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X

FATTENING PATTERNS IN YEARLING STEERS SERIALLY SLAUGHTERED AFTER GRAZING SPRING-SUMMER COOL SEASON GRASS PASTURE

A Thesis

Presented for the

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ABSTRACT

A total of 90 Angus steer calves varying in body type (frame score 1 to 4) were purchased in October 1980 and wintered (October through March) on stockpiled cool season pasture plus limited hay. The steers were grazed 112 days (April through July) on fescue, orchard grass, and ladino clover. The steers' average weight was 221 kg at purchase, 221 kg at end of wintering, and 317 kg at the end of spring-summer grazing. Following the pasture phase, they were randomly assigned, within frame size, to slaughter groups and were serially slaughtered after 0, 28, 56, 84, 112, and 140 days on a ration of whole shelled corn plus supplement.

The carcasses were fabricated according to the procedure of Wellington (1953). Those cuts deemed most logical for use as ground beef were separated into bone and edible portion (lean and fat). Each cut was ground and a representative sample retained for fat determination. All ground cuts from each carcass were then blended and a representative sample taken for total fat determination.

Mean yield grades, live weights, carcass weights, marbling, and percentage fat of the blended samples were: 1.6, 313 kg, 161 kg, PD^{65}, and 12.01% for the group slaughtered at the end of grazing; 1.8, 370 kg, 197 kg, Tr^{67}, and 18.31% for 28 days on feed; 1.9, 402 kg, 211 kg, SL^{93}, and 22.08% for 56 days on feed; 2.6, 455 kg, 245 kg, SM^{79}, and 25.08% for 84 days on feed; 2.8, 479 kg, 267 kg, MT^{24}, and 28.91% for 112 days on feed; and 2.7, 479 kg, 285 kg, MT^{59}, and 32.65% for 140 days on feed.

These data, collected from yearling Angus steers, suggest that acceptable quality and yield grades and an acceptable fat percentage of the ground beef can be obtained after 65 days of grain feeding.

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CHAPTER I

INTRODUCTION

The increase in beef prices and decline in beef supplies has caused consumers to purchase more pork and poultry products and less expensive beef products rather than more expensive cuts of beef. Also, there has been an increase in the number of grain-fed cattle and a decrease in the number of commercial cows in the slaughter mix. Fast-food outlets are the fastest growing segment of the away-from-home market. Hamburger prices are, therefore, experiencing greater inflation than the more expensive cuts of beef.

Thirty-five to 45% of all meals were consumed away from home in 1979. Approximately 45% of the beef produced in this nation was eaten in restaurants, school cafeterias, and other institutions in that year. Fast-food restaurants used 25% of the cattle slaughtered each day. In 1970, 20% of the beef supply was consumed in the ground form. In 1979, this amount had risen to 45%, and predictions are that it will increase to 60% in the early 1980's. Some of the reasons for this increase in ground beef consumption are convenience, price, palatability, and versatility. Much of this change has been brought about by the fast-food industry. These factors, along with tenderization techniques, new sausage manufacturing techniques, new concepts in structuring of meats and steak, and the consumer demand for leaner meat for health reasons, have stimulated an increased demand for lean beef.

There is, however, still a demand for high quality beef in restaurants and supermarkets catering to an elite clientel. Predictions are that the demand for this type of beef will also continue. The objective of this study was to determine the effects of the length of time high-energy diets are consumed on the characteristics of yearling steers serially slaughtered after summer grazing and feedlot finishing for 28, 56, 84, 112, and 140 days.

CHAPTER II

REVIEW OF LITERATURE

The high price of feed grains has generated renewed interest in alternative feeding regimes involving roughage for growing and finishing cattle. An increased interest in these alternatives results when there is a food grain shortage or when weather or export agreements make grain feeding to cattle for an extended period unprofitable.

Among the systems involving roughage are finishing cattle on grass only, feeding grain to cattle on pasture, growing cattle on grass and finishing on drylot for different lengths of time, or feeding rations containing more roughage to cattle in drylot. Harrison et al. (1978) studied the carcass characteristics of calves which had been: (1) grass-fed on a winter growing ration for 134 days plus 133 days on bromegrass and bluestem pasture; (2) short-fed a finishing ration of 75.2% cracked corn, 20% alfalfa hay, and 4.8% protein for 49 days after a 133-day summer grazing period as in treatment 1; (3) long-fed the short-fed ration for 98 days after grazing the summer pasture; and (4) forage-fed on a 40% corn silage, 20% alfalfa haylage, 36% cracked corn, and 4% supplement ration for 98 days after the summer grazing period. Increasing feeding time appeared to improve the carcass quality characteristics of these cattle. Both the long-fed group and the forage-fed group had significantly higher marbling scores, quality grades, and whiter fat. The forage-fed and long-fed cattle had an average quality grade of low choice, while the grass-fed groups barely graded low good. The authors

suggested that weight gain during the first 49 days of grain feeding was possibly a result of increased muscle size, while the 49-98 days of grain feeding may have been from increased fat deposition. Taste panel palatability responses favored those cattle fed the longest time on feed and the highest plane of nutrition. Steaks from the short-fed and forage-fed groups were found to be similar in tenderness and significantly less tender than those from the long-fed group. Grass-fed beef steaks were less tender than long- and forage-fed beef steaks. Time on feed and not feeding regime appeared to have the main effect on flavor scores. The long-fed and forage-fed beef steaks had similar and superior flavor scores when compared with the short-fed and grass-fed groups. Forage-fed beef steaks were significantly juicier than short-fed and grass-fed groups.

According to Aberle et al. (1981), there is evidence that the feeding of a high-energy diet before slaughter improves beef palatability, but the duration of this improvement is short, and little benefit is obtained from longer feeding periods. Moody et al. (1970) determined that carcass grade increased gradually to low choice at 84 days on feed but did not improve significantly after 84 days. No differences were found in the intramuscular fat (% ether extract) of the longissimus muscle after 56 days. Marbling degree increased with time on feed up to 84 days. No definite trend was found between any of the organoleptic traits and time on feed except for flavor, which was significantly less at 28 days on feed.

Zinn et al. (1970) concluded that the first 180 days on feed had a beneficial effect on tenderness of beef when Hereford steer and heifer

calves were slaughtered at 30-day intervals for 270 days. After 180 days on feed, the age of the animal appeared to have the greatest influence on beef tenderness of the triceps brachii, longissimus, and semimembranosus muscles. The triceps brachii became significantly more tender after 90 days and did not change until 210 days. The longissimus muscle was significantly more tender at 150, 180, and 210 days than at any of the other slaughter periods. The semimembranosus muscle was significantly more tender between 60 and 210 days than at 30 or 240 days on feed. These tenderness evaluations were made by a Warner-Bratzler shear test. Leander et al. (1978) also found that tenderness of both the longissimus and semitendinosus muscles of Hereford steers fed 56 or 112 days on a high concentrate ration increased with days on feed. These steers had been grazed on fescue pasture for 180 days prior to being put in drylot. Smith et al. (1977) found that the reduced taste panel scores of grass-fed steers of numerous breed combinations seemingly disappeared after 49 days on feed. The results were the same when a 20% or a 60% forage ration was fed in drylot.

Zinn et al. (1962) determined that carcass grade increased steadily with days on feed from average standard at zero days to choice at 270 days when cattle were slaughtered at 30-day intervals. Godfrey et al. (1977) fed Angus backgrounded yearling steers a whole shelled corn ration for 90 and 110 days. They found a difference of 1/3 of a quality grade between cattle in the two slaughter groups. The cattle slaughtered after 90 days on feed averaged high good, and the group slaughtered after 110 days on feed averaged low choice. Tatum et al. (1980) found increased

days on feed was associated with an increased percentage of cattle grading choice.

Dinus and Cross (1978) fed steers a forage feedlot diet of alfalfa hay for 105 days and then an 85% concentrate diet of corn grain for zero, three, six, and nine weeks. The length of feeding period did not affect lean color, texture, or firmness. Days on feed were found to have an effect on the increase in marbling degree. Tenderness, juiciness, and amount of connective tissue were similar for all treatments. Therefore, length of the feeding period had little influence on palatability. According to Tatum et al. (1980), only flavor desirability scores were higher for steers fed 100 to 160 days on feed. Juiciness, tenderness, and overall palatability were not affected by length of feeding time.

Longer feeding periods also result in increased fat deposition and lower carcass cutability. Harrison et al. (1978) indicated that cattle fed either a grain or a silage ration for 98 days after grazing had a greater adjusted fat thickness, kidney and pelvic fat, and yield grade than cattle off grass or cattle fed 49 days on a grain ration. Tatum et al. (1980) found that increased time on feed was associated with increased carcass maturity, fat deposition, and yield grade. Dinus and Cross (1978) also found that fat deposition increased with length of feeding period. Moody et al. (1970) studied the effects of feeding Angus yearling steers a high-roughage diet of corn silage ad libitum and ground shelled corn at 1.5% of body weight and serially slaughtered at 28, 56, 84, and 112 days. No significant increase in dressing percent was found after 84 days. Carcass conformation scores increased beyond the 56-day slaughter group but not the 84-day group.

The longissimus muscle area increased as cattle became older and larger but not proportionally to carcass weight.

Forage-finished beef does not compete favorably with grain-finished beef at the retail level. Its acceptability is usually discriminated against because of color of muscle and fat and palatability (mainly flavor and/or tenderness). Bowling et al. (1977) compared forage-finished carcasses of the same maturity and marbling scores but different subcutaneous fat thicknesses. They found the grain-finished beef to be more tender and to possess a more desirable flavor and overall palatability than forage-finished beef. The grain-finished beef possessed the largest amount of subcutaneous fat, longest sarcomeres, and lowest shear force values. High-temperature chilling increased tenderness but did not make it comparable to the tenderness and flavor of grain-finished beef.

Skelly et al. (1978) fed a number of combinations of corn silage, coastal bermuda grass pellets, corn, and urea to weaned steers. Steers on rations not containing grain had the lowest degree of marbling and quality grades and also the lowest taste panel ratings. The authors concluded that beef cattle finished on high forage rations should receive a concentrate such as corn at the level of at least 1% of their body weight to ensure choice grade and desirable palatability characteristics. Reagen et al. (1977) grazed winter pastures of ryegrass rye, oats, ryegrass and arrowleaf clover pasture plus cracked corn ad libitum for 193 days prior to slaughter. Marbling scores were determined to be significantly different between the grass- and clover-fed cattle and the grass-grain supplemented cattle. The degree of marbling was found

to be higher for the grass-grain supplemented cattle even though a chemical fat analysis of the longissimus muscle showed no differences in percent ether extract among the three treatments. Flavor and overall satisfaction sensory scores were highest for the grain supplemented beef after three days' storage in vacuum bags, but no significant differences were found among treatments in degree of juiciness and tenderness.

Davis et al. (1981) examined the effect of forage versus grain feeding of yearling steers which had been backgrounded on a low-energy stockpiled pasture and hay ration. The cattle were then fed: (1) a forage ration of fescue (Ky 31), orchard grass, and ladino clover; (2) a limit-grain feeding, which was fed in order to achieve similar weight gains to the forage-fed group; and (3) a complete grain finishing ration. No significant differences were found between the forage-fed cattle and the limited grain-fed cattle for slaughter weight, total gain, carcass weight, or dressing percent. The grain-finished cattle averaged significantly higher degrees of marbling, lean firmness, lean texture, lean color, and a more desirable white subcutaneous fat. The grain-limited cattle had a better fat color but did not have a higher degree of marbling than the forage-fed cattle. Steaks from the forage-fed cattle had less tenderness, juiciness, flavor, and overall desirability taste panel scores than the limited-grain or grain-finished cattle. Panelists noted that the forage-fed beef had a grassy or dairy flavor and a lack of beefy flavor. Brown et al. (1979) found that flavor scores of ground beef from grass-fed steers was significantly lower than for limited-grain or grain-fed steers. An off-flavor in the grass-fed beef, described

as a grassy, milky, or fishy flavor was most likely responsible for the lower flavor score.

Schroeder et al. (1980) grazed cattle four months, slaughtered some off grass, and slaughtered the remainder after 104 days on an 80% concentrate diet. The added time on grain was found to improve marbling score, lean firmness, lean texture, lean color, and quality grade and increased the amount of extractable fat from various cuts. Cattle from the forage diet had a significant advantage in cutability. The grain-finished beef had higher juiciness, flavor, and tenderness scores and lower shear force values. The taste panelists described the difference in flavor as a "fatty" flavor for the grain-finished beef and a grassy flavor for the forage-finished beef. The authors concluded that forage-finished beef had marketing limitations in reduced shelf life; darker, less attractive color; and decreased palatability (especially tenderness and flavor).

Bryant et al. (1965) indicated that feeding grain to calves on pasture, before putting them in drylot, improved quality grade by 1/2 grade but did not improve the quality grade of yearling steers on pasture. Edwards et al. (1973) fed ten variations of forage diets based on corn silage, corn, and pelleted coastal bermuda grass to Polled Hereford and Angus steers for approximately 210 days and found that the addition of corn in varying amounts to silage or bermuda grass increased carcass grade (choice versus good) and external fat.

Malphrus et al. (1962) compared the quality characteristics and taste panel evaluations of predominately beef breed steers grazed on pasture and fed grain ad libitum to the same characteristics of steers

fed a high-concentrate grain ration in drylot. Drylot steers were fed to a high good grade and pasture steers to an average good. The carcasses had 1/3 quality grade difference. A trained taste panel did not discriminate against the pasture grain-fed beef and gave both groups acceptable flavor and tenderness ratings. They also sold steaks and roasts from these animals through the supermarket and asked consumers to rate them for taste, tenderness, and aroma. No preference was shown for the steaks and roasts from the steers in either category. Edwards et al. (1968) fed Angus and Polled Hereford cattle various combinations of ryegrass, clover, and cracked corn; fescue pasture and corn; and drylot grain plus bermuda grass hay. It was determined that cattle grazed on fescue pasture plus grain ad libitum or ryegrass-clover pasture plus grain ad libitum graded low choice, whereas cattle fed 140 days on grain and bermuda grass in drylot graded high good.

Hunt et al. (1953) found that there was no significant difference in the percent ether extract of the longissimus muscle, tenderness, or overall palatability of two-year-old grade Hereford steers fattened to the same degree of finish on grass or grain. The only difference they found was that the grass-fed cattle had a yellow fat color.

Duncan (1958) determined that a good method for the production of slaughter beef was to winter heavy weanling calves on a low-cost, high-roughage ration, pasture them during the summer (without grain), and finish them in drylot for 56 days. This study was conducted on grade Hereford and Angus-Hereford cross calves. The calves were fed a grain mixture and alfalfa hay in drylot.

Young et al. (1962) compared the effects of corn silage plus limited ground shelled corn versus corn silage for 98 days and then full-fed a ground shelled corn ration for Angus, Hereford, and Angus x Hereford cross steers and heifers. They found that corn, either limit-fed with corn silage or full-fed after silage, produced similar choice yearling carcasses. These cattle were slaughtered when live animal observation appeared to be choice grade.

The genetic resources of the beef cattle population are formed from cattle of widely different types and mature sizes. These differences in the mature size of cattle should provide a number of ways to finish cattle to a desired carcass composition and slaughter weight and, therefore, can be used to increase production efficiency or meet changes in market demand. Byers (1980) suggested that smaller, earlier maturing cattle are better suited to growing-deferred feeding programs than larger cattle because the large cattle will yield unacceptably large carcasses when they finally reach low choice grade and fatness. Although both small and large mature size cattle will grow with similar rates and efficiencies of gain on grain, rate and efficiency of gain favor small size cattle for forage diets. Grain feeding programs, starting with weaned calves, will cause very rapid fat deposition in small and average frame size cattle. This may cause them to reach the optimum carcass fatness at very light weights and young ages, possibly before they have had adequate time to deposit adequate marbling to reach low choice grade. Large size cattle have the ability to deposit more protein per day and are able to reach the carcass fatness required for the acceptable

slaughter grade at an acceptable carcass weight on a long-term, high-energy diet.

Prior et al. (1977) also found that the increase in live weight and carcass weight of small type cattle (Angus x Hereford crossbreds), due to an increase in dietary energy, was a result of increased fat deposition. The carcass fat weight of these cattle increased significantly while moisture and protein decreased as the dietary energy intake was increased. Carcass fat in large type cattle (Charolais, Chianina x Hereford, or Chianina x Angus), however, increased only slightly as energy density of the ration was increased and efficiency of live weight gain was not offset by undesirable carcass composition. Smith et al. (1977), however, found no biological type by feeding regime interaction for composition or palatability traits among numerous British, dairy, and exotic breed combinations of steers. These steers had been fed a variation of forage and/or grain combination with widely differing energy densities. The authors suggested that placing cattle directly into the feedlot on moderate energy rations would minimize excess fat at equal quality grades. Large type steers had slightly lower palatability scores at constant weight but not at constant age or longissimus muscle fat endpoints of 4% ether extract. Feed efficiency was not affected by biological type on a carcass weight or composition constant basis.

Moody (1976) stated that, within limits, nutritional regime of cattle has little effect on beef palatability. Preston (1971) concluded that composition is affected more by slaughter weight and by mature size of cattle than by variations in plane of nutrition within the range of diets that are practical for beef cattle production. Lipsey et al. (1978)

found that later maturing type cattle (Maine-Anjou and Gelbvieh) were more efficient, as well as faster gaining, than Hereford x Angus cross steers. They concluded that physiological maturity as expressed by carcass composition was highly related to the utilization of energy density available for growth and, if fed to the same energy efficiency for growth endpoint, carcass composition of different type steers would be similar.

Although many cattlemen hold the opinion that beef type cattle produce carcasses with a higher proportion of the more valuable cuts and have a higher muscle-to-bone ratio than dairy type cattle, research has shown that fat is the most important variable in determining retail yield (Dikeman et al., 1977). In this study, carcasses were selected on the basis of chilled carcass weight and 12th rib fat thickness. Light-weight carcasses (227-250 kg) and heavy-weight carcasses (318-340 kg) from three major British breeds of cattle and heavy-weight carcasses from Holstein cattle were evaluated. All carcasses had back fat thicknesses (average of three measurements taken along the longissimus muscle) between 6.4 and 12.7 mm. The average back fat thicknesses were 8.1, 11.2, and 9.7 mm for the Holstein, heavy British, and light British groups, respectively. The heavy British carcasses had the largest longissimus muscle area, but the light British group had the largest longissimus muscle area expressed as a percentage of carcass weight in kilograms. The Holstein carcasses had the smallest area per 100 kg carcass weight. The light British group had a greater percentage of total retail cuts and a greater retail cut yield from the round, loin, rib, and chuck than the Holsteins. No difference was found in total retail cut yield of the

Holsteins and heavy British cattle or retail cut yield from the round, loin, rib, and chuck. The heavy British group had a greater total fat trim, fat trim from the round, loin, rib, and chuck and less bone than Holsteins but were no different from the light British group. There was a trend, however, toward more fat trim from the heavy British group. Holsteins had a greater percentage of bone but less percentage of external fat than the light British group. Holstein carcasses did have a greater percentage of total fat trim because of a greater amount of intermuscular fat in the round, loin, rib, and chuck. The authors concluded, from muscle-to-bone and muscle-to-fat ratios, that the effect of muscle development upon retail cut is less marked than the influence of amount and distribution of fat. The muscle-to-bone ratios of both British groups were identical, but the light-weight group was superior in percentage of retail cuts because of less fat. The combined percentage of the four primal cuts from the round, loin, rib, and chuck expressed as a percentage of carcass weight was not different among any of the three groups of carcasses. No differences were observed in proportions of retail cuts from these wholesale cuts. Kidney and pelvic fat comprised a greater proportion of the total fat content of the light British carcasses but seemed to be reduced as external fat became more extensive in the heavy British group of carcasses. Both British groups had a quality grade of low choice, and the Holsteins graded good plus. Carcass yield grades were not different among groups.

Harte and Conniffee (1967b) conducted a study of Friesians, Angus x Shorthorn, and Hereford x Shorthorn steers and found that Friesians had less percentage of total fat but a greater percentage of bone in the

carcass. The other two breed crosses showed little variation in composition. No major differences were found among breeds in percent yield of cuts or percentage of high-priced cuts. The advantage of the lesser muscle-to-bone ratio of the beef breeds was considerably reduced when bone was expressed as a percent of fat-free carcass.

Barber et al. (1981) compared various characteristics of Angus and Charolais steers slaughtered at equal percentages of mature cow weights for each breed. They slaughtered steers from each breed at 86%, 100%, and 114% of mature cow weight, assuming a mature Angus and Charolais cow equaled 476 kg and 612 kg mature weight, respectively. Average daily gain and feed conversion did not differ between breeds in any slaughter group. They concluded that Angus required more total feed energy per unit of lean body weight because they deposited a larger proportion of their weight as fat in all slaughter groups. Mean backfat measurements were less for the Charolais breed in all slaughter groups, and the Angus had a lower cutability of retail cuts. All slaughter groups in the Angus breed were of acceptable palatability, but the light slaughter group was less palatable than the medium and the heavy Charolais cattle groups. Quality grades improved between light and medium slaughter weights for both breeds. Chemical fat analyses of the longissimus muscle were similar between breeds, but Angus graded average choice, and Charolais graded low choice at light slaughter weights. The authors suggested that marbling in the longissimus muscle of Charolais cattle is not as easily observed by graders. Angus reached choice grade at 364 kg shrunk body weight. The Charolais had the same amount of fat in the longissimus muscle as the Angus breed at 464 kg but were not graded

choice until 567 kg body weight. Angus required 79 days on feed and Charolais about 141 days on feed to reach low choice grade.

Cole et al. (1964) conducted an experiment to determine the yield of wholesale cuts and separable muscle, fat, and bone of slaughter animals varying greatly in conformation. They studied animals from six breeds and one breed cross representing British, Zebu, and dairy cattle. British type cattle had a significantly lower percent of untrimmed round, chuck, and foreshank but a higher percent of the fat cuts (flank, plate, and brisket). Zebu-type sides were highest in percent round and chuck but lowest in percent kidney fat. Dairy-type sides had the greatest percent rib and kidney fat but the lowest percent flank and brisket. The fatter breeds had a higher percent of each of the minor wholesale cuts along the belly and, therefore, a lower percent of major wholesale cuts down the back. Most differences in the composition of the major and minor cuts were found to be in muscle and fat but not bone.

Klosterman (1972) said cattle of various types and sizes fed to a similar degree of finish or grade show little, if any, difference in feed efficiency but differ in final weight and rate of gain. Butts et al. (1980) found that "rangy" cattle (large frame score) produced heavier carcasses than compact cattle but were similar in carcass characteristics when slaughtered at a constant fat thickness. Butler (1957) concluded that fatter carcasses cut out at a distinct disadvantage, while a poorly shaped carcass will cut out an average percent of lean cuts. Fat caused the major variability in cutting yields, while lean and bone appeared to develop proportionately over a wide range of carcass shapes. He also stated that an animal breeder has a great deal of freedom in

selecting animals of different shapes without encountering great changes in the proportion of wholesale cuts and that selection emphasis should be placed on production efficiency.

Crouse et al. (1976) stated that adjusted fat thickness was the best single estimator of retail product of all carcass measurements. Abraham et al. (1980) showed that the variables now used in the USDA yield grade equation were the most effective in predicting carcass yield. Zinn et al. (1963) concluded that percent fat trim is over twice as important in predicting percent boneless primal cuts as percent bone. Butts et al. (1980) stated that others have reported that 80-85% of the variation in percent boneless, closely trimmed retail cuts is associated with the amount and distribution of fat.

Charles and Johnson (1976), however, determined that back fat thickness was less associated with the percentage of total dissectable fat and subcutaneous fat in Friesian and Charolais cross cattle than in Angus and Hereford cattle. They found a difference among breeds in the amount of total dissectable fat when fat thickness was constant. Less difference among breeds was found when kidney and pelvic fat was removed from the equation and fat thickness was just as effective in predicting total dissectable fat. Unlike the findings of Dikeman et al. (1977), intermuscular fat was found to vary little among breeds. Herefords and Angus cattle had less total dissectable fat than Friesians and Charolais cross at a constant fat thickness. They suggested that if breed is ignored, fat thickness would overestimate the amount of total dissectable fat and underestimate the yield of edible beef in Herefords and Angus in relation to Friesians and Charolais cross cattle.

A study by Abraham et al. (1968) resulted in similar findings. It was determined that the USDA equation resulted in higher coefficients of determination for Hereford and Angus than Charolais and Brahman in predicting boneless steak and roast meat. Fat thickness seemed to have less effect on yield of boneless steak and roast meat. It was suggested that a given prediction equation might not be applicable to all breeds.

Studies have been conducted to determine the effectiveness of various objective and subjective live animal measurements in predicting efficiency of production and carcass characteristics. Tallis et al. (1959) found heart girth, circumference at the navel, wither height, and hook height to be the most repeatable of linear body measurements between two investigators. Ratios of weight:height and weight:length were found to be the best estimators of dressing percent, area of the rib eye, and percentage edible portion of the carcass. Length, height, and circumference at the navel were found to be valuable measurements for describing type in beef cattle. Black et al. (1938) found that wither height was negatively correlated with percent fat and percent separable lean of the carcass if weight of the animal was held constant on steers of beef, dual-purpose, and dairy breeding. They concluded that wither height is one of the best measures of animal performance. Lush (1928) concluded that wither height is affected little, if at all, by fatness. From his study, it appeared that for all steers of the same age and fatness, measured under similar external conditions, the relative results of wither height measurements were nearly the same. He found that if the steer carried his head up, had his back level and his forefeet placed squarely under him, wither height was a very useful

measurement. Knapp and Cook (1933) also concluded that steers with lower wither heights were of better beef type if all animals were slaughtered at 900 pounds live slaughter weight.

Studies by Gregory et al. (1962) indicated that experienced cattle appraisers can subjectively estimate group means for carcass weight, fat thickness at the 12th rib, percent kidney fat, ribeye area at the 12th rib, cutability, and carcass grade reasonably accurately, provided they have a knowledge of the feeding and management program to which the cattle have been subjected and of the animal's live weight. It appeared that live cattle could be appraised more accurately on cutability than quality differences. Butts et al. (1980) found no significant relationship between initial muscling score and yield grade at slaughter. They also found that frame score was as effective as objective measurements in relation to carcass weight and days on feed. Calves in this study which had more initial fat when put on feed required less time to reach 12 mm of fat at the 12th rib when all cattle were slaughtered. Subjective condition or fat estimators were not as effective as ultrasonic fat measurements. Lush (1928) stated that steers became broader, slightly taller, and somewhat lower set, and bones grew slightly during the fattening process. Fat steers were shorter and smaller boned, as well as broader and distincly lower set, than thin steers of the same weight. Relative to weight, nearly all extremes were more extreme with older steers than with young ones. Gains made by older steers consisted of more fat than younger steers. Younger steers made a considerable increase in absolute size of skeletal and muscular tissue during the fattening period.

Blumer (1963) defined palatability as agreeableness to the taste, a complex of sensations resulting from the stimulation of the senses of odor, taste, and feel, plus ease of mastication.

It has been suggested that the effect of marbling on palatability may be overemphasized. Webb et al. (1964) found that taste panelists found no difference in tenderness between US choice and US cutter grades, but a Warner-Bratzler shear test showed choice to be significantly more tender. Romans et al. (1965) evaluated beef ribs and found no significant differences in tenderness due to marbling. Marbling was significant only for juiciness. Steaks with moderate marbling were rated significantly more juicy than steaks with slight marbling.

Blumer (1963) suggested that intramuscular fat may cause beef to be more tender because of the increased total amount of product versus the mass of connective tissue or that it may affect ease of mastication and swallowing. Tatum et al. (1980) found that taste panel ratings increased and shear force values decreased as marbling increased but not always significantly or consistently. Steaks with modest marbling had higher tenderness, flavor, desirability, and overall palatability ratings than those with slight-minus or traces-plus marbling. High and average choice steaks had a more desirable flavor and lower shear force than high good or less. Very few palatability attributes were significantly different between low choice and high and average good grades. These cattle, however, had all been fed a high-concentrate ration.

According to Francis et al. (1977), research finds no clear-cut relationship between marbling and beef palatability. Most taste panelists reported a difference of only one unit on a hedonic scale, or

reported no difference, in the palatability of ribeye steaks from Angus, Hereford x Angus, Holstein, and Shorthorn steer carcasses with slight-plus and typical modest marbling. Marbling accounted for 16% of the juiciness score of the steaks. Seventy percent reported a difference of one unit or less for flavor and 19% reported no difference. Steaks with modest marbling tended to have higher tenderness scores, but not significantly, and tenderness showed the greatest variability among differences in marbling. Differences between the two levels of marbling were not consistent. Fifty-six percent of the panelists favored the sample tasted first. The authors concluded that steaks with slight marbling were sufficient in palatability from the initial taste sensation but could not predict whether this would persist throughout the eating of an entire steak.

Jennings et al. (1978) evaluated carcasses of Hereford and Hereford x Angus steers with greater than 1.52 cm fat thickness with modest marbling or greater, less than 1.02 cm fat thickness with modest marbling or greater, greater than 1.52 cm fat thickness with slight marbling or less, and less than 1.02 cm fat thickness with slight marbling or less. The results of their study indicated that marbling was the only significant correlation between the carcass traits studied and tenderness and juiciness. An increase in marbling above modest was associated with an increase in tenderness, and the opposite was true for slight marbling or less. They concluded that the degree of palatability varies and is dependent upon the degree of marbling, and slightly less than 1.02 cm is sufficient for prevention of tenderness, juiciness, and shelf-life problems.

Romans et al. (1965) found degree of marbling to be closely related to fat content. Bowling et al. (1977) found that an increase in back fat thickness at the 12-13th rib interface from 1.27-8.9 mm was associated with increased tenderness. It was suggested that fatter carcasses sustain less shortening of muscle fibers and/or increased proteolysis during development of rigor mortis.

Blumer (1963) stated that older animals generally result in lower palatability scores. Romans et al. (1965), however, found no significant differences in shear force values among A, B, C, and D maturity carcasses at slight and modest marbling levels, but there was a trend toward higher shear force values for more mature carcasses.

Garrett and Hinman (1971) reported that 4.3% ether extract in the longissimus muscle is sufficient for small marbling. Koch et al. (1976) found that 5.0% ether extract was equivalent to average small, which slightly exceeds the USDA requirement. Barber et al. (1981) found that 4.4% ether extract in the longissimus muscle reached low choice in Angus.

Ground beef is a popular meat purchase because it is one of the least expensive products available to consumers. Previous research indicates that consumers prefer ground beef patties containing 15% fat or more. Law (1964) found that 15% fat was rated over 25% fat for color before cooking, amount of shrinkage after cooking, general cooking qualities, flavor, and juiciness by 122 Baton Rouge, Louisiana families.

Cole et al. (1960), however, determined that consumers preferred ground beef patties containing 35% or 45% fat over 25% or 15% fat. The fat levels of 45, 35, 25, and 15% were chosen to approximate the total fat content of cattle grading prime, good, standard, and utility. They

assumed that choice would be approximately 40% fat. Two methods were used to determine preferences. They were: (1) families consuming ground beef patties, and (2) trained taste panel. Average husband and wife scores preferred 25% and 35% over 45%, and all three fat levels were preferred over 15% fat. The trained taste panel preferred patties in direct proportion to fat content. Juiciness, tenderness, and flavor scores did not differ significantly for 25, 35, and 45% fat but were lowest for 15% fat. The authors concluded that very lean ground beef which looks best to most consumers does not have the highest eating quality when broiled.

Cross et al. (1980) determined that ground beef patties containing 16% fat were significantly tougher than those containing 24-28%. A linear increase in patty tenderness was found with increased fat levels. More fat was also associated with lower instron shear force values. The amount of connective tissue decreased as fat level increased up to 24% fat. Upon chemical analysis, however, collagen content was not affected by increased fat level. Patties containing 28% fat were more juicy than those containing 16-20% fat. Flavor intensity was not affected by fat level. Percent cooking loss of fat increased as fat content increased, but total cooking loss was not changed. The patty with more fat only appeared to lose more weight during cooking because the liquid fat remained in the pan during cooking, whereas low-fat patties lost water through evaporation, and the loss was not apparent.

Berry et al. (1979) evaluated the shelf-life and bacterial characteristics of ground beef as influenced by fat level. They found that ground beef formulated to 28% fat was scored as having more off-odor

than 16% fat product after a three-day display period. The authors concluded that the potential usefulness of a formulation must take into account shelf-life properties, as well as sensory, chemical, and cooking traits.

Glover (1964) determined that consumers discriminate against ground beef with high fat content because of excessive shrinkage and splattering during cooking, its implication as a cause of obesity, and its greasy taste. Consumers tested in Dallas and Houston, Texas preferred ground beef containing 20% fat over that containing 16, 25, or 30% fat for reasons of flavor, tenderness, juiciness, and general liking.

Cross et al. (1980) mixed quality chucks with choice flanks (24 and 28% fat); choice plates (16, 20, 24, and 28% fat); choice trimmings (24 and 28% fat); and choice brisket and kidney fat (24 and 28% fat). Tenderness, juiciness, connective tissue, flavor intensity, mouth coating, and total cooking loss were not affected by source of fat. It was believed that kidney fat was an unacceptable source of fat because of negative mouth coating effect and low ratio of polyunsaturated to saturated fat. This was not found in the experiment. Berry et al. (1979) found that kidney and brisket fat resulted in higher anaerobic bacterial counts in a shelf-life study, but bacterial increase over a three-day display period was less for products containing these sources of fat.

Cross et al. (1976) selected carcasses which graded average prime, choice, good, utility, and cutter. Ground chucks, plates, external fat, and kidney fat were mixed to form 24% fat ground beef patties. Ground beef formulated from prime or choice carcasses was more acceptable than utility or cutter carcasses in all palatability traits except juiciness.

Chucks and plates from choice and cutter grade carcasses were mixed to determine if the addition of choice beef would offset the low palatability of ratings of ground beef from cutter carcasses. Tenderness and amount of detectable connective tissue were improved but not above the unacceptable level. Flavor and juiciness ratings, however, did increase to an acceptable level.

CHAPTER III

MATERIALS AND METHODS

In this study, 183 steer calves (of predominately Angus breeding) averaging 224 kg were purchased from East Tennessee Feeder Calf Sales in October 1979. The calves were transported to the Grassland Unit of the University of Tennessee Experiment Station at Crossville, Tennessee. Weight, height, and fat thickness measurements were taken. The steers were wintered on stockpiled fescue and were fed grass-legume hay when a sufficient amount of stockpiled forage was unavailable or the forage was covered by snow. The winter grazing period began in November 1979 and ended on April 14, 1980.

On April 14, 1980, weight, wither height, and ultrasonic measurements of the subcutaneous fat over the 12th rib were taken on each animal. The calves were implanted with 36 mg of Ralgro and allowed to graze on summer pasture consisting of orchard grass, fescue, and ladino clover until August 4, 1980.

The cattle were then removed from summer pasture, and weight, wither height, and ultrasonic fat measurements were taken. Subjective evaluations of frame size, condition, and age were also made by a trained grader. The steers were divided into three groups designated as small, medium, or large frame animals. Steers were designated into the following three groups: (1) frame scores 1 or 2 were assigned to a small-frame pen; (2) frame score 3 was assigned to a medium-frame pen; and (3) frame score 4 and above was assigned to a large-frame pen.

A total of 91 animals were selected for the experiment. Sixty animals from the small-frame group and 18 animals from the medium-frame group were selected at random. However, due to a small number of large-frame animals, all 13 from this group were put on the experiment.

Fifteen steers (ten small-frame, three medium-frame, and two large-frame) were transported to Lay Packing Plant in Knoxville, Tennessee for slaughter. The remaining 76 steers were taken to the 70-N unit of the Plateau Experiment Station in Crossville and allotted to pens. They were fed a ration of whole shelled corn, Co-op Tend-R-Leen (with rumensin added) and hay during a 14-day adjustment period. After being put on full feed, all steers received whole shelled corn ad libitum and Tend-R-Leen at the rate of 1.1 pounds per head per day.

Each 28 days, after the 14-day adjustment period, a group of 15 animals (ten small-frame, three medium-frame, and two large-frame) were transported to Lay Packing Plant for slaughter. Therefore, a group of animals was slaughtered after zero, 28, 56, 85, 112, and 140 days on full feed. The group slaughtered at 84 days consisted of 16 animals, with three large-frame steers instead of two. Back fat, wither height, and weight measurements were also taken on all steers every 28 days before each slaughter group was transported to Knoxville.

Forty-eight hours after slaughter, quality and yield grade evaluations were made by a USDA grader at the slaughter plant. Carcass measurements and subjective color evaluations of carcass lean and fat were also made. The left side of each carcass was purchased and transported to The University of Tennessee Meats Laboratory.

The sides were broken into wholesale cuts according to the procedure by Wellington (1953). The brisket, chuck, flank, foreshank, hindshank, loin flap, plate, and ribends from each side were separated into bone, connective tissue, and lean plus fat. Each cut and the separate components of each cut were weighed.

The edible portion was ground through a 12-mm plate, and a representative sample was taken from each cut. The ground wholesale cuts from each animal were then mixed, and a sample was taken to represent the total composite of the eight cuts. The representative samples from each cut and the composite sample from each animal were ground through a 3-mm plate. These samples were kept frozen in a 0°C freezer until they could be powdered for chemical analysis.

The samples were frozen in liquid nitrogen and powdered in a Waring blender. After being powdered, the samples were stored at 0°C until analyzed for fat and moisture content.

Triplicate 2-g samples from each cut were placed in Whatman no. 1 filter papers, and the papers were closed by staples. Samples were dried for approximately five hours at 100°C in a vacuum oven and weighed for moisture determination. After weighing, the samples were extracted for 24 hours in a soxhlet apparatus according to A.O.A.C. procedures. The samples were dried approximately five hours in a 100°C vacuum oven and weighed again for fat determination.

The two samples of the triplicates which had 5% error or less between the percentage moisture and fat were averaged, and the third sample was discarded. If all samples had less than 5% error, the two samples which had the closest percentage fat determination were averaged.

If the error among the triplicates was greater than 5%, the sample was re-extracted until two of the triplicates were within the 5% range.

An average of the percent fat of each cut was calculated and multiplied by its weight to obtain the weight of fat contained in each of the separate cuts. The mean weight of the total fat combined from all cuts except the chuck was calculated for each animal. This weight was divided by the total weight of all cuts except the chuck and multiplied by 100. This percent fat (percent total fat without the chuck) was used as another dependent variable to determine the percent fat contained in ground beef if the chuck was not included.

Cod and KPH fat were not included in the composite ground beef samples in this experiment.

Statistical analysis of the data was conducted in two phases. A regression analysis was conducted in both phases, and the independent variables which had a significant influence ($P < 0.05$) were used in the final model in order to obtain prediction equations for each of the dependent variables. All independent variables which had no significant relationship ($P < 0.05$) to the dependent variables were deleted from the final model. R-square values were calculated to determine the amount of variation which was explained by the model for each dependent variable.

The dependent variables used in phase 1 of the analysis were the fat percentages of all minor cuts, the fat percentages of the blended samples and the total calculated after the chuck was removed, and various carcass measurements which included marbling, yield grade, fat thickness, and carcass weight. The independent variables were selected from various live animal measurements and evaluations taken prior to the grain feeding

phase of the project. Partial sum-of-squares was used to detect those independent variables which were significantly related to the dependent variables in the model, and coefficients of partial regression were obtained for the prediction equation.

The dependent variables used in phase 2 of the analysis were the fat percentages of each of the minor cuts, the fat percentages of the blend-samples and the calculated total percent fat with the chuck removed from the samples. The independent variables included various carcass measurements which could be used to predict the percent fat in the various cuts. Partial F tests were also used to determine significant variables ($P < 0.05$) in the model, and coefficients of partial regression were obtained.

The analyses in phase 1 were calculated according to the following model (Model 1):

Y = Days on Feed (DOF)	Days on Feed squared $(DOF)^2$
Initial Weight (IWT)	Initial Fat Thickness (IFat)
Initial Wither Height (IWH)	

The dependent variables in the model were marbling, yield grade, percent total fat, percent total fat without the chuck, final fat thickness, hot carcass weight, percent chuck fat, percent brisket fat, percent plate fat, percent rib ends fat, percent foreshank fat, percent flank fat, percent loin flap fat, and percent hindshank fat. The independent variables in the model were number of days the cattle were on a high-energy grain ration (DOF), the quadratic term for days on feed $(DOF)^2$, weight of the calves in kg at the beginning of the grain feeding trial

(IWT), fat thickness measured ultrasonically in mm at the beginning of the grain feeding trial (IFat), and wither height measured in cm at the beginning of the grain feeding trial (IWH).

The analyses in phase 2 were calculated according to the following model (Model 2):

$$Y = \begin{matrix} \text{Carcass Fat Thickness} & \text{Marbling} \\ \text{Carcass Weight} & \text{KPH Fat} \end{matrix}$$

The dependent variables in the model were percent total fat, percent total fat without the chuck, percent chuck fat, percent brisket fat, percent plate fat, percent rib ends fat, percent foreshank fat, percent loin flap fat, and percent hindshank fat.

CHAPTER IV

RESULTS AND DISCUSSION

A model was selected to calculate a prediction equation that could be used to explain the variation in the dependent variables as the length of feeding a high-energy ration to yearling steers increases. Also, using these prediction equations, an attempt was made to determine the percent fat in the ground beef taken from the minor cuts at a specific degree of marbling and yield grade.

The effect of frame score was initially included in a model along with days on feed and was determined to have no significant effect ($P < 0.10$).on any of the dependent variables except carcass weight. Butts et al. (1980b) also found frame score to have a significant effect on carcass weight. Cattle with higher frame scores produced heavier carcasses than more compact cattle. Klosterman (1972) suggested that cattle of various types and sizes fed to a similar degree of finish differed only in final weight. Butts et al. (1980b), however, found frame score to have a significant effect on yield grade. The variation of frame score was not very large (range = 1-4), and there was probably not enough difference in cattle type to cause a significant difference in yield grade in the present study. Therefore, frame score was not included in the model.

A model including all independent variables in Model 1 and the interactions between days on feed, initial weight, initial fat thickness, and initial wither height was selected to determine whether any

interactions were significantly ($P < 0.10$) related to any of the dependent variables. No interactions were found to have an effect on the dependent variables and were deleted from the model. Also, fat thickness and wither height measurements obtained in October 1979 and April 1980 were included in the model and were found to have no significant relationship ($P > 0.10$) to the dependent variables in the model and were deleted.

Appendix Table A-1 shows the mean square and R-square values of Model 1 for marbling, yield grade, percent total fat, percent total fat without the chuck, carcass fat thickness, and carcass weight. Days on feed contributed to the explanation of the greatest amount of variation in each of the dependent variables in the model. The coefficients of determination for marbling, yield grade, percent total fat, percent total fat without the chuck, final fat thickness, and carcass weight were 0.60, 0.43, 0.72, 0.69, 0.62, and 0.68, respectively. Marbling and carcass fat thickness were found to have quadratic responses to an increase in days on feed. Yield grade, percent total fat, percent total fat without the chuck, and carcass fat thickness were found to have a significant relationship ($P < 0.10$) to initial fat thickness. Yield grade was influenced ($P < 0.10$) by initial wither height. Carcass weight was affected ($P < 0.001$) by initial weight. All variables which had significance levels of $P < 0.10$ were deleted from the model to obtain a prediction equation for each dependent variable. Table 1 gives the mean square and R-square values and Table 2 the intercepts and coefficients of partial regression for those independent variables which had significant influences ($P < 0.10$) on the dependent variables in Appendix Table A-1.

TABLE 1

MEAN SQUARES AND R-SQUARE VALUES FOR CARCASS TRAITS AND PERCENT FAT OF BLENDED MINOR CUTS USING THOSE INDEPENDENT VARIABLES THAT WERE SIGNIFICANT FOR EACH TRAIT IN MODEL 1

	Marbling		Yield Grade		Percent Total Fat		Percent Total Fat w/o Chuck		Fat Thickness		Carcass Weight	
Source	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS
DOF	1	40.37[a]	1	15.96[a]	1	3921.70[a]	1	3465.55[a]	1	302.50[a]	1	152802.90[a]
$(DOF)^2$	1	7.65[b]							1	54.91[b]		
IWT											1	33957.45[a]
IFat			1	1.94[b]	1	61.18[c]	1	76.51[d]	1	191.25[a]		
IWH			1	0.74[c]								
ERROR	87	1.19	86	0.23	87	17.31	79	18.87	86	6.69	87	481.10
R^2		0.63		0.52		0.73		0.71		0.74		0.82

[a] $P < 0.001$.

[b] $P < 0.01$.

[c] $P < 0.10$.

[d] $P < 0.05$.

TABLE 2

COEFFICIENTS OF PARTIAL REGRESSION FOR DAYS ON FEED AND THOSE INITIAL MEASUREMENTS THAT HAD A SIGNIFICANT EFFECT ON CARCASS TRAITS AND PERCENT FAT OF BLENDED MINOR CUTS

Source	Marbling	Yield Grade	Percent Total Fat	Percent Total Fat w/o Chuck	Fat Thickness	Carcass Weight
Intercept	2.57	-0.76	11.30	13.26	-1.79	-27.91
DOF	0.05[a]	0.009[a]	0.14[a]	0.14[a]	0.14[a]	0.87[a]
$(DOF)^2$	-0.00015[b]				-0.0004[b]	
IWT						0.61[a]
IFat		0.15[b]	0.84[c]	1.02[d]	1.50[a]	
IWH		0.02[c]				

[a] $P < 0.001$.

[b] $P < 0.01$.

[c] $P < 0.10$.

[d] $P < 0.05$.

Only days on feed and its quadratic term had significant relationships ($P < 0.001$ and $P < 0.01$, respectively) to marbling. None of the initial measurements were found to have an effect on marbling. Butts et al. (1980b) also found no relationship between any initial weaned calf measurements and quality grade but significant linear and quadratic terms for days on feed. They determined the coefficient of partial regression for the quadratic term was negative, which is consistent with the findings of this study. The coefficients in this study were 0.05 for days on feed and -0.0015 for the quadratic term. As the length of grain feeding increased, marbling increased at a slower rate. The mean degree of marbling by days on feed (Table 3) also followed this pattern. For the first 84 days of grain feeding, marbling increased approximately one degree every 28 days. From 86 to 112 days on grain, marbling increased by about 0.5 degree, and from 112 to 140 days it increased by about 0.25 degree. These results agree with those of a study conducted by Moody et al. (1970), in which the quality grade of cattle on grain increased significantly from zero to 84 days, but no significant difference was found between 84 and 112 days.

This model for marbling had a coefficient of determination of 0.63, which was approximately the same as the model which included all variables in Appendix Table A-2. The amount of variation explained by those significant variables in Model 1 for each dependent variable were very close. The decision was made to use only the significant variables in the models for the prediction equations because they were approximately as effective in explaining the variation in the dependent variables and contained fewer independent variables.

TABLE 3

MEANS AND STANDARD DEVIATIONS OF PERCENT TOTAL FAT AND CARCASS MEASUREMENTS BY DAYS ON FEED

Days On Feed	Percent Total Fat	Percent Total Fat w/o Chuck	Final Fat Thickness (mm)	Yield Grade	Marbling*	Carcass Weight (kg)
0	12.01 ± 3.29	14.46 ± 4.04	2.34 ± 1.34	1.61 ± 0.41	2.65 ± 0.54	160.91 ± 21.18
28	18.31 ± 3.67	20.03 ± 3.26	4.49 ± 2.24	1.84 ± 0.44	3.67 ± 0.62	197.36 ± 25.86
56	22.08 ± 4.82	24.22 ± 4.71	7.70 ± 2.78	1.91 ± 0.32	4.93 ± 1.65	210.91 ± 31.36
84	25.08 ± 3.84	28.72 ± 4.54	10.87 ± 4.17	2.55 ± 0.60	5.79 ± 1.17	244.80 ± 36.13
112	28.91 ± 5.09	31.35 ± 5.27	14.05 ± 2.94	2.81 ± 0.52	6.24 ± 1.17	266.52 ± 24.98
140	32.65 ± 4.49	35.05 ± 4.50	12.07 ± 2.62	2.69 ± 0.56	6.59 ± 1.12	286.72 ± 35.35

*1 = devoid, 5 = small, 10 = abundant, etc.

Yield grade was influenced by days on feed ($P < 0.001$), initial fat thickness ($P < 0.01$), and initial wither height ($P < 0.10$). The coefficient of determination for this model was 0.52. Butts (1980b) found yield grade to be related to wither height but not initial fat thickness. Other researchers have determined that final fat thickness accounts for the major portion of the variation in carcass yield (Cole et al., 1964; Crouse and Dikeman, 1976; Abraham, 1980). The initial fat thickness at the beginning of grain feeding significantly influenced ($P < 0.001$) final fat thickness. This probably caused the relationship between initial fat thickness and yield grade. Tallis et al. (1959) found ratios of weight:height to be a good estimator of the edible portion of the carcass.

An increase in initial wither height resulted in an increase in yield grade (Table 2, page 35). These results agree with those of Black et al. (1938), who found a negative correlation between wither height and percent separable lean of the carcass at constant weight. Initial wither height was more closely related to yield grade than any of the other carcass measurements in this study (Table 4).

Days on feed and initial fat thickness were related to percent total fat with significance levels of $P < 0.001$ and $P < 0.10$, respectively. This model explained 73% of the variation in percent total fat. This is in agreement with Barksdale et al. (1980), who found that as fat thickness at the beginning of the grain feeding trial of yearling steers which had been grazed during the summer and days on feed increased, the percentage of fat in blended samples from the same minor cuts used in

TABLE 4

COEFFICIENTS OF CORRELATION AMONG VARIOUS TRAITS

Trait	Initial Wither Height	Initial Fat	Initial Weight	KPH Fat	Marbling	Carcass Weight	Final Fat Thickness	Final Quality Grade	Yield Grade	Percent Total Fat w/o Chuck	Percent Total Fat	Percent Rib Ends Fat	Percent Plate Fat	Percent Loin Flap Fat	Percent Hindshank Fat	Percent Foreshank Fat	Percent Flank Fat	Percent Chuck Fat	Percent Brisket Fat
Days on Feed	0.04	0.06	0.04	0.75	0.78	0.82	0.79	0.82	0.66	0.83	0.85	0.81	0.83	0.73	0.60	0.61	0.74	0.81	0.78
Percent Brisket Fat	0.08	0.20	0.11	0.68	0.79	0.78	0.81	0.81	0.72	0.93	0.87	0.83	0.86	0.83	0.69	0.66	0.85	0.82	
Percent Chuck Fat	-0.01	0.09	0.02	0.67	0.77	0.77	0.81	0.79	0.72	0.89	0.86	0.87	0.86	0.81	0.68	0.68	0.84		
Percent Flank Fat	0.04	0.23	0.06	0.68	0.77	0.71	0.75	0.79	0.75	0.93	0.85	0.86	0.88	0.81	0.67	0.58			
Percent Foreshank Fat	-0.03	0.14	0.02	0.46	0.57	0.59	0.65	0.58	0.54	0.67	0.66	0.62	0.62	0.67	0.60				
Percent Hindshank Fat	0.03	0.12	0.02	0.52	0.71	0.60	0.74	0.71	0.70	0.76	0.67	0.67	0.63	0.69					
Percent Loin Flap Fat	0.09	0.23	0.11	0.67	0.74	0.74	0.81	0.75	0.76	0.87	0.83	0.85	0.82						
Percent Plate Fat	0.07	0.17	0.13	0.71	0.80	0.82	0.80	0.83	0.73	0.96	0.90	0.91							
Percent Rib Ends Fat	0.13	0.16	0.10	0.71	0.81	0.78	0.81	0.84	0.77	0.92	0.89								
Percent Total Fat	0.04	0.16	0.07	0.75	0.85	0.82	0.84	0.86	0.76	0.93									
Percent Total Fat w/o Chuck	0.06	0.17	0.06	0.74	0.84	0.82	0.85	0.86	0.81										
Yield Grade	0.21	0.29	0.19	0.74	0.70	0.69	0.87	0.71											
Final Quality Grade	0.07	0.10	0.06	0.61	0.98	0.78	0.83												
Fat Thickness	0.08	0.35	0.14	0.71	0.81	0.81													
Carcass Weight	0.30	0.22	0.41	0.74	0.76														
Marbling	0.08	0.09	0.08	0.60															
KPH Fat	0.17	0.30	0.25																
Initial Weight	0.69	0.46																	
Initial Fat	0.19																		

this study also increased. Percent total fat increased linearly with days on feed throughout the 140 days in this study.

Percent total fat in the combined cuts other than the chuck increased as days on feed ($P < 0.001$) and initial fat thickness ($P < 0.05$) increased. This model explained 71% of the variation. The percent increase with each additional day on feed was 0.14 (Table 2, page 35). This is consistent with the increase in percent total fat with the chuck included, which was also 0.14. Initial fat thickness had a greater influence on percent total fat without the chuck than percent total fat. The coefficient of regression of initial fat thickness was 0.84 for percent total fat, while it was 1.02 for percent total fat without the chuck. Although there was some decrease in the R-square value after some of the independent variables from Model 1 (Appendix Table A-2) were removed, none of the insignificant variables were approaching the 0.10 level of significance, so they were removed from the model.

Carcass fat thickness was influenced by days on feed ($P < 0.001$), the quadratic term for days on feed ($P < 0.01$), and initial fat thickness ($P < 0.001$). The coefficient of determination for the model was 0.74. Other researchers (Harrison et al., 1978; Tatum et al., 1980; Dinus and Cross, 1978) have also reported a significant increase in fat thickness with length of feeding time on a high-energy diet. In the present study, an increase in each day of grain feeding resulted in a 0.14 mm increase in carcass fat thickness. Initial fat thickness had a greater influence on carcass fat thickness than any of the other dependent variables. Barksdale (1980) found a linear increase in carcass fat thickness of yearling steers over 140 days of grain feeding, whereas fat

thickness in this experiment increased both linearly and quadratically. Mean carcass fat thickness decreased from 14.05 mm at 112 days on feed to 12.07 mm at 140 days on feed. The mean final live animal fat thickness, obtained from sonascope measurements, did not show this decrease between the last two slaughter groups, but there was less of an increase than was found among the four previous groups. The mean live animal final fat thickness was 11.2 mm at 112 days on feed and 11.7 mm at 140 days on feed. The mean final live animal fat thickness measurements were fairly consistent with the carcass fat thickness measurements for all slaughter groups except at 112 days. There could have been an error in measurement, or there could have been a slaughter group which, by chance, had unusually large or small fat thickness throughout the trial due to the small number of observations (15) making up each mean. The same models were analyzed using live animal fat thickness as the dependent variable, however, and the same relationship to days on feed, the quadratic term for days on feed, and initial fat thickness was found.

Figure 1 shows the increase in carcass fat thickness as days on feed increased. The prediction equation taken from Table 2, page 35, was used, and the intercept was adjusted for the effect of initial fat thickness by multiplying the mean initial fat thickness (2.47 mm) by its partial regression coefficient and adding it to the intercept. Using this equation, a fat thickness of 12 mm was reached between 105 and 110 days of grain feeding. A small degree of marbling was reached, however, when the carcass fat thickness was about 8 mm. A yield grade of 2 was reached at about 7 mm carcass fat thickness and does not increase to 3

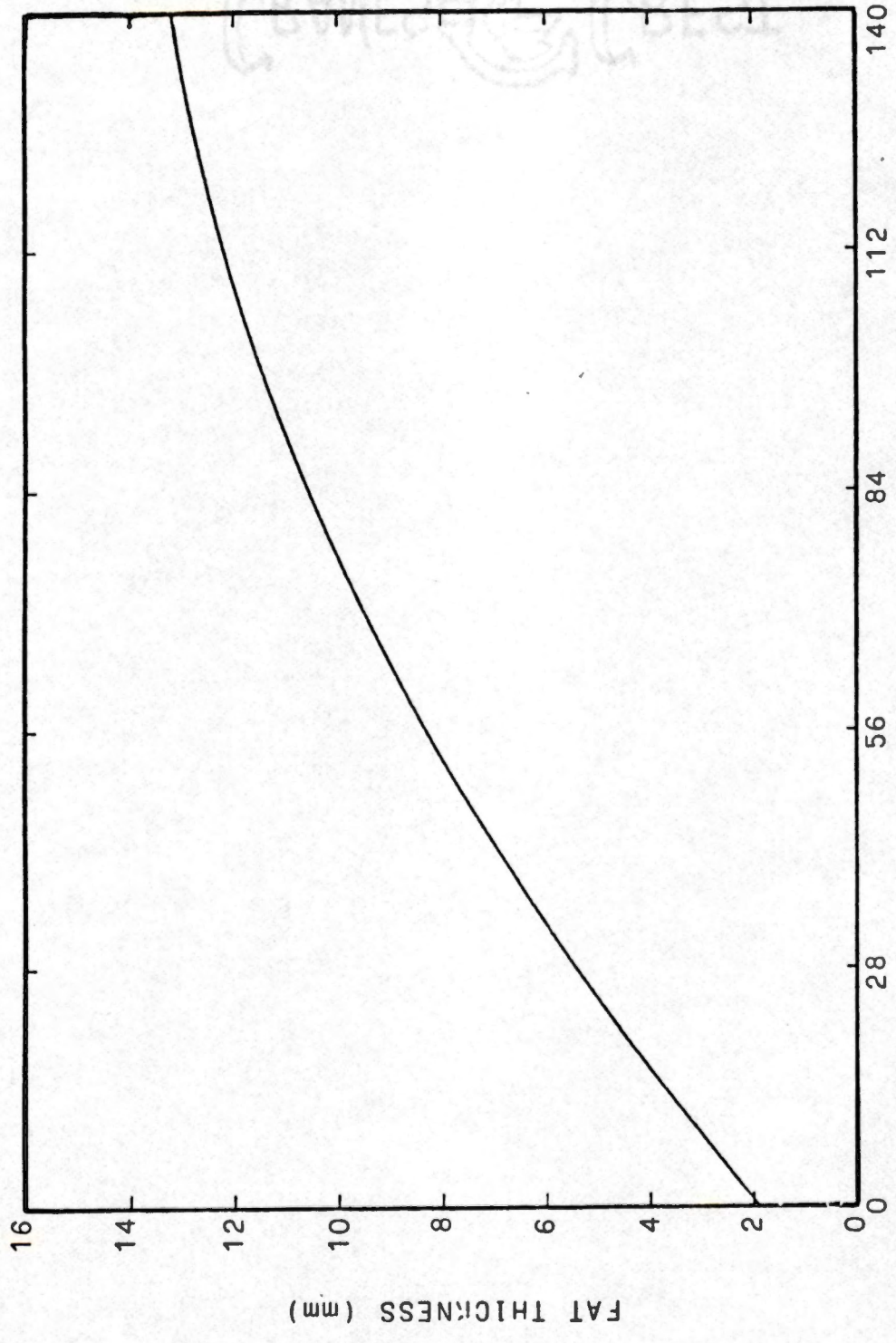


Figure 1. Linear and quadratic response of carcass fat thickness of Angus steers serially slaughtered after varying intervals of feedlot finishing.

within the 140-day feeding period. Carcass fat thickness reached 13 mm between 130 and 135 days on feed.

Carcass weight was very highly significantly related ($P < 0.001$) to days on feed and initial weight with the model explaining 82% of the variation. Butts et al. (1980a) found weaned calf wither height and fat thickness to influence carcass weight, as well as weaned calf weight. If a model was run which included days on feed, initial wither height, and initial fat thickness, however, all variables were significant ($P < 0.001$, $P < 0.001$, and $P < 0.05$, respectively). There was a fairly high correlation of 0.61 between initial wither height and initial weight (Table 4, page 39), and the effect of height and fat could account for some of the variation explained by initial weight. This model did not explain as much of the variation. The R-square value for this model was 0.76 versus 0.82 for the model including days on feed and initial weight.

Figure 2 shows the linear increase of carcass weight as days on feed are increased. The prediction equation was taken from the model including days on feed and initial weight (Table 2, page 35). The intercept was adjusted for the effect of initial weight by multiplying the mean initial weight (317.58 kg) by its partial regression coefficient. Figures 3 and 4 show the linear response of percent total fat and percent total fat without the chuck and linear and quadratic response of marbling to days on feed. The prediction equations used were taken from Table 2, page 35. The intercept for percent total fat and percent total fat without the chuck was adjusted for the effect of initial fat thickness by multiplying the mean initial fat thickness (2.47 mm) by its regression coefficient for each of the two dependent variables.

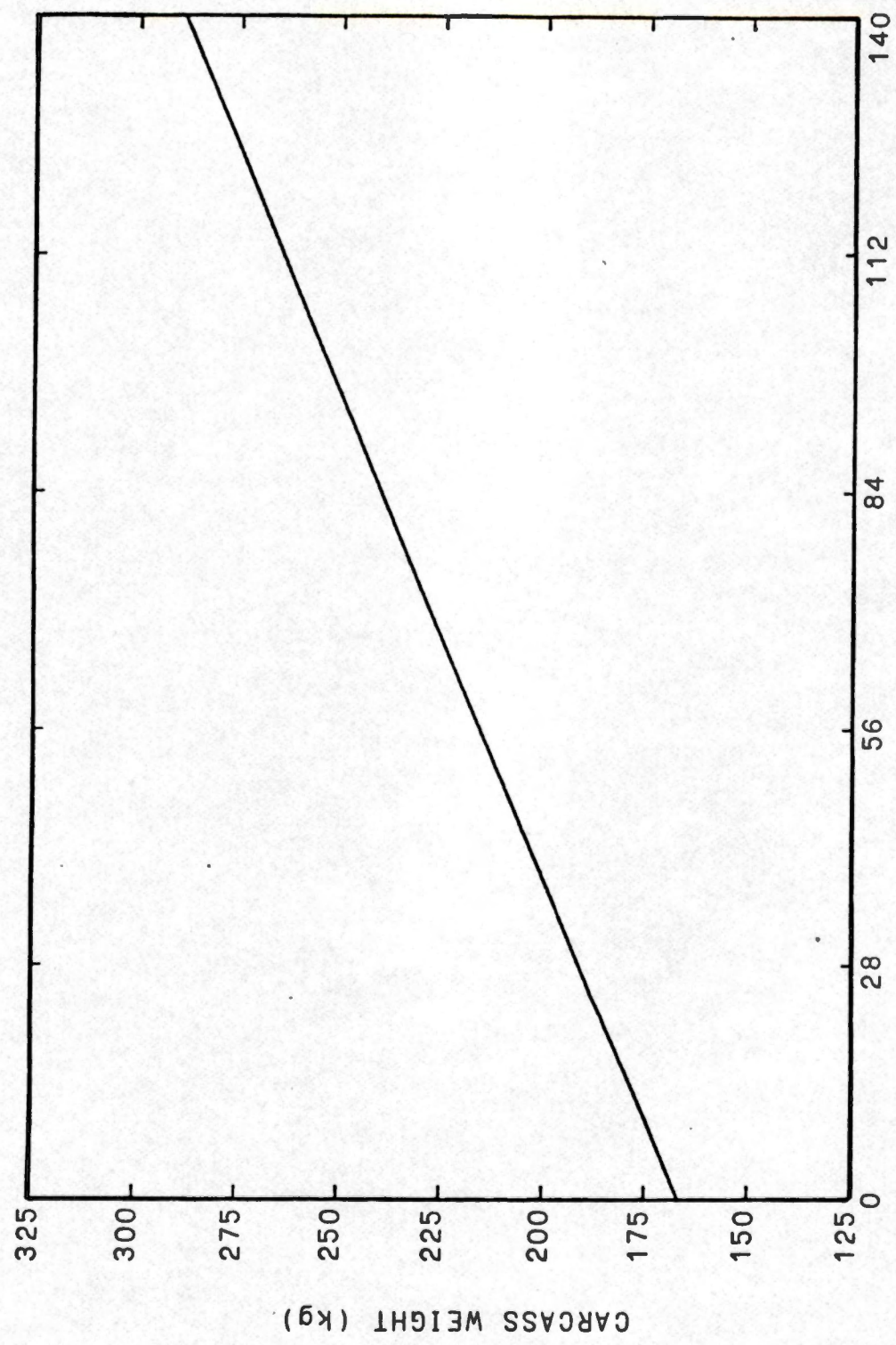


Figure 2. Linear response of carcass weight of Angus steers serially slaughtered after varying intervals of feedlot finishing.

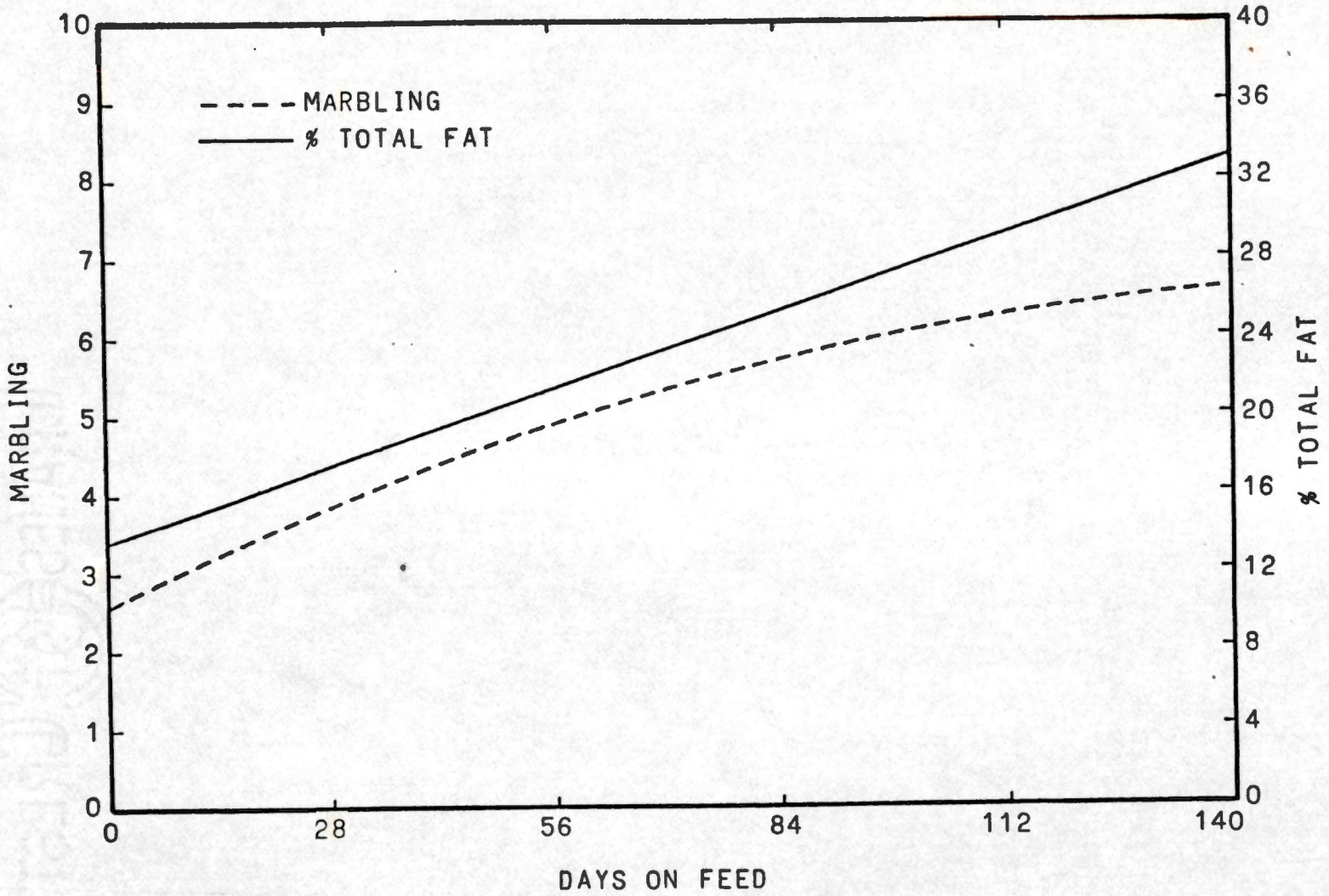


Figure 3. Linear response of percent extractable fat from ground beef which includes the chuck and linear and quadratic response of degree of marbling of Angus steers serially slaughtered after varying intervals of feedlot finishing.

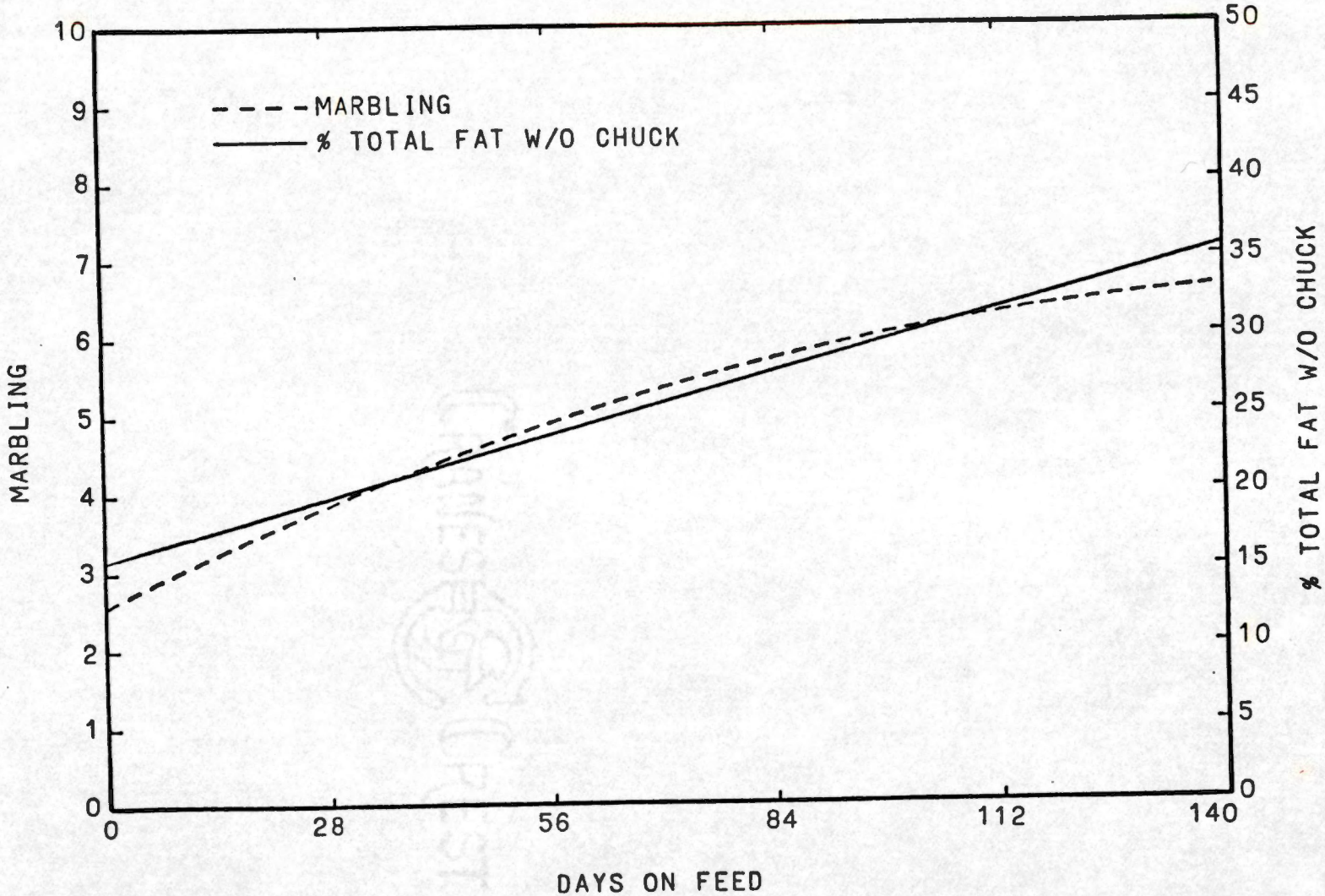


Figure 4. Linear response of percent extractable fat from ground beef with the chuck not included and linear and quadratic response of degree of marbling of Angus steers serially slaughtered after varying intervals of feedlot finishing.

Figure 3 shows that when a marbling degree of small is reached at 60 to 65 days on feed, there is 22% total fat. The degree of marbling does not reach modest until approximately 100 days on feed and remains within the modest degree across the remaining 40 days. The percent total fat reaches 25% between 80 and 85 days and does not reach 30% until 115 to 120 days of grain feeding. These results suggest that if the chuck is included along with the minor cuts in ground beef, yearling Angus steers can be fed grain to an endpoint that will produce a low choice carcass with an acceptable lean percentage in the ground beef taken from the chuck and those minor cuts most suitable for ground beef. The USDA requires that ground beef contain not less than 14% nor more than 28% fat. A study conducted by the USDA in 1976 resulted in the conclusion that ground beef should be no less than 20% and no more than 30% fat to ensure optimum palatability and economic value. The results of the present study suggest that the ground beef from these cattle fell within this range from 50 to 100 days on feed.

Figure 4 shows the change in percent total fat without the chuck and in marbling as days on feed increase. When a degree of small marbling is reached, the percent total fat without the chuck reaches 24%. Thirty percent fat is reached between 100 and 105 days, while modest marbling is reached between 95 and 100 days. Therefore, if the chuck is utilized for roasts, ground beef with an acceptable percent lean could still be produced from the minor cuts if the cattle were slaughtered at low choice.

Figures 5 and 6 show the increase of total percent fat and total percent fat without the chuck with the increase in yield grade. In the

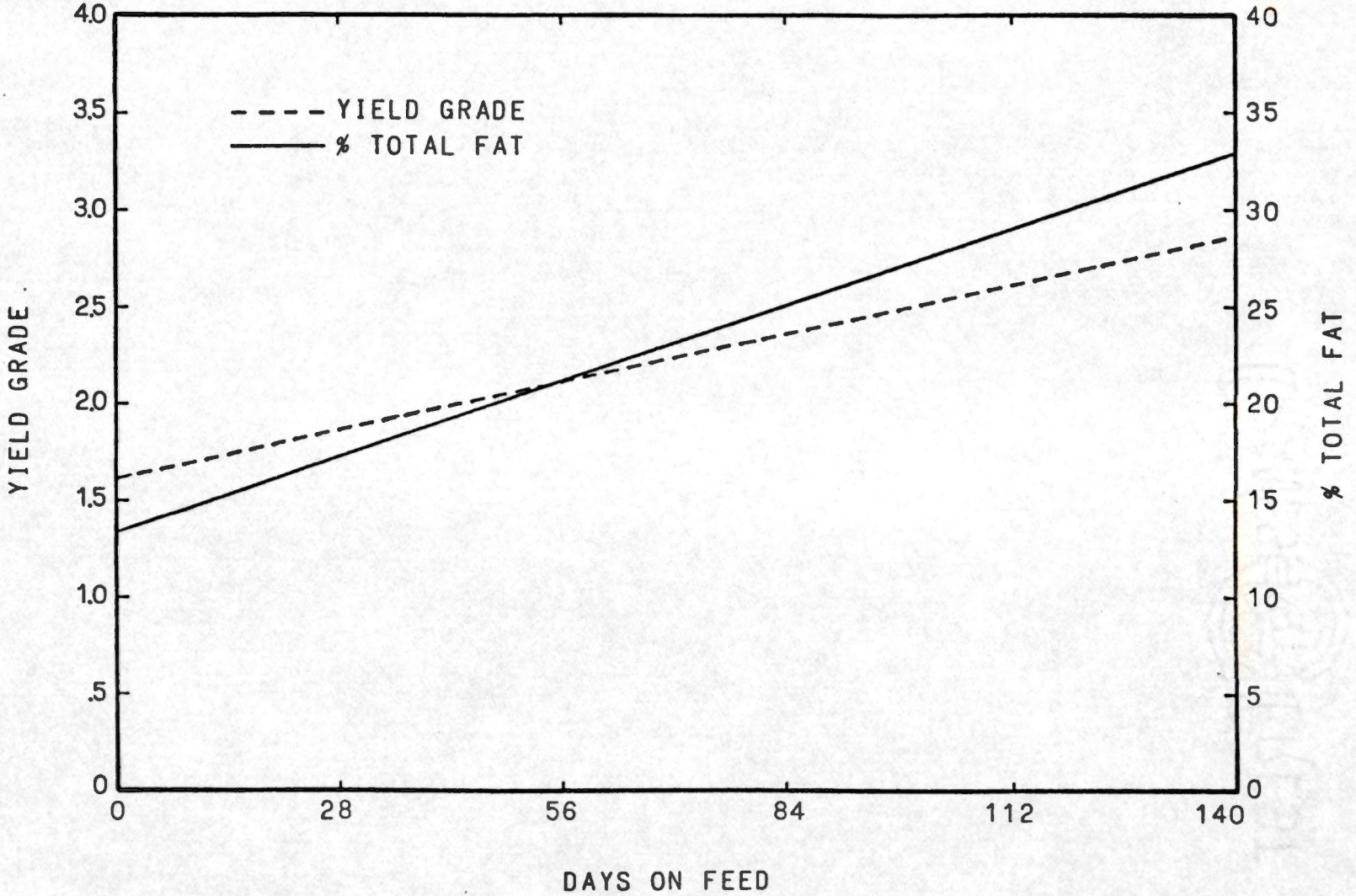


Figure 5. Linear response of percent extractable fat from ground beef which includes the chuck and linear response of yield grade of Angus steers serially slaughtered after varying intervals of feedlot finishing.

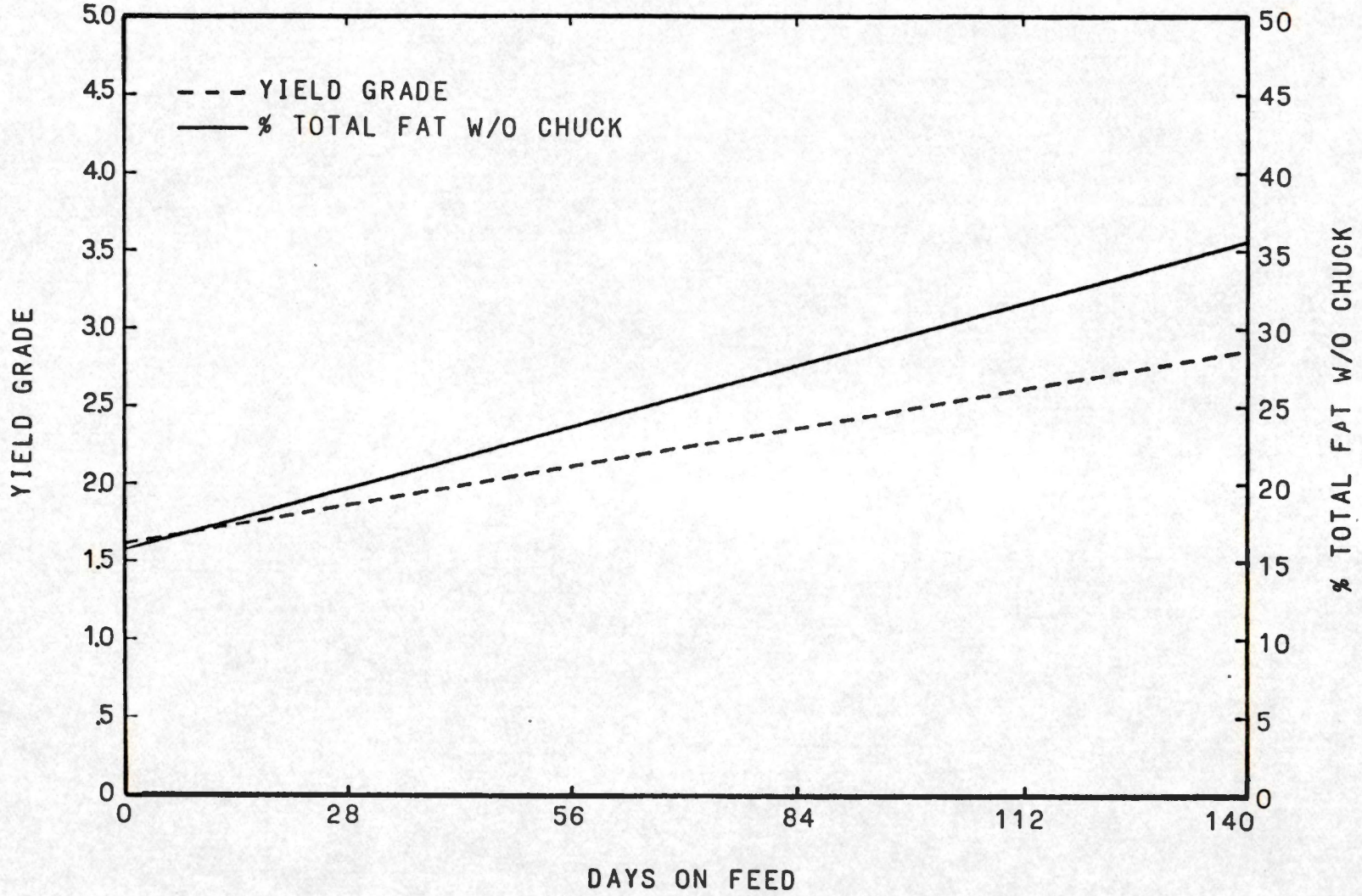


Figure 6. Linear response of percent extractable fat from ground beef with the chuck not included and linear response of yield grade of Angus steers serially slaughtered after varying intervals of feedlot finishing.

prediction equation for yield grade (Table 2, page 35), the intercept was adjusted by multiplying the mean initial fat thickness by its partial regression coefficient and the mean initial wither height by its partial regression coefficient. The mean initial fat thickness was 2.47 mm, and the mean initial wither height was 108.8 cm. A yield grade of 3 was not reached by 140 days in this equation. The mean yield grade by days on feed did not reach 3 in the experiment either (Table 3, page 37). A yield grade of 2 is reached between 40 and 45 days on feed.

Appendix Table A-2 gives the mean square and R-square values for the percent fat of each minor cut with days on feed, the quadratic term for days on feed, initial weight, initial fat thickness, and initial wither height as independent variables. Days on feed was very highly significantly related ($P < 0.001$) to all dependent variables except the percent fat of the foreshank and hindshank. The significance levels of days on feed for these two variables were $P < 0.10$ and $P < 0.05$, respectively. The amount of variation explained by days on feed was 0.65, 0.61, 0.69, 0.65, 0.37, 0.54, 0.50, and 0.36, respectively, for the percent fat in the chuck, brisket, plate, rib ends, foreshank, flank, loin flap, and hindshank. Neither initial wither height nor initial weight were found to have any significant influence ($P > 0.10$) on any of the dependent variables in the model.

Table 5 gives the mean squares, coefficients of determination, coefficients of partial regression, and intercepts for the percent fat of each minor cut using only those independent variables that were found to be significant in phase 1 of the analyses. The brisket, foreshank, loin flap, and hindshank were found to have a linear response to

TABLE 5

MEAN SQUARES, R-SQUARES, AND COEFFICIENTS OF PARTIAL REGRESSION FOR PERCENT FAT OF MINOR CUTS USING DAYS ON FEED AND THOSE INITIAL MEASUREMENTS THAT WERE SIGNIFICANT FOR EACH TRAIT IN MODEL 1

Percent Fat	Source	DF	MS	R-Square	Intercept	Coefficient of Partial Regression
Chuck	DOF	1	655.31[a]	0.68	9.32	0.20
	$(DOF)^2$	1	110.64[b]			-0.001
	ERROR	86	17.09			
Brisket	DOF	1	4008.59[a]	0.64	15.23	0.14
	IFat	1	154.98[b]			1.34
	ERROR	87	27.89			
Plate	DOF	1	1373.45[a]	0.72	16.42	0.29
	$(DOF)^2$	1	245.75[c]			-0.001
	ERROR	87	28.09			
Rib Ends	DOF	1	1978.05[a]	0.69	15.01	0.35
	$(DOF)^2$	1	441.02[c]			-0.001
	ERROR	86				
Foreshank	DOF	1	595.51[a]	0.37	7.98	0.05
	ERROR	88	11.56			
Flank	DOF	1	795.63[a]	0.58	11.13	0.22
	$(DOF)^2$	1	119.64[d]			-0.0006
	IFat	1	167.39[b]			1.46
	ERROR	85	3107.74			
Loin Flap	DOF	1	4648.45[a]	0.54	10.39	0.15
	IFat	1	332.86[b]			1.97
	ERROR	87	51.37			
Hindshank	DOF	1	763.03[a]	0.36	8.87	0.07
	ERROR	84				

[a] $P < 0.001$.

[b] $P < 0.05$.

[c] $P < 0.01$.

[d] $P < 0.10$.

days on feed, while the chuck, plate, rib ends, and flank increased linearly and quadratically with an increase in days on feed. Initial fat thickness had an effect on the percent fat of the brisket, flank, and loin flap.

Days on feed was very highly significantly related ($P < 0.001$) to the percent fat change in all minor cuts. It was the only independent variable in the model which had an influence on the percent fat of the foreshank and the hindshank. As can be seen from the coefficients of determination (Appendix Table A-2), the model was not very effective in explaining the variation in the percent fat of these two cuts. These cuts contain the least percent fat of the cuts, and the major portion of the variation in percent fat was not explained by these models.

The quadratic term of days on feed significantly influenced the chuck ($P < 0.05$), plate ($P < 0.01$), rib ends ($P < 0.01$), and flank ($P < 0.10$). The coefficients of partial regression for the quadratic term were negative for all dependent variables significantly influenced by the term. Figure 7 shows the curvilinear response of the chuck as days on feed increases. There does not seem to be any particular pattern of fat deposition. The two cuts containing the greatest percent fat, the plate and rib ends, were both curvilinear. The two cuts with the least percent fat, foreshank and hindshank, were both linear. The flank, which is intermediate in fat content, was curvilinear. The chuck, which was intermediate between the flank and shanks, was also curvilinear. Three of the four cuts are found in the forequarter. The flank was the only cut from the hindquarter which increased curvilinearly.

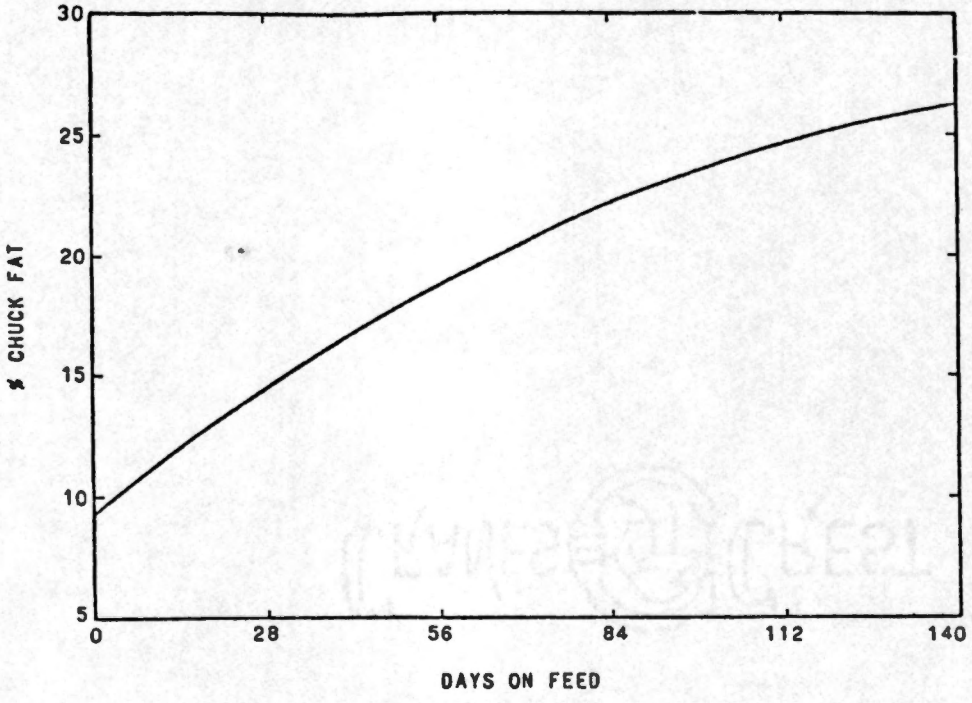


Figure 7. Linear and quadratic response of percent extractable fat from the chuck of Angus steers serially slaughtered after varying intervals of feedlot finishing.

With the exception of the flank and the shanks, those dependent variables that were not influenced by the quadratic term for days on feed were influenced by initial fat thickness. The percent fat of the brisket and loin flap was significantly affected ($P < 0.05$) by initial fat thickness. The flank was significantly affected ($P < 0.05$) by initial fat thickness and the relationship between days on feed squared and percent flank fat was approaching significance ($P < 0.10$).

In phase 2 of the analysis, a model was calculated to determine the relationship of certain carcass characteristics to the fat percentages in each cut and in the total samples and total samples without the chuck.

At first, ribeye area was included in the model. It was determined to have no significant relationship ($P < 0.10$) to any of the dependent variables and was removed from the model. Appendix Table A-3 gives the mean square and R-square values for the complete model.

Those variables that were non-significant ($P > 0.10$) in Model 2 were removed, and a model of only the significant variables was calculated for each dependent variable. Table 6 gives the mean squares, R-squares, intercepts, and coefficients of partial regression for each of these models.

All independent variables had an influence on percent total fat and percent total fat without the chuck with coefficients of 0.83 and 0.84, respectively. Marbling was the most significant ($P < 0.001$) independent variable influencing the percent fat of these two variables. Carcass fat thickness was significant ($P < 0.01$ and $P < 0.05$, respectively) for percent total fat and percent total fat without the chuck.

TABLE 6

MEAN SQUARES, R-SQUARES, AND COEFFICIENTS OF PARTIAL REGRESSION FOR PERCENT FAT OF MINOR CUTS USING THOSE CARCASS MEASUREMENTS THAT WERE SIGNIFICANT IN MODEL 2

Percent Fat	Source	DF	MS	R-Square	Intercept	Coefficient of Partial Regression
Total	Fat Thickness	1	59.42[a]	0.83	1.04	0.33
	Marbling	1	307.20[b]			1.88
	KPH Fat	1	120.45[c]			2.81
	Carcass Weight	1	35.35[d]			0.02
	ERROR	85	10.89			
Total w/o Chuck	Fat Thickness	1	105.17[c]	0.84	3.23	0.45
	Marbling	1	237.79[b]			0.02
	KPH Fat	1	68.40[a]			2.20
	Carcass Weight	1	50.01[a]			0.03
	ERROR	77	10.83			
Chuck	Fat Thickness	1	178.85[b]	0.71	1.13	0.56
	Marbling	1	99.34[a]			1.06
	Carcass Weight	1	90.05[a]			0.04
	ERROR	85	15.32			
Brisket	Fat Thickness	1	125.06[a]	0.74	5.78	0.49
	Marbling	1	229.05[b]			1.62
	KPH Fat	1	61.72[d]			2.01
	Carcass Weight	1	61.66[d]			0.03
	ERROR	85	20.85			
Plate	Marbling	1	622.39[b]	0.77	-1.18	2.31
	KPH Fat	1	157.57[a]			3.09
	Carcass Weight	1	320.70[b]			0.07
	ERROR	85	23.64			
Rib Ends	Fat Thickness	1	233.00[c]	0.76	5.37	0.63
	Marbling	1	706.54[b]			2.70
	KPH Fat	1	367.68[b]			4.51
	ERROR	85	31.74			
Foreshank	Fat Thickness	1	685.50[b]	0.43	7.00	0.55
	ERROR	88	10.53			

TABLE 6 (Continued)

Percent Fat	Source	DF	MS	R-Square	Intercept	Coefficient of Partial Regression
Flank	Marbling	1	1533.63[b]	0.67	3.75	2.92
	KPH Fat	1	572.23[b]			4.94
	ERROR	86	28.30			
Loin Flap	Fat Thickness	1	1311.41[b]	0.68	7.99	1.30
	Marbling	1	173.53[a]			1.34
	ERROR	87	35.66			
Hindshank	Fat Thickness	1	178.25[b]	0.60	4.24	0.48
	Marbling	1	94.23[c]			0.99
	ERROR	83	10.37			

[a] $P < 0.05$.

[b] $P < 0.001$.

[c] $P < 0.01$.

[d] $P < 0.10$.

KPH fat was highly significant ($P < 0.01$) for percent total fat and significant ($P < 0.05$) for percent total fat without the chuck. Carcass weight was significant ($P < 0.05$) for percent total fat without the chuck and approaching significance ($P < 0.10$) for percent total fat. The intercepts and coefficients of partial regression shown in Table 5, page 51, are given to hopefully develop a prediction equation which can be used to estimate the percent fat that a carcass with specific carcass traits will produce. The equation for percent total fat could be used if the chuck was included in the ground beef, and the equation for percent total fat could be used if the chuck was used for some other purpose.

Marbling had a significant relationship ($P < 0.001$) on the percent fat of the brisket, plate, rib ends, and flank. These cuts were highly correlated to the percent fat of the total and total without the chuck (Table 4, page 39), which also had a very highly significant relationship to marbling. Percent hindshank fat was significantly affected ($P < 0.01$) by marbling. The percent fat of the loin flap and chuck were also influenced ($P < 0.05$) by marbling.

Carcass fat thickness had a significant effect ($P < 0.001$) on the percent fat of the chuck, foreshank, loin flap, and hindshank. It was the only independent variable which had a significant effect ($P < 0.10$) on the foreshank. The coefficient of determination was small (0.43) compared to the other dependent variables. Carcass fat thickness had a significant effect ($P < 0.05$) on the brisket and a very significant effect ($P < 0.01$) on the rib ends.

Percent KPH fat significantly influenced ($P < 0.001$) percent flank and rib ends fat. It also had some effect ($P < 0.10$) on the percent brisket fat and significantly influenced ($P < 0.01$) percent plate fat.

Carcass weight was included in the model because it is somewhat affected by the amount of fat which the carcass contains. It is also used in the USDA yield grade equation. There was a significant relationship ($P < 0.001$) between carcass weight and percent plate fat. Percent chuck fat and percent brisket fat were influenced by carcass weight with significance levels of $P < 0.05$ and $P < 0.10$, respectively.

CHAPTER V

SUMMARY AND CONCLUSIONS

A total of 90 Angus steer calves varying in body type (frame score 1 to 4) were purchased in October 1980 and wintered (October through March) on stockpiled cool season pasture plus limited hay. The steers were grazed 112 days (April through July) on fescue, orchard grass, and ladino clover. The steers' average weight was 221 kg at purchase, 221 kg at end of wintering, and 317 kg at the end of spring-summer grazing. Following the pasture phase, they were randomly assigned, within frame size, to slaughter groups and were serially slaughtered after zero, 28, 56, 84, 112, and 140 days on a ration of whole shelled corn plus supplement.

The carcasses were fabricated according to the procedure of Wellington (1953). Those cuts deemed most logical for use as ground beef were separated into bone and edible portion (lean and fat). Each cut was ground and a representative sample retained for fat determination. All ground cuts from each carcass were then blended and a representative sample taken for total fat determination.

Mean yield grades, live weights, carcass weights, marbling, and percentage fat of the blended samples were: 1.6, 313 kg, 161 kg, PD^{65}, and 12.01% for the group slaughtered at the end of grazing; 1.8, 370 kg, 197 kg, Tr^{67}, and 18.31% for 28 days on feed; 1.9, 402 kg, 211 kg, SL^{93}, and 22.08% for 56 days on feed; 2.6, 455 kg, 245 kg, SM^{79}, and 25.08% for 84 days on feed; 2.8, 479 kg, 267 kg, MT^{24}, and 28.91% for 112 days on feed; and 2.7, 479 kg, 285 kg, MT^{59}, and 32.65% for 140 days on feed.

These data, collected from yearling Angus steers, suggest that acceptable quality and yield grades and an acceptable fat percentage of the ground beef can be obtained after 65 days of grain feeding.

Based on the results of the analyses of these data and the prediction equations that were calculated, carcasses can be produced from Angus yearling steers which grade low choice, have acceptable yield grades, and contain an acceptable percent fat in the ground beef with or without the chuck being utilized for ground beef. If the cattle are fed to a quality of mid-choice, some lean trim may have to be added to the ground beef to obtain an acceptable percent fat level. A small degree of marbling can be reached between 55 and 65 days of grain feeding after yearling Angus steers are allowed to utilize available spring and summer forage. Yield grades should not be greater than 2. The percent fat of the ground beef should be less than 25% if the brisket, plate, rib ends, foreshank, flank, loin flap, and hindshank are used for this purpose. If the chuck is also included in the ground beef, it should be no more than 23% fat.

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APPENDIX

TABLE A-1

MEAN SQUARES AND R-SQUARE VALUES FOR CARCASS TRAITS AND PERCENT FAT OF BLENDED MINOR CUTS USING INITIAL MEASUREMENTS AND DAYS ON FEED AS INDEPENDENT VARIABLES

	Marbling		Yield Grade		Percent Total Fat		Percent Total Fat w/o Chuck		Fat Thickness		Carcass Weight	
Source	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS
DOF	1	39.25[a]	1	1.95[b]	1	489.93[a]	1	468.64[a]	1	300.29[a]	1	16199.63[a]
$(DOF)^2$	1	7.37[c]	1	0.07	1	20.99	1	28.95	1	53.99[b]	1	301.22
IWT	1	0.04	1	0.15	1	1.34	1	10.14	1	3.19	1	14558.12[a]
IFat	1	0.07	1	1.92[b]	1	50.07[d]	1	80.71[c]	1	168.18[a]	1	3.62
IWH	1	0.14	1	0.78[d]	1	0.15	1	5.99	1	0.72	1	11.66
ERROR	84	1.23	84	0.22	84	17.65	76	19.03	84	6.81	84	499.58
R^2		0.63		0.52		0.73		0.72		0.74		0.82

[a] $P < 0.001$.

[b] $P < 0.01$.

[c] $P < 0.05$.

[d] $P < 0.10$.

TABLE A-2

MEAN SQUARES AND R-SQUARE VALUES FOR PERCENT FAT OF MINOR CUTS USING DAYS ON FEED AND INITIAL MEASUREMENTS AS INDEPENDENT VARIABLES

	Percent Fat															
	Chuck		Brisket		Plate		Rib Ends		Foreshank		Flank		Loin Flap		Hindshank	
Source	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS
DOF	1	637.24[a]	1	446.68[a]	1	1297.48[a]	1	1857.75[a]	1	38.86[b]	1	798.10[a]	1	771.45[a]	1	109.53[c]
$(DOF)^2$	1	105.52[c]	1	11.26	1	222.58[d]	1	399.30[d]	1	0.42	1	116.00[b]	1	78.33	1	8.87
IWT	1	0.01	1	1.05	1	21.18	1	15.80	1	0.21	1	21.32	1	10.72	1	2.19
IFat	1	6.49	1	114.65[c]	1	37.34	1	74.40	1	18.02	1	192.25[c]	1	264.61[c]	1	27.21
IWH	1	3.88	1	4.47	1	4.08	1	76.74	1	3.13	1	2.92	1	16.62	1	0.62
ERROR	84	17.54	84	28.69	84	27.67	83	39.01	83	11.80	83	37.13	84	52.05	80	16.54
R^2		0.68		0.64		0.73		0.71		0.39		0.59		0.55		0.38

[a] $P < 0.001$.

[b] $P < 0.10$.

[c] $P < 0.05$.

[d] $P < 0.01$.

TABLE A-3

ANALYSIS OF VARIANCE FOR PERCENT FAT OF MINOR CUTS USING VARIOUS CARCASS TRAITS AS INDEPENDENT VARIABLES

	Percent Fat																	
	Total		Total w/o Chuck		Chuck		Brisket		Plate		Rib Ends		Foreshank		Flank		Loin Flap		Hindshank	
Source	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS	DF	MS
Fat Thickness	1	59.42[a]	1	105.17[b]	1	128.79[b]	1	125.06[a]	1	46.43[a]	1	146.43[a]	1	91.30[c]	1	55.33	1	524.93[c]	1	142.76[c]
Marbling	1	307.20[c]	1	237.79[c]	1	106.94[b]	1	229.05[b]	1	329.10[c]	1	530.56[c]	1	2.24	1	458.43[c]	1	102.38	1	95.60[b]
KPH Fat	1	120.45[b]	1	68.40[a]	1	29.54	1	61.72[d]	1	103.31[a]	1	217.38[b]	1	3.44	1	228.87[b]	1	77.89	1	0.01
Carcass Weight	1	35.35[d]	1	50.01	1	41.34[a]	1	61.66[d]	1	213.26[b]	1	48.52	1	16.66	1	1.26	1	27.42	1	2.75
ERROR	85	10.89	77	10.83	84	15.15	84	20.85	85	23.38	84	31.54	85	10.61	84	28.14	85	34.51	81	10.59
R^2		0.83		0.84		0.72		0.74		0.77		0.76		0.44		0.68		0.70		0.60

[a] $P < 0.05$.

[b] $P < 0.01$.

[c] $P < 0.001$.

[d] $P < 0.10$.

TABLE A-4

MEAN PERCENTAGES OF MINOR CUTS BY DAYS ON FEED

Days On Feed	Percent Chuck Fat	Percent Brisket Fat	Percent Plate Fat	Percent Rib Ends Fat	Percent Foreshank Fat	Percent Flank Fat	Percent Loin Flap Fat	Percent Hindshank Fat
0	8.90 ± 3.03	17.68 ± 6.28	15.83 ± 6.34	14.55 ± 5.62	7.95 ± 2.51	13.21 ± 6.92	13.44 ± 7.30	8.85 ± 2.65
28	15.38 ± 2.75	22.91 ± 4.21	25.07 ± 3.64	24.49 ± 4.17	9.14 ± 1.72	22.70 ± 5.68	20.15 ± 6.88	10.06 ± 3.10
56	18.13 ± 3.88	26.61 ± 5.89	29.85 ± 5.20	31.08 ± 7.86	11.87 ± 2.69	24.53 ± 5.85	24.33 ± 6.86	12.42 ± 3.92
84	23.23 ± 5.61	30.92 ± 4.84	34.36 ± 5.74	37.18 ± 7.75	12.75 ± 3.27	30.27 ± 4.81	29.78 ± 8.27	15.87 ± 6.39
112	23.11 ± 3.77	34.70 ± 6.55	38.24 ± 5.91	37.69 ± 5.74	12.76 ± 2.78	29.87 ± 7.40	32.17 ± 7.54	15.68 ± 3.46
140	26.97 ± 4.64	37.74 ± 4.97	40.74 ± 4.82	42.62 ± 5.62	16.31 ± 6.02	35.53 ± 5.26	36.36 ± 7.77	17.47 ± 2.94

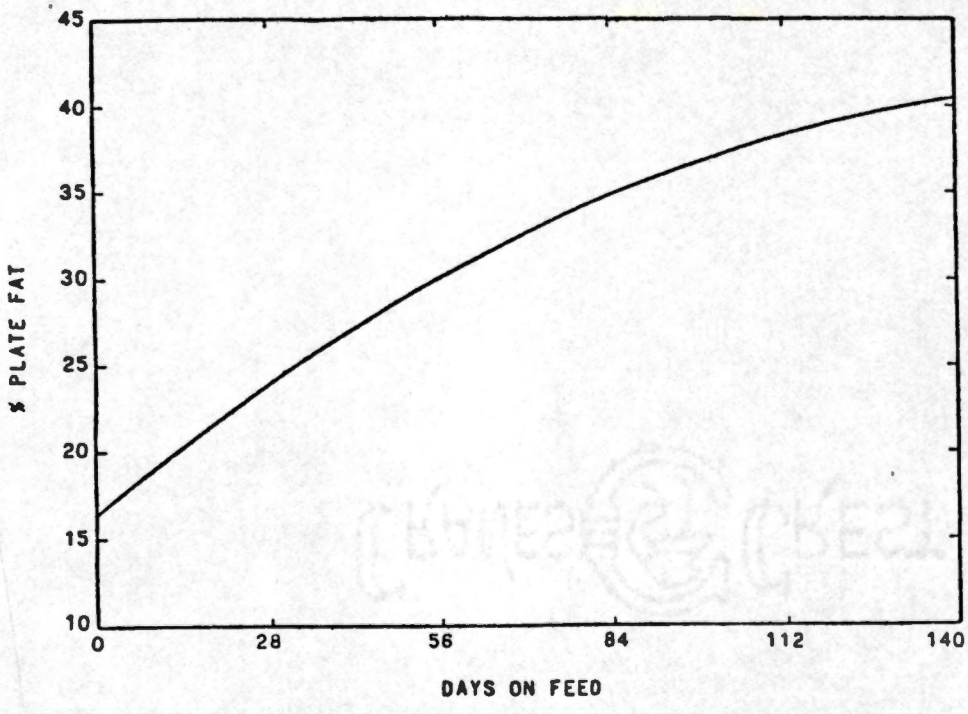


Figure A-1. Linear and quadratic response of percent extractable fat from the plate of Angus steers serially slaughtered after varying intervals of feedlot finishing.

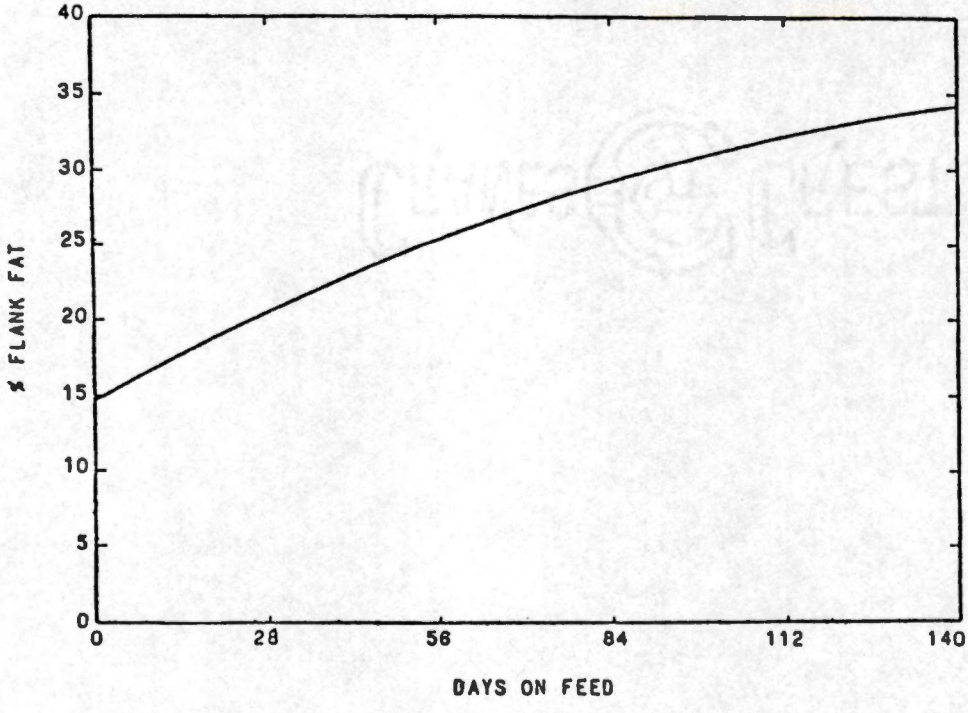


Figure A-2. Linear and quadratic response of percent extractable fat from the flank of Angus steers serially slaughtered after varying intervals of feedlot finishing.

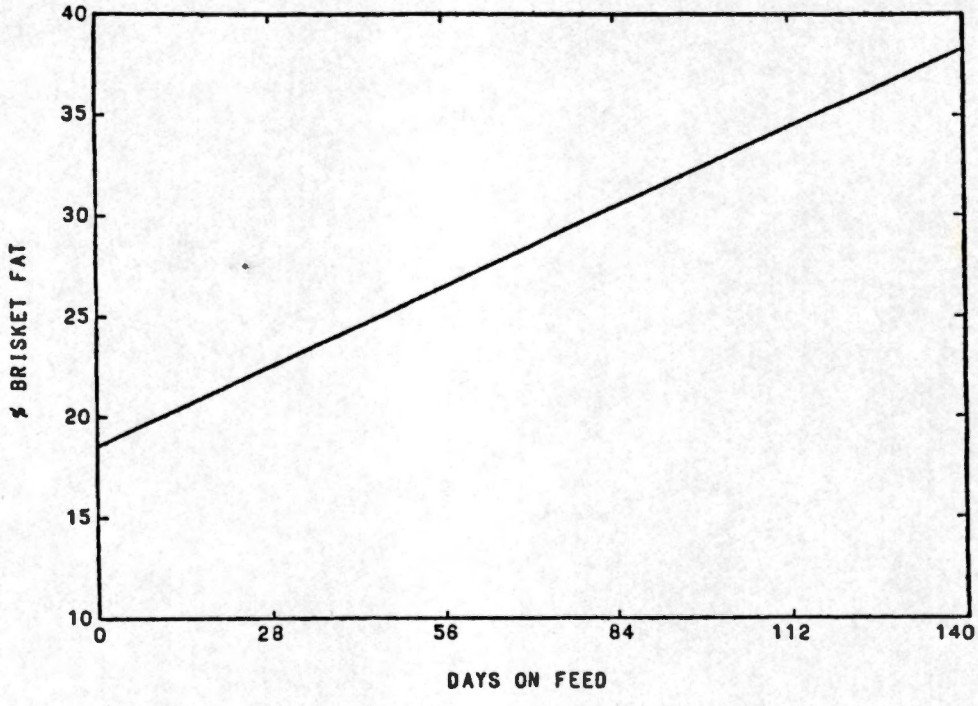


Figure A-3. Linear response of percent extractable fat from the brisket of Angus steers serially slaughtered after varying intervals of feedlot finishing.

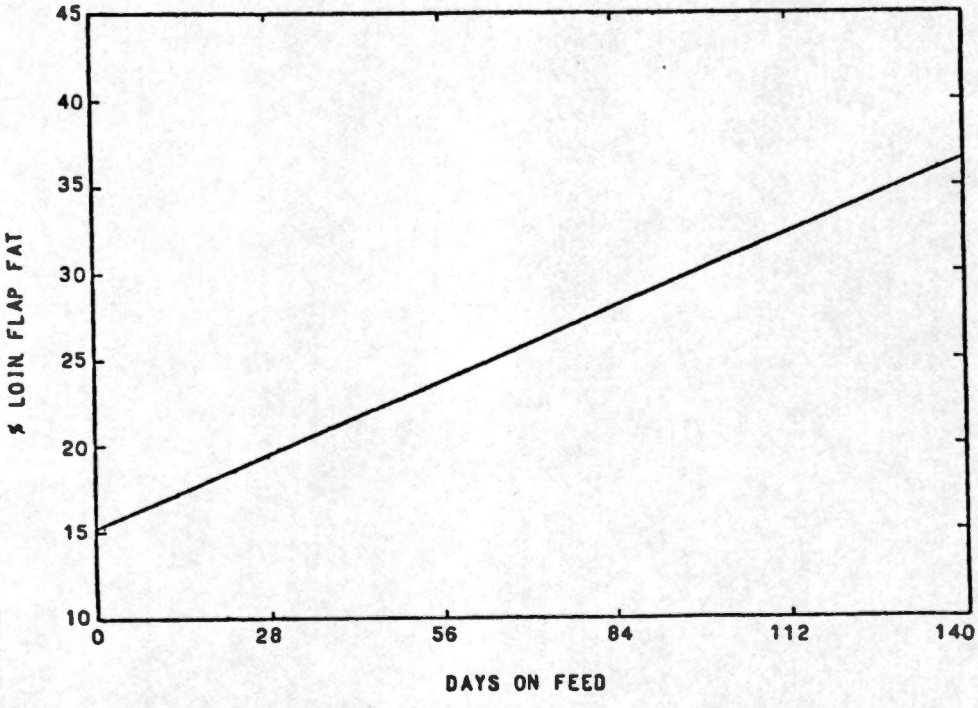


Figure A-4. Linear response of percent extractable fat from the loin flap of Angus steers serially slaughtered after varying intervals of feedlot finishing.

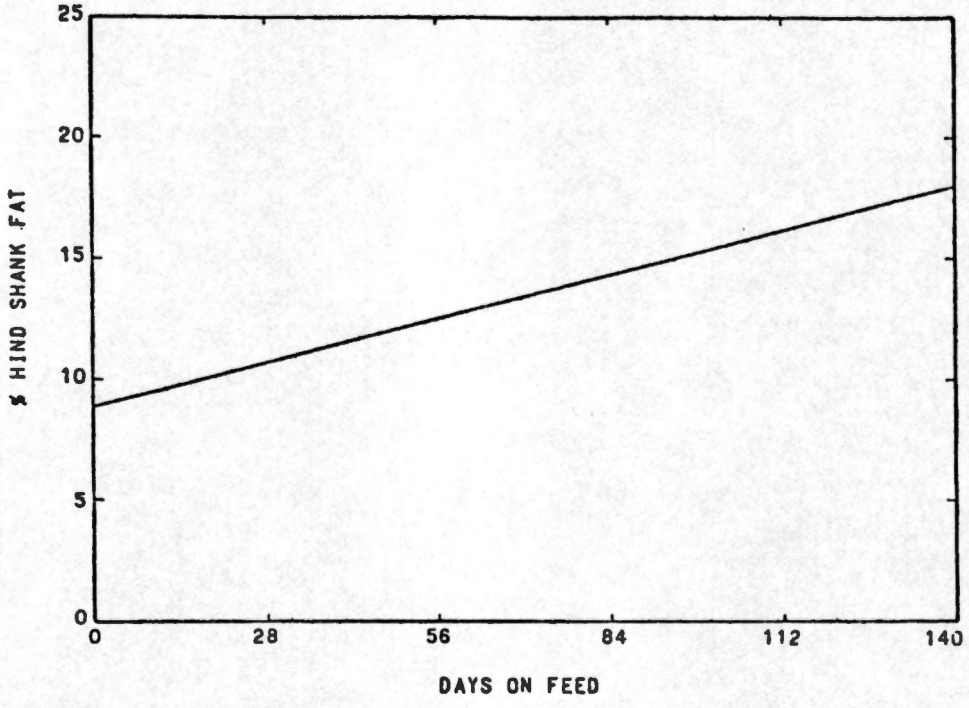


Figure A-5. Linear response of percent extractable fat from the hind-shank of Angus steers serially slaughtered after varying intervals of feedlot finishing.

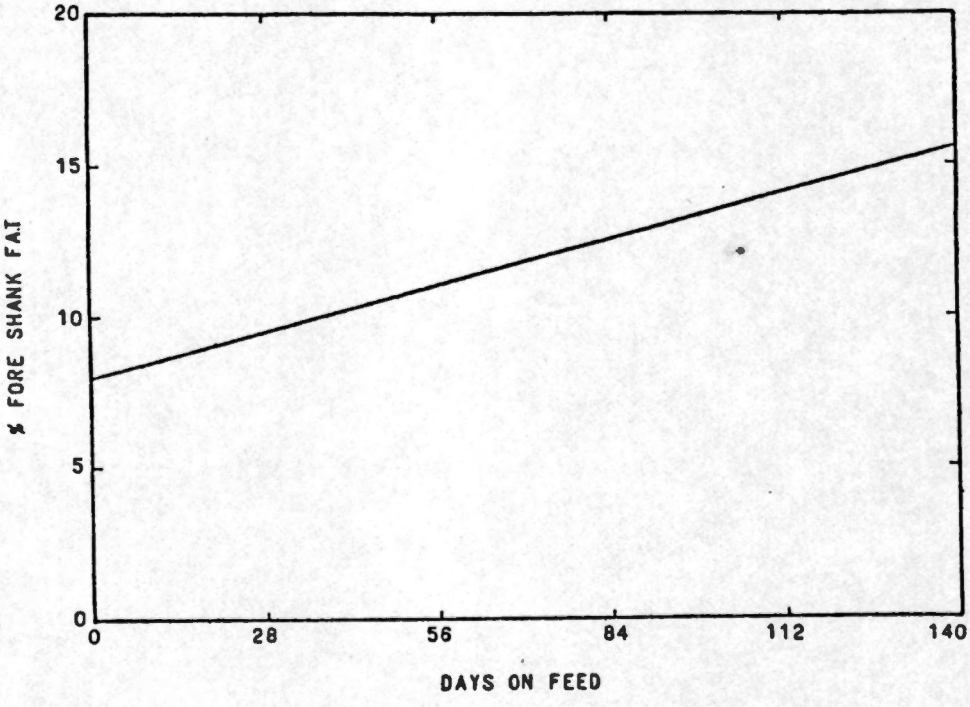


Figure A-6. Linear response of percent extractable fat from the foreshank of Angus steers serially slaughtered after varying intervals of feedlot finishing.

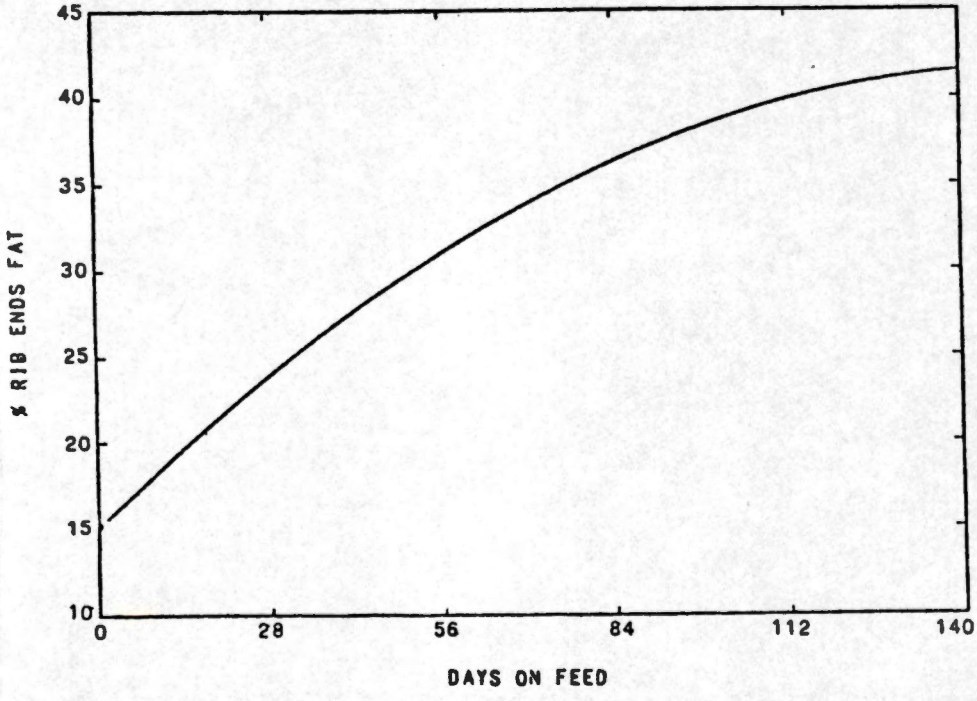


Figure A-7. Linear and quadratic response of percent extractable fat from the rib ends of Angus steers serially slaughtered after varying intervals of feedlot finishing.

VITA

Billy Bruce Greene was born July 9, 1957 in Morristown, Tennessee. He received his primary and secondary education in Hancock County, Tennessee. He graduated from Hancock County High School in Sneedville, Tennessee in June 1975.

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