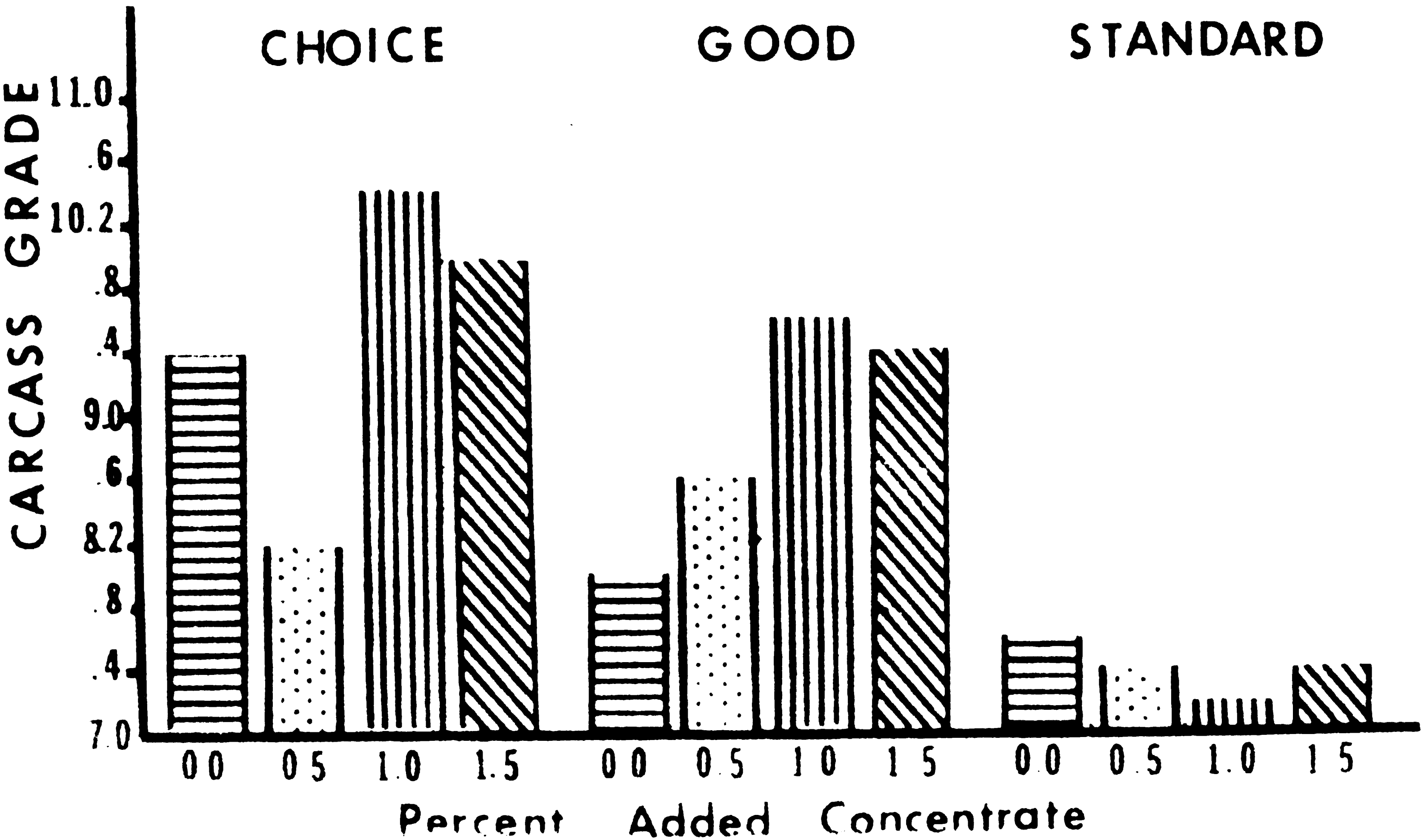


Figure 1 - cont.)



gain) and carcass grade within the Choice and Good grade feeders. Figure 1 illustrates these results.

There were no significant differences for any of the traits studied due to the varying concentrate levels within the Standard grade. From these data it appears that there was no advantage in adding concentrates to a full-feed of corn silage for Standard grade feeders (Holsteins).

A significant interaction between feeder grade and concentrate level was found for average daily gain. This can be explained by the fact that there was no significant change in daily gain on the various concentrate levels for the Standard grade; however, there was a significant increase in daily gain from level I to level II and a large increase from level II to level III for both the Choice and Good grade feeders. Feeder grade and concentrate level interaction approached significance ($P < .06$) for carcass grade and the same trend was observed for the carcass grade interaction that appeared for daily gain.

Comparison of Standard, Good, and Choice Grade Feeders

Least square means and Duncan's multiple range test for performance and carcass traits are presented in Table 7 by feeder grade.

Standard grade feeders (Holsteins) had significantly higher daily gains than either the Choice or Good grade feeders. Standard feeders also had significantly lower dressing percents and a higher ($P < .05$) estimated percent of lean cuts than the other two feeder grades. The higher

Table 7. Exp. II - Least square means for performance and carcass traits by feeder grade and test of significance between means.

	Choice	Good	Standard	Std. error of means[5]
No. steer calves	48	48	48	--
Av. initial wt., lb.	641	618	632	--
Total gain, lb.	372.1[a]	386.3[a]	419.9[b]	6.26
Av. daily gain, lb.	2.50[a]	2.58[a]	2.80[b]	0.041
Live slaughter grade[1]	10.81[a]	9.74[b]	6.48[c]	0.18
Carcass Evaluation:				
Conformation grade[1]	9.82[a]	9.26[a]	6.86[b]	0.28
Marbling score[2]	14.24[a]	13.36[a,b]	12.53[b]	0.54
Carcass grade, final[1]	9.53[a]	8.91[b]	7.41[c]	0.23
Fat thickness, 12th rib, in.	.64[a]	.60[a]	.39[b]	0.029
Rib-eye area, sq. in.	10.69[a]	10.29[b]	10.01[b]	0.14
Dressing percent	60.4[a]	58.3[b]	56.3[c]	0.45
Kidney knob percent	1.78	1.68	1.72	0.055
Cutability score[3]	3.44[a]	3.31[a]	2.87[b]	0.097
Selling price per cwt. live[4]	$26.63[a]	$25.39[b]	$23.93[c]	0.23

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slightly; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed, round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 130 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

lean cut yield for the Standards was primarily a result of having significantly less fat covering than the Choice or Good feeders. In this trial a highly significant ($P < .01$) correlation (.89) was found between average fat thickness at the 12th rib and cutability score. The Choice and Good feeders graded significantly higher (Low-Choice and High-Good, respectively) than the Standards (Low-Good). These results are in agreement with Hanke et al. (1964), Carroll et al. (1964), Madamba et al. (1965) and Burroughs et al. (1965), which further demonstrates that the dairy breeds, which make up the majority of the Standard feeders, have the inherent ability to gain faster, produce a higher percent of retail cuts with a minimum amount of fat, dress lower and have lower grading carcasses than beef-type steers, which grade primarily Choice and Good.

Choice grade feeders had significantly larger rib-eye areas than the Standard or Good feeders. Choice and Good feeders did not differ from each other in daily gain, fat thickness at the 12th rib, or in cutability score; however, dressing percent, slaughter grade, and carcass grade significantly favored the Choice feeders over the Goods. These results were similar to those reported by Burroughs et al. (1963) with the exception that the carcass and slaughter grades of the Choice and Good feeders were the same.

Comparison of Angus, Hereford, Shorthorn and Charolaise x Hereford Breed-Types for Performance and Carcass Characteristics

In view of the results obtained in Experiment I, it was decided to examine further the relationship of breed-types to performance and carcass characteristics; thus, the Choice grade in this trial was composed of Angus, Hereford, Shorthorn and Charolaise x Hereford cross breed-types (see Table 8).

Of the three British breeds, Shorthorns had significantly higher average daily gains than either the Angus or Herefords, and significantly lower grading carcasses than the Angus. This appeared to be due to less marbling; however, the difference in marbling was not significant.

Shorthorns had higher cutability scores (indicating a lower percent of boneless trimmed lean cuts) than either the Angus or Herefords; however, this difference was not significant. There were no apparent or significant differences between the Angus or Herefords for the traits studied, with the following exceptions: the Angus had higher marbling scores and carcass grades, and more kidney knob than the Herefords, although none of these differences were significant.

The Charolaise x Hereford cross compared favorably with Shorthorns for daily gain and had significantly higher gains than either the Angus or Herefords, while their carcass grade was significantly lower than the Angus. The

Table 8. Exp. II - Least square means for performance and carcass measurements by breed-type and test of significance between means.

	Angus	Hereford	Short-horn	Charolaise x Hereford	Std. error of means[5]
No. steer calves	12	12	12	12	--
Av. initial wt., lb.	639	625	675	627	--
Total gain, lb.	$363.6^{a,b}$	352.6^{a}	$387.0^{a,b}$	395.2^{b}	10.08
Av. daily gain, lb.	2.43^{a}	2.35^{a}	2.59^{b}	2.64^{b}	0.068
Live slaughter grade[1]	11.25^{a}	$10.58^{a,b}$	11.42^{a}	10.00^{b}	0.29
Carcass Evaluation:					
Conformation grade[1]	11.30	9.97	9.47	8.89	0.71
Marbling score[2]	16.26	14.67	12.59	13.34	1.37
Carcass grade, final[1]	10.81^{a}	$9.64^{a,b}$	9.15^{b}	8.90^{b}	0.45
Fat thickness, 12th rib, in.	.71	.68	.67	.58	0.003
Rib-eye area, sq. in.	11.09	10.58	10.07	10.86	0.31
Dressing percent	60.2	60.7	60.3	59.8	--
Kidney knob percent	1.96	1.68	1.78	1.70	0.11
Cutability[3]	3.48	3.48	3.78	3.22	0.22
Selling price per cwt. live[4]	$26.83	$26.77	$26.48	$26.00	0.41

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 30 degrees of freedom.

[a,b]Means on the same line have the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

Charolaise x Hereford cross had slightly lower conformation, marbling, carcass grade, fat thickness and dressing percent, but slightly higher cutability than the three straight bred breeds, but none of these differences were significant. Klosterman _et_ _al_. (1964) reported a higher percent of edible meat, less fat trim, lower carcass grades, less marbling, less fat, and higher daily gain for Charolaise x Hereford crossbreeds when compared with straight bred Herefords.

In this trial there was less variation between the Angus, Hereford, and Shorthorn breeds than in Experiment I. However, there also appears to be more variation within breeds because many of the differences are as large, but not significant. Larger numbers could have possibly made some of the differences significant.

There was no significant interaction between breed type and concentrate level for any of the traits studied.

Experiment III

General

It was decided that the results obtained in Experiment II merited further investigation. Experiment III was essentially a repeat of the preceding one, with two exceptions: (1) feed data were analyzed for the concentrate levels and feeder grades studied; and (2) only two feeder grades were compared; Choice and Standard.

Analysis of variance and Duncan's multiple range test were run at the ($P < .05$) level and will be reported at this level in the results and discussion that follows.

Comparison of Four Concentrate Levels Added to a High Corn Silage Ration

Table 10 reports performance, feed, and carcass data from four concentrate treatments; I, 0.0; II, 0.5; III, 1.0; IV, 1.5 pounds of total concentrate (shelled corn and 64% protein supplement), which were added to a full feed of corn silage.

Chemical analysis and digestibility coefficients of the four complete concentrate rations are reported in Table 9.

The digestibility coefficients were determined by feeding eight wether lambs the four concentrate rations, which were identical to the average composition of the rations fed the steers for the first 82 days on Experiment III. There were two replications (lambs) per concentrate level.

An attempt was made to have all concentrate rations isonitrogenous. This proved to be successful since analysis showed there was no significant difference in crude protein percent between the four rations. Gross energy per pound of feed was also very similar between rations.

Digestibility coefficients for dry matter and energy (kcal, D.M. basis) increased quite uniformly as the percent of added concentrate increased.

The 0.5, 1.0 and 1.5 percent levels were significantly higher in percent digestible dry matter than the 0.0 percent level. Levels 1.0 and 1.5 percent concentrate had significantly

Table 9. Exp. III - Chemical analysis and digestibilities[1] of four concentrate rations and test of significance between means.

	Percent Concentrate Added				Std. error of means[2]
	0.0	0.5	1.0	1.5	
Dry matter, %	29.0	35.0	34.0	37.2	--
Crude protein (dry), %	13.2	13.0	13.6	13.4	0.44
Gross energy per lb., kcal.	1982	1992	1991	1990	--
Digestibility coefficients:					
Dry matter, %	55.2[a]	64.9[b]	65.9[b]	70.2[b]	2.10
Protein (dry), %	43.0	52.3	48.6	51.4	2.44
Energy (dry), %	55.5[a]	64.6[a,b]	67.0[b]	70.5[b]	2.38

[1]Digestibilities determined with lambs. Two replications per level.

[2]Based on 4 degrees of freedom.

[a,b]Means on the same line having the same superscript letter do not differ significantly. All others differ significantly. ($P < .05$).

higher digestible energy coefficients than the 0.0 percent level. Protein digestibility was not significantly different for the various concentrate rations. Brent (1959) reported in a digestion study with lambs, that digestible energy in the ration increased as the percentage of roughage decreased. This he found to be a linear relationship. Kane et al. (1961) noted increased ration digestibilities of dry matter, crude protein, ether extract, and nitrogen free extract for higher concentrate rations, when fed to cows. Jones and Hogue (1960) found that lambs fed high energy rations required more protein than those fed low energy rations to maintain feed

Table 10. Exp. III - Means for performance and carcass characteristics by concentrate level and test of significance between means.

	Percent Concentrate Added				Std. error of means[8]
	0.0	0.5	1.0	1.5	
No. steer calves	32	32	32	32	--
Av. initial wt., lb.	515	514	513	514	--
Av. final wt., lb.	993	996	1018	1017	--
Av. daily gain, lb.	2.20^{a}	2.28^{a}	2.47^{b}	2.71^{c}	0.058
Av. daily ration:					
Corn silage, lb.	48.6^{a}	44.2^{b}	37.3^{c}	31.2^{d}	0.56
Dry sh. corn, lb.	0.0^{a}	2.83^{b}	6.51^{c}	10.23^{d}	0.039
Protein supp., (64%), lbs.	1.00	1.00	1.00	1.01	--
Mineral mix, lb.	0.12	0.12	0.12	0.12	--
Total, (85% D.M.), lb.	18.1^{a}	19.3^{b}	20.5^{c}	21.9^{d}	0.15
Feed consumed/cwt. gain, lb. (85% D.M.)	811	851	835	810	14.3
Daily feed per 100 lb. B.W.					
Total (85% D.M.), lb.	2.39^{a}	$2.59^{b,c}$	2.68^{d}	2.90^{d}	0.039
Concentrate, lb.[1]	1.11^{a}	1.39^{b}	1.73^{c}	2.12^{d}	0.014
Roughage, lb.	1.28^{a}	1.15^{b}	0.95^{c}	0.78^{d}	0.016
Conc,: roughage ratio	46:54	55:45	65:35	73:27	--
Feed cost per 100 pounds gain ($)[2]	11.34^{a}	12.59^{b}	$13.54^{b,c}$	14.25^{c}	0.35
Pounds of beef per acre[3]	1487^{a}	1217^{b}	1130^{b}	980^{c}	44.5
Carcass Evaluation:					
Conformation grade[4]	17.2^{a}	17.9^{b}	17.8^{b}	17.1^{a}	0.18
Marbling score[5]	13.5^{a}	15.7^{b}	16.3^{b}	16.7^{b}	0.72
Carcass grade, final[4]	17.5^{a}	18.5^{b}	18.4^{b}	18.2^{b}	0.22
Quality grade[4]	18.47	19.38	19.53	19.53	0.32
Fat thickness, 12th rib, in.	0.43	0.44	0.46	0.47	0.026
Rib-eye area, sq. in.	10.80	11.13	11.30	11.30	0.19
Dressing percent	55.5^{a}	58.1^{b}	57.9^{b}	58.3^{b}	0.73

kidney knob percent	2.61[a,b]	2.30[a]	2.80[b]	2.96[b]	0.12
Cutability[6]	2.76	2.72	2.87	2.94	0.11
Selling price per cwt., carcass ($)	41.67	41.97	41.86	41.73	0.10
Av. net return per steer[7] ($)	41.78	51.25	12.01	7.16	--

[1]Includes grain content of corn.

[2]Feed cost on basis of: 32% D.M. corn silage, $8 per ton (29% D.M. = $7.71); Dry sh. corn, $1.12 per bu.; protein supp. (64%) $5.47 per cwt.; mineral mix, $3.67 per cwt.

[3]Pounds of beef per acre on basis of: 100 bu. of corn and 16 ton corn silage per acre.

[4]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

[5]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[6]Cutability: Estimation of percent boneless, trimmed round, rib, loin and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[7]Average net return: based on selling price minus purchase price and feed cost. Purchase price was $18.00 cwt. for the Standards, and $30.00 cwt. for Choice feeders.

[8]Feed data means based on 3 degrees of freedom; all others based on 119.

[a,b,c,d]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

intake and growth rate.

The digestibility of energy increased as the amount of added concentrate (shelled corn) increased, because as more shelled corn is added to the ration, a more highly digestible form of energy was being supplied than corn silage.

Daily gains increased with increasing concentrate levels, with levels III and IV both being significantly higher (daily gains) than either level I or II (see Table 11). Inconsistent with Experiment II, level IV had a significantly higher daily gain than level III.

Concentrate intake and corn silage consumption were inversely related, with corn silage consumption decreasing significantly as concentrate intake rose. Deans et al. (1962) reported an inverse relation between silage intake and concentrate level.

Total daily feed (85% D.M.) intake and total daily feed intake (85% D.M.) per 100 pounds body weight increased significantly as the concentrate level was increased. However, Hughes et al.(1964) reported reduced feed and caloric intake for cattle on a 95 percent concentrate ration compared to a 65 percent ration.

Feed cost per 100 pounds of gain rose as the concentrate level increased, with a significant increase in levels III and IV over level I.

Pounds of beef produced per acre decreased rapidly as the concentrate, corn silage ratio increased. Neumann *et al*. (1960) found that a much larger percentage of steers could be finished from a given acreage of corn as the corn silage-shelled corn ratio increased. They reported a 100 percent increase in beef produced per acre from a complete ration of corn silage versus a full-feed of shelled corn.

The most economical gains were made by steers fed level I; however, these cattle did not gain as rapidly as those fed higher levels. Efficiency of gain (feed consumed per 100 pounds of gain) was highest for levels I and IV, but there were no significant differences for this trait. Newland *et al*. (1962) found no relationship between TDN per pound of gain and energy level. However, Shepard *et al*. (1965) reported that cattle on limited-fed corn and full feed of corn silage required 23.7 percent less TDN per pound of gain at a 20.7 percent lower feed cost than cattle on a full-feed of corn plus silage.

Carcass grade increased significantly from level I to II and then remained unchanged through level IV. Marbling score followed much the same pattern.

Level I had significantly the lowest dressing percent. Generally, this would have been explained by a lower percent of fat in the carcass, but there appeared to be no difference in fat thickness among the four concentrate levels.

A nonsignificant but slight increase in cutability score (indicating a lower percent of boneless, trimmed round, rib, loin and chuck) was apparent as the concentrate level increased.

A significantly higher percent of kidney knob was produced from levels III and IV than II, thus indicating more internal fat being laid down at the higher concentrate levels.

Neumann et al. (1962) noted that as the percent silage increased in a shelled corn and corn silage ration, outside fat was reduced, marbling increased, and yield of lean trimmed cuts improved.

Considering all grades and breeds combined as presented in Table 10, there was not a consistent relationship between concentrate levels and the various economic and performance factors studied. The higher concentrate levels resulted in significantly greater gains at the expense of greater feed costs, less beef produced per acre and less net return per steer. Surprisingly, adding concentrates beyond 0.5% (level II) did not result in improvement of any of the carcass traits studied. Under the conditions of this experiment, that is relative prices, etc., and when grades and breeds are combined, there appears to be no one optimum concentrate level for a silage feeding program which combines all factors; the higher levels having the advantage from the standpoint of length of time in the feedlot, and the lower levels being more economical and yielding more beef per acre.

Comparison of Four Concentrate Levels Within Two Feeder Grades

Table 11 summarizes the comparison of four concentrate levels: I, 0.0; II, 0.5; III, 1.0; IV, 1.5 pounds of total concentrate (shelled corn and 64% protein) added daily

Table 11. Exp. III - Means for performance and carcass traits by concentrate level within feeder grade and test of significance between means within feeder grades.

	Choice				
	0.0	0.5	1.0	1.5	Std. error of means[8]
No. steer calves	16	16	16	16	--
Av. initial wt., lb.	476	475	473	473	--
Av. final wt., lb.	970	1013	1026	990	--
Av. daily gain, lb.	2.03^{a}	2.21^{b}	2.43^{c}	2.56^{c}	0.06
Av. daily ration:					
Corn silage, lb.	43.9^{a}	39.9^{b}	34.7^{c}	28.4^{d}	0.65
Gr. shelled corn, lb.	0.00^{a}	2.66^{b}	6.28^{c}	9.65^{d}	0.065
Protein suppl. (64%)	1.02	1.00	1.00	1.00	--
Mineral mix	0.07	0.07	0.08	0.08	--
Total (85% D.M.), lb.	16.7^{a}	18.0^{b}	19.6^{c}	20.6^{d}	0.15
Feed consumed/cwt. gain, lb. (85% D.M.)	802	870	817	808	23.2
Daily feed per 100 lb. B.W.					
Total (85% D.M.), lb.	2.31	2.54	2.62	2.86	0.083
Concentrate, lb.[1]	1.06^{a}	1.32^{b}	1.68^{c}	2.08^{d}	0.025
Roughage, lb.	1.25^{a}	1.12^{b}	0.94^{c}	0.78^{d}	0.020
Concentrate, roughage ratio	46:54	54:46	64:36	73:27	--
Feed cost per gain ($)[2]	11.49	13.34	13.20	14.12	0.65
Pounds of beef per acre[3]	1511^{a}	1191^{b}	1214^{b}	982^{c}	25.44
Carcass Evaluation:					
Conformation grade[4]	19.13	19.94	20.06	19.63	0.31
Marbling score[5]	14.56^{a}	18.31^{b}	17.56^{b}	18.50^{b}	1.03
Carcass grade, final[4]	18.94	20.13	19.63	20.06	0.35
Quality grade[4]	19.38^{a}	20.56^{b}	$19.88^{a,b}$	20.75^{b}	0.15
Fat thickness, 12th rib, in.	0.61	0.65	0.68	0.67	0.05
Rib-eye area, sq. in.	11.34	11.74	11.82	11.63	0.32
Dressing percent	57.2^{a}	$58.4^{a,c}$	59.3^{c}	60.0^{c}	0.68
Kidney knob percent	2.78^{a}	2.26^{b}	$2.60^{a,b}$	$2.61^{a,b}$	0.16

Cutability[6]	3.11	3.10	3.30	3.29	0.19
Selling pr.($) per cwt., carcass	42.53[a,b]	42.81[a]	42.34[b]	42.53[a,b]	0.15
Av. net return per steer[7]($)	37.22	37.17	42.70	37.72	--
			Standard		
No. steer calves	16	16	16	16	--
Av. initial wt., lb.	554	552	553	554	--
Av. final wt., lb.	1016	979	1009	1024	--
Av. daily gain, lb.	2.37[a]	2.36[a]	2.52[a]	2.86[b]	0.11
Av. daily ration:					
Corn silage, lb.	53.3[a]	48.5[b]	39.8[c]	34.1[d]	0.91
Gr. shelled corn, lb.	0.00[a]	3.00[b]	6.75[c]	10.79[d]	0.038
Protein suppl. (64%)	1.00	1.00	1.00	1.01	--
Mineral mix	0.17	0.16	0.16	0.16	--
Total (85% D.M.), lb.	19.4[a]	20.7[b]	21.4[c]	23.3[d]	0.29
Feed consumed/cwt. gain, lb. (85% D.M.)	820	832	853	812	15.4
Daily feed per 100 lbs. B.W.					
Total (85% D.M.), lb.	2.48[a]	2.65[b]	2.74[c]	2.95[d]	0.026
Concentrate, lb.[1]	1.17[a]	1.47[b]	1.78[c]	2.16[d]	0.014
Roughage, lb.	1.31[a]	1.19[b]	0.96[c]	0.79[d]	0.014
Concentrate, roughage ratio	47:53	55:45	65:35	73:27	--
Feed cost per gain ($)[2]	11.20[a]	11.84[a]	13.88[b]	14.39[b]	--
Pounds of beef per acre[3]	1464[a]	1244[b]	1046[c]	978[c]	23.5
Carcass Evaluation:					
Conformation grade[4]	15.25[a]	15.88[b]	15.56[a,b]	14.56[c]	0.18
Marbling score[5]	12.44	13.13	15.13	14.88	1.01
Carcass grade, final[4]	16.00[a]	16.88[b,c]	17.19[b]	16.38[a,c]	0.27
Quality grade[4]	17.56	18.19	19.19	18.31	0.53
Fat thickness 12th rib, in.	0.24	0.24	0.24	0.27	0.020
Rib-eye area, sq. in.	10.27	10.51	10.78	10.97	0.22
Dressing percent	53.9	57.7	56.4	56.7	1.28
Kidney knob percent	2.44[a]	2.34[a]	3.00[b]	3.31[b]	0.16
Cutability[6]	2.41	2.34	2.46	2.59	0.31
Selling pr.($) per cwt., carcass	40.81[a]	41.13[a,b]	41.38[b]	40.94[a]	0.15
Av. net return per steer[7] ($)	72.02	82.05	76.35	60.35	--

Table 11. Continued (Footnotes).

[1]Includes grain content of corn.

[2]Feed cost on basis of: 32% D.M. corn silage, $8.00 per ton (29% D.M. = $7.71); Dry sh. corn, $1.12 per bu.; protein suppl. (64%) $5.47 per cwt.; mineral mix, $3.67 per cwt.

[3]Pounds of beef per acre on basis of: 100 bu. of corn and 16 ton corn silage per acre.

[4]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

[5]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[6]Cutability: Estimation of percent boneless, trimmed round, rib, loin and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[7]Average net return: based on selling price minus purchase price and feed cost. Purchase price was $18.00 cwt. for the Standards, and $30.00 cwt. for Choice feeders.

[8]Feed data means based on 3 degrees of freedom; all others based on 119.

[a,b,c,d]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

per 100 pounds of body weight within the Choice and Standard feeder grade of steers. There was a significant inverse relationship between corn silage intake and the amount of concentrate added within both feeder grades. Total daily feed intake (85% D.M.) increased significantly with each increase in concentrate level for both Choice and Standard grades. Total daily feed intake per 100 pounds of body weight also increased significantly with rising concentrate levels for the Standard feeders; however, there was no significant difference between levels for the Choice feeder grade.

Within the Choice feeder grade, average daily gains increased significantly with each added level of concentrate up to level III, and then rose slightly to level IV. Level II appeared to have the lowest feed efficiency, although there were no significant differences between levels in the Choice feeders. Levels II, III and IV produced carcasses with significantly more marbling than level I; however, there was no significant difference between carcass grade for the Choice steers. Dressing percent was higher for levels III and IV compared with level I ($P < .05$). Feed costs rose slightly from level I to level II, decreased at level III and then increased up to level IV. These differences were not significant. Average net return per steer, calculated with actual prices, favored level III; however, this was not statistically analyzed. From the data in Table 11, one pound of total concentrate added daily to a full-feed of corn silage seemed to be the optimum level for Choice feeders. This conclusion was based on performance (daily gain) along with adequate carcass cut-out and favorable profit (average net return).

Within the Standard feeder grade, average daily gain rose slightly from level I up to level III, then increased significantly from level III to level IV. Feed efficiency of the Standards did not change significantly with the different concentrate levels; however, feed cost per pound of gain was higher for levels III and IV than levels I or II ($P < .05$). Carcass grade favored level III over level I and IV ($P < .05$). Pounds of beef produced per acre of corn decreased significantly as concentrate level rose. Kidney fat percentage was higher for levels III and IV than levels I or II for the Standards, indicating more internal fat deposition. Average net return favored levels II and III; however, this was primarily due to a lower dressing percentage for level I. For Standard grade steers, a full-feed of corn silage without added concentrate would appear to be adequate for performance (daily gain), and was superior in economy of gain and pounds of beef produced per acre. However, a small amount of added concentrate (0.5% of body weight) appeared necessary for desired carcass grade and net return over feed costs.

Comparison of Standard and Choice Grade Feeders

Means of performance and carcass data by feeder grades and tests of significance between means are shown in Table 12.

Table 12. Exp. III - Means for performance and carcass traits by feeder grade and test of significance between means.

	Choice	Standard	Std. error of means[7]
No. steer calves	64	64	--
Av. initial wt., lb.	474[a]	553[b]	--
Av. final wt., lb.	1000	1007	--
Av. daily gain, lb.	2.31[a]	2.53[b]	0.41
Av. daily ration:			
Corn silage, lb.	36.7[a]	43.9[b]	0.40
Dry sh. corn, lb.	4.65[a]	5.13[b]	0.030
Protein supp. (64%) lb.	1.01	1.00	--
Mineral mix, lb.	0.07	0.16	--
Total (85% D.M.), lb.	18.7[a]	21.2[b]	0.11
Feed consumed/cwt.gain, lb. (85% D.M.)	824	830	20.3
Daily feed per 100 lb. B.W.			
Total (85% D.M.), lb.	2.58[a]	2.70[b]	0.031
Concentrate, lb.[1]	1.53[a]	1.64[b]	0.010
Roughage, lb.	1.02[a]	1.06[b]	0.010
Concentrate, roughage ratio	60:40	61:39	--
Feed cost per 100 pounds gain ($)[2]	13.03	12.83	0.25
Pounds of beef per acre[3]	1224	1183	31.4
Carcass Evaluation:			
Conformation grade[4]	19.69[a]	15.31[b]	0.13
Marbling score[5]	17.23[a]	13.89[b]	0.51
Carcass grade, final[4]	19.69[a]	16.61[b]	0.16
Rib-eye area, sq. in.	11.63[a]	10.63[b]	0.14
Fat thickness, 12th rib, in.	0.65[a]	0.25[b]	0.020
Quality grade[4]	20.14[a]	18.31[b]	0.22
Dressing percent	58.74[a]	56.16[b]	0.52
Kidney knob percent	2.56[a]	2.77[b]	0.083
Cutability[6]	3.20[a]	2.45[b]	0.076
Selling price per cwt., carcass ($)	42.55[a]	41.06[b]	0.072

[1]Includes grain content of corn.

[2]Feed cost on basis of: 32% D.M. corn silage, $8.00 per ton (29% D.M. = $7.71); dry sh. corn, $1.12 per bu.; protein supp. (64%) $5.47 per cwt.; mineral mix, $3.67 per cwt.

[3]Pounds of beef per acre on basis of: 100 bu. of corn and 16 ton corn silage per acre.

[4]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

Table 12. Footnotes, continued.

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[5]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[6]Cutability: Estimation of percent boneless, trimmed round, rib, loin and chuck (U.S D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[7]Feed data means based on 7 degrees of freedom; all others based on 119.

[a,b]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

The Standards were significantly heavier than the Choice feeders at the beginning of this trial, and yet gained significantly more weight per day. Standard steers also consumed significantly more feed per 100 pounds of body weight. This latter comparison was in agreement with Burroughs *et al*. (1965).

Choice feeders had higher feed costs and produced more pounds of beef per acre; however, neither of these differences were significant.

With regards to the carcass evaluation, Choice steers were significantly superior in conformation, marbling, quality grade, final carcass grade, rib eye area, dressing percent, and selling price. Choice feeders also had a lower percent of kidney knob. Standard steers excelled the Choice feeders by having less fat at the 12th rib and a higher estimated percent of boneless, trimmed round, rib, loin, and chuck (indicated by a lower cutability score). Cole *et al*. (1963) and (1964) found that Standard cattle (Holsteins) had significantly lower grading carcasses, less external fat, more kidney fat and yielded more separable lean than Choice feeders (beef-type steers). Ramsey *et al*. (1965), reporting on the same comparison as Cole, found significantly lower dressing percents for the Standards (Holsteins).

Results of this feeder grade comparison are in agreement with those of Experiment II and the results shown by Burroughs *et al*. (1965).

Comparison of Angus, Hereford, Shorthorns and Charolaise x Hereford Breed-types

To further elucidate possible differences in breed-type, comparisons were made of the performance and carcass means with analysis of variance and Duncan's multiple range test (see Table 13).

In agreement with Experiment I, the Shorthorns and Herefords significantly outgained the Angus. The Charolaise x Hereford cross was also significantly superior in daily gain to the Angus.

The Charolaise x Hereford cross received significantly lower carcass grades than the three British breeds. This was primarily a result of having the lowest marbling score and carcass conformation grade.

Angus steers had significantly superior conformation, more marbling, and higher grading carcasses, than the other

Table 13. Exp. III - Means for performance and carcass measurements by breed-type and test of significance between means.

	Angus	Hereford	Shorthorn	Charolaise x Hereford	Std. error of means[4]
No. steer calves	16	16	16	16	--
Av. initial wt., lb.	503	477	424	494	--
Av. final wt., lb.	998	1024	944	1045	--
Av. daily gain, lb.	2.13[a]	2.40[b]	2.28[b]	2.42[b]	0.055
Carcass Evaluation:					
Conformation grade[1]	20.63[a]	19.66[b]	19.44[b]	19.00[b]	0.26
Marbling score[2]	20.56[a]	16.25[b]	17.06[b]	15.06[b]	0.90
Carcass grade, final[1]	20.94[a]	19.44[b]	19.75[b]	18.63[c]	0.29
Quality grade[1]	21.31[a]	19.75[a,b]	20.44[b]	19.06[c]	0.31
Fat thickness, 12th rib, in.	0.76[a]	0.70[a]	0.66[a]	0.50[b]	0.042
Rib-eye area, sq. in.	11.66[a]	11.78[a]	10.25[b]	12.83[c]	0.22
Dressing percent	60.1[a]	58.2[a,b]	57.5[b]	59.2[a,b]	0.64
Kidney knob percent	2.97[a]	2.09[b]	2.68[a]	2.53[a]	0.16
Cutability[3]	3.56[a]	3.20[a]	3.50[a]	2.54[b]	0.16
Selling price per cwt., carcass ($)	42.91[a]	42.53[a]	42.72[a]	42.06[b]	0.16

[1]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Based on 47 degrees of freedom.

[a,b,c]Means on the same line having the same superscript letters do not differ significantly. All others differ significantly ($P < .05$).

three breed-types. This comparsion of the three British breeds was in agreement with Merkel and Bray (1957), and Gregory et al. (1966b).

Significantly less fat was measured at the 12th rib of the Charolaise x Hereford cross compared with the three British breeds, with no difference in fat thickness between the Angus, Hereford, and Shorthorn breed-types. Charolaise x Hereford crossbreeds also had a significantly higher percent (estimated, U.S.D.A. formula) of boneless, trimmed round, loin, rib, and chuck than the other breed-types. This was shown by a lower cutability score for the Charolaise x Hereford cross. Murphey et al. (1960) reported the highly inverse relationship of fat thickness and yield of retail cuts.

A highly significant ($P < .01$) correlation (.85) was found between fat thickness measured at the 12th rib and cutability score, using the animals from Experiment III. Cutability score and percent salable yield from the loin, rib, round, and chuck are inversely related.

Herefords had a significantly lower percent of kidney knob, which agrees with Merkel and Bray (1957) and Butler et al. (1962) and confirms the results of Experiments I and II.

Shorthorns and Angus differed significantly in dressing percent, with the Angus having the largest and Shorthorns the smallest.

Selling price significantly favored the three British breeds--Angus, Herefords, and Shorthorns, primarily a result of their having higher grading carcasses. Selling price was based on carcass grade. Merkel and Bray (1957) reported that a significantly higher price was paid for Angus steers compared to Herefords and Shorthorns, although, this price was also based primarily on carcass grade.

There was no significant interaction between breed-type and concentrate level for any of the traits studied. This was in agreement with Experiment II.

V. SUMMARY

Comparison of Four Concentrate Levels Added to a High Corn Silage Ration

Two experiments were conducted to investigate the effects of adding four levels (I, 0.0; II, 0.5; III, 1.0; and IV, 1.5 pounds of total concentrate per 100 pounds of body weight added daily to a full-feed of corn silage) on production factors and carcass characteristics of various feeder grades and breed types of cattle.

In Experiment II, the previously mentioned concentrate levels were compared. There were thirty-six steers per level of which three feeder grades--Choice, Good and Standard--and four breed-types--Angus, Hereford, Shorthorn and Charolaise x Hereford cross--were equally represented within each concentrate lot. The following results were obtained:

Average daily gain increased significantly with each increase in concentrate level up to level III and then remained relatively unchanged from level III to level IV. Level III and IV produced significantly higher carcass grades (High Good) than levels I or II (Low Good and Average Good, respectively). Marbling score followed the same pattern as carcass grade, being significantly higher for levels III and IV than level II. Dressing percent, rib-eye area, kidney knob percent, cutability or selling price were not significantly affected by the various concentrate levels studied. Level III, 1.0 pound of concentrate daily per 100 pounds of body weight added to a full-feed of corn silage, was the optimum level from the standpoint of performance (daily gain) and carcass grade for this experiment.

Experiment III was composed of the same ration treatments as Experiment II; however, only two feeder grades, Choice and Standard were represented in this trial. The same four breed-types made up the Choice grade, and Holsteins represented the Standard grade. There were 32 steer calves per ration treatment. The following observations were made:

Concentrate levels III and IV produced significantly higher average daily gains than either level I or II. Level IV significantly increased daily gain from level III. There was no significant difference for feed efficiency. A significant inverse relationship between the amount concentrate added and silage consumption was observed. Total daily dry matter (85% D.M.) intake and total daily feed intake (85% D.M.) per 100 pounds of body weight increased significantly as the concentrate level increased. Feed cost steadily rose at this higher concentrate level, with levels III and IV showing significantly higher costs per 100 pounds of gain than level I. Pounds of beef produced per acre of corn decreased rapidly as concentrate level rose, with level I producing significantly the highest and level

IV significantly the lowest, with levels II and III intermediate. Carcass grade increased significantly from level I (High-Good) to level II (Low-Choice) and then remained approximately the same with each increase of concentrate up to level IV.

Considering the pooled response from Experiment II and III it was difficult to designate a specific concentrate level for a high corn silage program which was optimum in all respects. This was particularly true where the various grades were averaged. From the standpoint of daily gains and carcass desirability, the 1.0 percent level of concentrates appeared most optimum, while the lower levels resulted in higher net returns per steer and more pounds of beef produced per acre of corn.

Comparison of Four Concentrate Levels Within Various Feeder Grades

Two experiments were analyzed for differences in performance and carcass merit while comparing four concentrate levels (I, 0.0; II, 0.5; III, 1.0; IV, 1.5 pounds of total concentrate per 100 pounds of body weight added daily to a full-feed of corn silage) within various feeder grades.

In Experiment II, 48 Choice, 48 Good and 48 Standard feeders were equally divided into the four specified concentrate treatments within each respective feeder grade. The following results were observed: within the Choice and Good feeder grades, average daily gain increased significantly with each increase in concentrate up to level III and then declined slightly at level IV. Carcass grade was significantly higher for levels III and IV than level II within the Choice feeder grade. For the Good feeder grade carcass grade was significantly higher for levels III and IV than level I. Carcass grade dropped nonsignificantly from level III to level IV for both the Choice and Good feeder grades. There was no significant effect of concentrate level on the other carcass traits studied. Level III, 1.0 percent of total concentrate added daily to a full-feed of corn silage, appeared to be the most optimum in this experiment for maximum daily gain and carcass grade among the Good and Choice feeders. There were no significant differences in rate of gain or any of the other traits studied as a result of varying concentrate level within the Standard grade. Performance data alone in this experiment would dictate full-feeding of corn silage without added concentrates for Standard grade feeders. There appeared to be no significant advantage of adding concentrate to their ration. There was a significant interaction between feeder grade and concentrate level for average daily gain and this can be explained by the previously mentioned significant relationship between concentrate level and daily gain for the Choice and Good grade feeders, while there was no significant relationship between the factors for the Standard feeders.

In Experiment III, 64 Choice and 64 Standard feeders were equally divided into the four specified concentrate treatments within each respective feeder grade. The following observations were made:

Within the Choice feeder grade average daily gain increased significantly with each increase in concentrate level up to level III and then rose slightly to level IV. One pound of concentrate added per 100 pounds of body weight (level III) to a full-feed of corn silage appeared to be the most adequate concentrate level for optimum feedlot performance. There was no significant increase in feed cost as concentrate level rose to this level nor was there any significant difference in feed efficiency. Thus, the increase in daily gain decidedly favored this level for optimum performance within the Choice feeders. Final carcass grade was not related significantly to concentrate level; however, dressing percent was higher for levels III and IV compared with level I ($P < .05$). Cutability did not vary greatly from one concentrate level to the next ($P < .05$). Average net return per steer based on actual prices favored level III; however, this was not analyzed statistically. When considering the most desirable combination of results, level III appeared to be the most optimum for performance, profit, and carcass cut-out.

For the Standard feeders, average daily gain increased slightly up to level III, and then rose significantly from level III to level IV, with no large difference in feed efficiency for the various concentrate levels ($P < .05$). Pounds of beef produced per acre decreased significantly as concentrate level increased. Average net return based on current prices favored levels II and III over level I. This was due primarily to a lower dressing percent for level I. It appears that a full-feed of corn silage without added concentrate would be adequate for performance (daily gain); however, level II, 0.5 pounds of total concentrate added daily to a full-feed of corn silage, would be favored in terms of net return and carcass grade, values for net return were not statistically analyzed.

There was a significant interaction between feeder grade and concentrate level for kidney knob percent. This seemed to result from the higher ($P < .05$) percentage of kidney knob for levels III and IV than level I or II within the Standard feeders, while the Choice feeders showed no increase in kidney knob percent at the two higher levels compared to the two lower levels.

Comparison of Various Feeder Grades for Performance and Carcass Merit

Two experiments were analyzed for differences in performance and carcass characteristics of 112 Choice, 112 Standard and 48 Good grade feeders. The Good grade steers were compared only in Experiment II with the Choice and Standards. These grades were compared when fed four different concentrate rations.

The following results were obtained in Experiment II from comparing 48 Choice, 48 Good and 48 Standard feeders.

Choice grade feeders had significantly larger rib-eye areas, higher dressing percents, and higher carcass grades than the Good grade feeders. Standard grade feeders were significantly higher than Choice and Good grade calves in average daily gain, had less fat thickness over the rib-eye, and a greater percentage of boneless, closely trimmed round, rib, loin and chuck (estimated with U.S.D.A. cutability formula). Choice and Good feeders both exhibited significantly larger rib eye areas, higher dressing percents, higher carcass grades, and superior carcass prices than Standard feeders.

Experiment III compared the 64 Choice and 64 Standard (Holsteins) feeders for the same traits as the previously mentioned trial with the addition of feed intake and efficiency data.

Average daily gain significantly favored the Standard over the Choice grade (2.53 vs. 2.31 lb. daily) with no significant difference between the two grades for feed consumed per 100 pounds of gain (feed efficiency). The Standards (Holsteins) consumed significantly more feed daily (85% D.M.) on a total basis and when compared per 100 pounds of body weight. No significant difference was found for feed cost and pounds of beef produced per acre. Carcass evaluation found Standards to have significantly less fat thickness at the 12th rib (.40 inch less), and higher estimated percent of boneless, closely trimmed round, rib, loin, and chuck (indicated by lower cutability score). Choice grade feeders had significantly superior carcass conformation, more marbling, higher quality and carcass grades (average Choice vs. average Good). Choice steers also had a higher dressing percent (58.74% vs. 56.15%), lower kidney fat percent (0.21% less), and higher average carcass prices.

Comparison of Various Breed-Types

Three experiments, involving a total of 142 steer calves were conducted to study the relationship of various breed-types to performance and carcass merit.

Ten Angus, 10 Hereford and 10 Shorthorn steers representing several sires and farm locations were group-fed and compared on a high-roughage ration until they individually reached 950 pounds. The Hereford and Shorthorn calves significantly outgained the Angus. Herefords dressed significantly lower and had a significantly higher percent of hide than the other two breeds. Significantly less fat was measured over the rib-eye of Herefords than the Angus or Shorthorns. Shorthorn steers had significantly the smallest rib-eye measurement of the three breeds. Angus steers were rated significantly higher for carcass conformation, marbling, and carcass grade than Herefords and nonsignificantly higher than Shorthorns. On a trimmed wholesale cut basis, Herefords had a significantly higher percent of preferred and lean cuts and a significantly lower percent of belly cuts than either the Angus or Shorthorns. Percent rib significantly favored the Angus and Herefords. All three breeds were significantly different for percent round with

Herefords ranking highest, the Angus lowest, and Shorthorns intermediate. Herefords had a significantly lower percent of kidney knob than the other two breeds. A very fundamental measure of cut-out, boneless closely trimmed wholesale cuts significantly favored the Herefords over the other two breeds for round, chuck, preferred cuts, lean cuts and lean cuts plus belly cuts, respectively, based upon a percent of the left side of the carcass. Angus and Hereford steers had a significantly higher percent of boneless, closely trimmed rib than the Shorthorns. There were no significant differences found for tenderness, juiciness, flavor, or overall eatability between breeds.

Twenty-eight Angus, 28 Herefords, 28 Shorthorns and 28 Charolaise x Hereford crossbreds were compared in two experiments for performance and carcass merit, when fed four different rations, varying in the amount of concentrate added. There was no interaction between concentrate level and breed-type, and thus, all significant differences were considered to be significant at every concentrate level. Shorthorns and Charolaise x Hereford crossbred steers were significantly superior in average daily gain to Angus steers in both experiments. In Experiment III, Herefords were significantly higher in daily gain than Angus, but in Experiment II they were slightly lower in daily gain than Angus steers, and significantly lower than Shorthorns and the crossbreds. These conflicting results must be explained by sampling error. The Angus steers had the highest marbling score and carcass grade, the crossbreds the lowest, for these two traits, with Shorthorns and Herefords intermediate in Experiments I and II. These differences were significant in Experiment III, with the following exception: the Charolaise x Hereford cross did not have significantly less marbling than the Herefords or Shorthorns. The Charolaise x Hereford cross had less fat thickness at the 12th rib and a higher estimated percent of boneless closely trimmed lean cuts (round, rib, loin, and chuck), than the other breed-types compared in Experiments I and II. These differences were statistically significant in Experiment III. Herefords had a lower percent of kidney knob than the other breed-types, significantly lower in Experiment III.

VI. CONCLUSIONS

The results obtained from this investigation have led the author to make the following conclusions:

1. When four concentrate levels were fed, 0.0, 0.5, 1.0, and 1.5 pounds of total concentrate added daily per 100 pounds of body weight to a full-feed of corn silage with all feeders, it was impossible to designate a specific concentrate level which was the most optimum for performance and carcass merit. From the standpoint of daily gains and carcass desirability, the 1.0 percent level of added concentrate was the most optimum, however, in terms of net return per steer and pounds of beef produced per acre the lower levels were more desirable.

2. One pound of total concentrate (shelled corn and protein supplement) per 100 pounds of body weight was the most optimum level to add to a full-feed of corn silage for the Choice and Good grade feeders. For Standard grade feeders, a full-feed of corn silage without added concentrate was the most optimum for performance and pounds of beef produced per acre of corn, however, average net return per steer and carcass grade favored 0.5 pounds of added concentrate per 100 pounds of body weight to a full-feed of corn silage.

3. When various feeder grades were compared without

regard to concentrate level, the following conclusions were made:

Standard grade feeders had significantly higher average daily gains than Choice or Good grade feeders. Standard feeders also had significantly less fat thickness over the rib-eye and a higher percentage of boneless closely trimmed lean cuts (round, rib, loin and chuck) than the Choice or Good grade feeders. Choice and Good grade feeders both had significantly larger rib eye areas, higher dressing percents, higher carcass grades, and superior carcass prices than the Standard feeders. The Standard feeders consumed significantly more feed daily (85% D.M.) on a total basis and when compared per 100 pounds of body weight than the Choice feeders. Choice grade cattle had significantly larger rib-eye areas, higher dressing percents and higher carcass grades than Good grade calves, but these two grades were comparable in feedlot performance.

4. When Angus, Hereford, Shorthorn and Charolaise x Hereford breed-types were compared on four different con-concentrate rations and a full-feed of corn silage the following conclusions were made:

Shorthorn and Charolaise x Hereford steers significantly outgained Angus steers. The Charolaise x Hereford steers had significantly less fat thickness at the 12th rib and a higher percent of boneless closely trimmed lean cuts (round, rib, loin, and chuck) than Angus, Hereford or Shorthorn steers. Herefords had a significantly lower percentage of kidney knob than the other breed-types studied. Angus steers had significantly higher conformation grade, more marbling, and higher grading carcasses than the other breed-types.

5. When comparing Angus, Herefords, and Shorthorn steers on a high roughage ration for the entire feeding period, the following conclusions were made:

Herefords and Shorthorn steers had significantly higher average daily gains than Angus calves. Herefords dressed significantly lower and had a significantly higher percent of hide than Angus or Shorthorns. Herefords had significantly less fat thickness over the rib-eye than the other two breeds. Rib-eye area was significantly smaller for Shorthorns than Angus or Herefords. Angus steers were significantly higher in carcass conformation, marbling, and carcass grade than Herefords and nonsignificantly higher than the Shorthorns. Herefords were significantly higher for percent of lean and preferred cuts on a trimmed wholesale cut basis and as a percent of boneless closely trimmed cuts of the left side of the carcass than the Angus or Shorthorn steers.

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APPENDIX

Appendix Table 1. Exp. II -- Means of performance and carcass traits for various concentrate levels on regular corn silage vs. high energy corn silage.

	Regular Corn Silage				High-Energy Corn Silage			
	Percent concentrate added				Percent concentrate added			
	0.0	0.5	1.0	1.5	0.0	0.5	1.0	1.5
No. steer calves	24	24	24	24	12	12	12	12
Days on experiment	159	159	152	152	152	138	152	138
Ave. initial wt., lb.	630	630	630	631	630	633	632	631
Ave. final wt., lb.	981	1009	1034	1029	1038	1053	1053	1044
Ave. daily gain, lb.	2.21	2.38	2.66	2.62	2.69	2.90	2.77	3.01
Ave. daily ration:								
Corn silage	51.01	42.87	37.73	28.17	45.54	37.34	32.47	23.12
Gr. shelled corn	--	3.35	7.16	11.09	--	3.33	6.81	10.64
Protein supp.(64%)	.71	.71	.70	.70	.98	.98	.99	.99
Mineral mix	.12	.14	.13	.12	.13	.14	.14	.13
Total (85% D.M.)	18.84	18.94	20.96	21.58	20.24	20.13	21.58	21.47
Daily feed per 100 lb. body wt.								
Total (85% D.M.)	2.27	2.29	2.51	2.59	2.42	2.40	2.54	2.55
Concentrates in corn	.95	.79	.68	.51	1.20	.99	.85	.61
Added concentrates	.09	.50	.95	1.42	.12	.52	.93	1.39
Roughage	1.23	1.01	.88	.66	1.10	.89	.76	.55
Concentrate: Roughage ratio[1]	46:54	56:44	65:35	75:25	55:45	63:37	70:30	78:22
Feed consumed per cwt. gain: (85% D.M. basis)	834	796	788	825	752	694	779	713
Feed cost per cwt. gain[2] ($)	10.54	11.26	12.14	13.89	10.69	10.73	12.83	12.77
Selling price[3] live[3] ($)	24.83	25.11	25.36	25.33	25.17	25.31	25.19	26.50

Carcass evaluation:								
Quality grade[4]	8.29	8.00	9.75	9.16	9.27	8.75	8.92	9.27
Conformation grade[4]	8.08	8.08	8.83	8.56	9.00	8.92	9.25	8.64
Marbling score[5]	12.00	11.38	15.00	13.79	15.55	13.33	14.25	15.64
Fat thickness, 12th rib, in.	.45	.48	.57	.51	.53	.60	.61	.58
Rib eye area, sq. in.	10.11	10.23	10.18	10.50	9.76	10.47	10.48	10.48
Dressing percent	58.44	58.36	57.66	58.45	57.99	57.68	57.85	57.73
Kidney knob, %	1.75	1.77	1.78	1.87	--	--	--	--
Cutability[6]	49.4	49.2	48.5	49.3	--	--	--	--

[1]Includes grain content of corn silage.

[2]Feed prices used: regular corn silage, $7 per ton; high energy corn silage, $10 per ton; shelled corn, $1.10 bu.; 64% protein supplement, $5.47 cwt.; mineral mix, $3.47 cwt.

[3]Selling price: actual return for each carcass divided by off-experiment weight.

[4]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[5]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[6]Cutability: Estimation of percent boneless, trimmed round, rib, loin and chuck (U.S.D.A. multiple regression formula).

Appendix Table 2. Exp. II -- Least square means for performance and carcass traits by concentrate level within breed-types and test for significance of concentrate level x breed-type interaction.

	Percent Concentrate Added								
	Angus				Hereford				Std. error of means[5]
	0.0	0.5	1.0	1.5	0.0	0.5	1.0	1.5	
No. steer calves	3	3	3	3	3	3	3	3	--
Ave. initial wt., lb.	649	653	633	620	594	632	649	625	
Total gain, lb.	322.1	375.5	406.1	350.8	318.8	344.1	375.1	372.5	20.18
Ave. daily gain, lb.	2.09	2.51	2.70	2.43	2.07	2.32	2.50	2.56	0.14
Live slaughter grade[1]	11.58	11.92	11.25	10.25	9.91	10.58	11.25	10.58	0.57
Carcass Evaluation:									
Conformation grade[1]	11.22	12.22	9.55	12.21	9.22	9.55	9.89	11.22	1.41
Marbling score[2]	18.68	15.68	15.34	15.34	13.68	11.34	17.01	16.68	2.74
Carcass grade (final)[1]	10.90	10.56	11.23	10.56	8.90	8.23	10.90	10.56	0.91
Fat thickness, 12th rib, in.	.78	.73	.66	.66	.52	.61	.92	.68	0.13
Rib-eye area, sq. in.	10.27	11.26	11.55	11.28	10.30	11.52	9.97	10.53	0.62
Kidney knob, per-cent	1.86	2.06	1.76	2.14	1.79	1.73	1.52	1.67	0.25
Cutability[3]	3.82	3.60	3.26	3.49	3.05	3.06	4.31	3.41	0.44
Selling price per cwt., live[4]	$26.46	$26.98	$27.12	$26.76	$26.70	$27.16	$26.75	$26.46	0.81

Table 2. Footnotes.

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 30 degrees of freedom.

Appendix Table 2 -- Continued.

	Percent Concentrate Added								Std. error of means[5]
	Shorthorn				Charolaise x Hereford				
	0.0	0.5	1.0	1.5	0.0	0.5	1.0	1.5	
No. steer calves	3	3	3	3	3	3	3	3	
Ave. initial wt., lb.	701	662	655	681	620	629	631	629	
Total gain, lb.	364.1	388.8	435.5	359.8	371.1	386.7	402.1	428.8	20.18
Ave. daily gain, lb.	2.36	2.60	2.89	2.48	2.40	2.54	2.68	2.96	0.14
Live slaughter grade[1]	11.25	11.25	12.25	10.91	9.92	8.92	10.58	10.58	0.57
Carcass Evaluation:									
Conformation grade[1]	10.22	6.55	8.89	12.22	8.89	7.89	9.22	9.55	1.41
Marbling score[2]	14.34	9.01	13.34	13.68	13.34	12.34	14.68	13.01	2.74
Carcass grade (final)[1]	9.56	6.56	10.23	10.23	8.90	7.90	9.56	9.22	0.91
Fat thickness, 12th rib, in.	.50	.65	.72	.78	.60	.48	.61	.62	0.13
Rib-eye area, sq. in.	10.23	9.61	10.58	9.86	9.94	10.76	11.33	11.42	0.62
Kidney knob, percent	1.61	1.71	1.90	1.89	1.69	1.30	1.64	2.17	0.25
Cutability[3]	3.36	3.77	3.86	4.20	3.44	2.94	3.10	3.57	0.44
Selling price per cwt., live[4]	$26.89	$24.66	$26.66	$27.70	$25.69	$26.62	$26.11	$25.57	0.81

Table 2 -- Footnotes.

[1]Coded: 5 = Standard; 8 = Good; 11 = Choice; 14 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Selling price: Actual return for each carcass divided by off experiment weight.

[5]Based on 30 degrees of freedom.

Appendix Table 3. Exp. II -- Correlation coefficients[1] between and within carcass and performance parameters.

Traits	Ave. daily gain	Total gain	Live carcass grade	Final price	Conf. grade	Marbling score	Carcass grade	Rib-eye area	Fat Thickness 12th rib	Cold Carcass wt.	Kidney knob %
Total gain	.95	--	--	--	--	--	--	--	--	--	--
Live carcass grade	-.26	-.25	--	--	--	--	--	--	--	--	--
Final carcass price	-.34	-.41	.47	--	--	--	--	--	--	--	--
Conformation grade	-.10	-.17	.50	.56	--	--	--	--	--	--	--
Marbling score	-.09	-.17	.18	.44	.49	--	--	--	--	--	--
Carcass grade	-.05	-.14	.46	.63	.77	.80	--	--	--	--	--
Rib-eye area	.08	.04	.24	.33	.27	.03	.23	--	--	--	--
Fat thickness, 12th rib	.00	-.06	.44	.41	.62	.37	.66	-.01	--	--	--
Cold carcass wt.	.39	.39	.22	.48	.25	.10	.26	.33	.24	--	--
Kidney knob, %	-.11	-.10	.09	.10	.07	.17	.11	-.06	.10	.10	--
Cutability score	.05	.02	.32	.32	.46	.33	.52	.38	.89	.30	.23

[1]All correlation coefficients above .164 are significant at the 5% level.

All correlation coefficients above .214 are significant at the 1% level. Based on 142 degrees of freedom.

Correlation coefficients were determined from 144 animals used in Experiment II.

Appendix Table 4. Exp. III -- Means for performance and carcass traits by concentrate level within breed-type and test of significance for concentrate level x breed type interaction.

	Percent Concentrate added								Std. error of means[4]
	Angus				Hereford				
	0.0	0.5	1.0	1.5	0.0	0.5	1.0	1.5	
No. steer calves	4	4	4	4	4	4	4	4	
Av. initial wt., lb.	505	507	499	500	478	476	478	477	
Av. final wt., lb.	960	1025	985	981	1007	1007	1078	1006	
Av. daily gain, lb.	1.87	2.12	2.13	2.38	2.17	2.17	2.64	2.62	0.11
Carcass Evaluation:									
Conformation grade[1]	19.75	21.00	21.50	20.25	19.25	20.00	20.50	19.00	0.53
Marbling score[2]	15.25	22.25	22.50	22.25	15.00	16.25	15.75	18.00	1.80
Carcass grade (final)[1]	20.00	21.75	21.25	20.75	19.25	20.00	19.25	19.25	0.57
Quality grade[1]	20.75	22.00	21.25	21.25	19.50	20.25	19.25	20.00	0.62
Fat thickness, 12th rib, in.	0.66	0.96	0.66	0.76	0.70	0.66	0.82	0.60	0.085
Rib-eye area, sq. in.	10.84	11.80	12.61	11.39	11.76	11.71	11.73	11.93	0.44
Dressing percent	58.6	61.2	60.3	60.4	55.3	58.9	58.8	59.8	1.28
Kidney knob	3.50	2.42	3.08	2.88	2.38	1.78	2.00	2.20	0.31
Cutability[3]	3.57	4.04	3.02	3.63	3.12	3.06	3.66	2.96	0.31
Selling price, per cwt., carcass ($)	43.00	43.00	43.00	43.00	42.63	43.00	42.25	42.25	0.32

Appendix Table 4. Footnotes.

[1]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent bonless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4.

[4]Based on 47 degrees of freedom.

Appendix Table 4 -- Continued.

	Percent Concentrate Added								
	Shorthorn				Charolaise x Hereford				Std. error of means[4]
	0.0	0.5	1.0	1.5	0.0	0.5	1.0	1.5	
No. steer calves	4	4	4	4	4	4	4	4	
Av. initial wt., lb.	428	421	425	421	494	495	494	495	
Av. final wt., lb.	927	955	957	939	990	1068	1088	1036	
Av. daily gain, lb.	2.04	2.20	2.33	2.56	2.04	2.35	2.60	2.68	0.11
Carcass Evaluation:									
Conformation grade[1]	19.00	19.50	18.75	20.50	18.50	19.25	19.50	18.75	0.53
Marbling score[2]	16.25	19.25	17.00	15.75	11.75	15.50	15.00	18.00	1.80
Carcass grade (final)[1]	19.00	20.00	19.25	20.75	17.50	18.75	18.75	19.50	0.57
Quality grade[1]	19.50	20.75	20.00	21.50	17.75	19.25	19.00	20.25	0.62
Fat thickness, 12th rib, in.	0.65	0.59	0.66	0.74	0.45	0.38	0.58	0.59	0.085
Rib-eye area, sq. in.	9.95	10.19	10.51	10.36	12.82	13.27	12.42	12.84	0.44
Dressing percent	57.1	54.5	59.0	59.2	57.7	59.1	59.3	60.5	1.28
Kidney knob	2.38	2.93	2.65	2.75	2.88	1.93	2.68	2.63	0.31
Cutability[3]	3.46	3.29	3.50	3.74	2.30	2.04	3.01	2.81	0.31
Selling price, per cwt., carcass ($)	42.63	43.00	42.25	43.00	41.88	42.25	41.88	42.25	0.32

[1]Coded: 14 = Standard; 17 = Good; 20 = Choice; 23 = Prime.

[2]Coded: 11 = Slight; 14 = Small; 17 = Modest; 20 = Slightly abundant.

[3]Cutability: Estimation of percent boneless, trimmed round, rib, loin, and chuck (U.S.D.A. multiple regression formula). Coded: 1 = 54.6; 2 = 52.3; 3 = 50.0; 4 = 47.7; 5 = 45.4

[4]Based on 47 degrees of freedom.

Appendix Table 5. Exp. III -- Correlation coefficients[1] between and within carcass and performance parameters.

Traits	Initial wt.	Av. daily gain	Final carcass price	Conf. grade	Marbling score	Quality grade	Carcass grade	Rib-eye area	Fat thickness 12th rib	Hot Carcass wt.	Kidney knob %
Av. daily gain	-.20	--	--	--	--	--	--	--	--	--	--
Final carcass price	-.53	-.23	--	--	--	--	--	--	--	--	--
Conformation grade	-.63	-.22	.82	--	--	--	--	--	--	--	--
Marbling score	-.12	-.02	.59	.45	--	--	--	--	--	--	--
Quality grade	-.20	-.08	.69	.49	.84	--	--	--	--	--	--
Carcass grade	-.48	-.16	.88	.85	.73	.83	--	--	--	--	--
Rib-eye area	-.05	.15	.29	.43	.21	.14	.34	--	--	--	--
Fat thickness	-.52	-.12	.74	.82	.47	.52	.78	.24	--	--	--
Hot carcass wt.	.20	.45	.22	.32	.35	.29	.35	.58	.36	--	--
Kidney knob, %	.19	.11	.04	-.18	.15	.12	.03	-.14	-.04	.00	--
Cutability score	-.35	0.6	.57	.55	.58	.49	.60	-.21	.85	.26	.25

[1]All correlation coefficients above .174 are significant at the 5% level.

All correlation coefficients above .228 are significant at the 1% level. Based on 126 degrees of freedom.

Correlation coefficients were determined from 128 animals used in Experiment II.