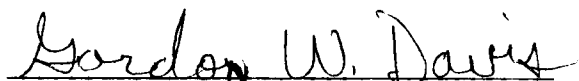


To the Graduate Council:

I am submitting herewith a thesis written by Aubrey Barksdale entitled "The Fat Deposition and Organoleptic Properties of Yearling Steers Serially Slaughtered at the End of Grazing and After Varying Lengths of Full Feed." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.


William R. Backus, Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

THE FAT DEPOSITION AND ORGANOLEPTIC PROPERTIES
OF YEARLING STEERS SERIALY SLAUGHTERED
AT THE END OF GRAZING AND AFTER
VARYING LENGTHS OF FULL FEED

A Thesis
Presented for the
Master of Science
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Aubrey Barksdale
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ABSTRACT

The objective of this study was to determine the effects of time on feed and feeder calf classification on the carcass characteristics of yearling steers serially slaughtered after summer grazing and feedlot finishing for 28, 56, 84, 112, and 140 days. And thereby delineating the fat deposition patterns in the lower value cuts which logically could be used for ground beef, and the organoleptic changes in the high value cuts which logically should be used for steaks and roast.

Sixty yearling steers (30 Angus and 30 Hereford) were grazed on spring and summer permanent pasture for 122 days. The steers were assigned to 6 groups of 10 steers each (5 Angus and 5 Hereford). One group was slaughtered at the end of the grazing period, one after 28 days on full food and one group at 28 day intervals thereafter through 140 days. The feedlot ration which was fed ad libitum consisted of whole shelled corn and a 36% commercial protein supplement.

The carcasses were chilled for 48 hours and ribbed for assessment of quality and quantity indicators. They were broken into wholesale cuts by the procedure of Wellington (1953). Those cuts deemed most logical for fabrication into ground beef were separated into bone, connective tissue and edible portion (lean and fat). Each cut was ground and a representative sample retained for fat determination. All cuts from each carcass were subsequently mixed together and a sample was retained for fat determination.

Along with the percentage extractable fat, the fat thickness (mm) and yield grade for the edible portion of the brisket, chuck,

plate, loin flap, flank ribends, foreshank, hind shank and total were determined. Sample steaks were retained from the short loin and shankless round (semimembranosus) and evaluated for juiciness, tenderness, flavor intensity and overall acceptability by a 10-member trained sensory evaluation panel.

Based on samples from Hereford and Angus steer carcasses, these data indicate that the percentage fat in all ground beef cuts and sensory flavor, tenderness and overall acceptability of cooked loin steaks was acceptable after a grain finishing period of 56 to 84 days.

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CHAPTER I

INTRODUCTION

As the slaughter cattle mix has changed in favor of high quality feedlot cattle and away from processing type cattle, the price relationship between hamburger and steak has changed. Since the spring of 1980 there has been a greater percentage increase in the price of ground beef than in the price of porter-house steak. The same comparison holds for canner and cutter cow prices which have risen proportionately more than U. S. choice steer prices. The growing demand for ground beef is increasingly difficult for the cattle industry to supply at prices acceptable to consumers.

Researchers at the USDA's Meat Science Research Laboratory in Beltsville, Maryland, indicated that 50% of the total beef produced in 1976 was eaten in the form of ground beef. In 1980 this figure will probably reach 55%. It is clear that the hamburger oriented chains dominate the fast food business. The top 100 chains include 15 in which hamburger is the dominant product. The top 10 chains include 7 in which hamburger is the dominant product. The reasons for the popularity of ground beef are many and varied, but some of the more obvious reasons cited by experiment station scientists are that ground beef contains no waste, fat or bone; it is very easy to cook; it is highly versatile from a menu-planning standpoint; it is extremely predictable in palatability; and, it can be purchased according to its fatness level (extra lean, lean, regular, etc.).

Demographics show that almost half of today's 57 million families have only two members. Half of all married American women work at jobs

outside the home. The Census Bureau projects that over 25% of all households will consist of only one person by 1990. These trends point to an increased demand for convenience foods, such as ground beef, luncheon meat and frozen entrees. Roast will be served primarily on "special" occasions and weekends.

Gary C. Smith (personal communication) states that price is what is causing problems for the cattle industry. Ground beef, over the years has been an attractive way to market inexpensive cuts and trimmings. Only a certain percentage of such cuts exist, thus as the demand for ground beef increases, then it can be supplied only by grinding up increasingly expensive portions of the carcass.

A part of the current problem is due to the stage of the cattle cycle - more cows being held back to rebuild herds and more calves being fed to produce high quality beef. Dr. Smith pointed out that grass-finished beef slaughter is off by 25 to 30%, creating a shortage in ground beef. It has been predicted that the number of cattle marketed out of feedlots will be even lower in the 1980's as rebuilding of cattle herds proceed, resulting in lower supplies of Choice beef. Supplies of manufacturing beef from cows and non-feedlot cattle, after dropping sharply in recent years could start to bottom out, moderating the rate of increase in hamburger prices.

Reduced rates of cattle kill will continue to put severe strain on the beef packing industry. The industry has been operating well below capacity, competition for dwindling supplies of cattle has been keen, and many plants have been forced to close. In addition, rising energy and packaging costs, higher interest rates, and wage settlements negotiated in 1979 have significantly increased the cost of operation.

While inflation, recession and energy worries may cramp consumer spending in general, small families and dual-incomes will probably enable the 1980's family to continue eating meals away from home, resulting in a continued demand for ground beef.

Therefore, the objective of this study was to determine the effects of time on feed and feeder calf classification on the carcass characteristics of yearling steers serially slaughtered after summer grazing and feedlot finishing for 28, 56, 84, 112 and 140 days. And thereby delineating the fat deposition patterns in the lower value cuts which logically could be used for ground beef, and the organoleptic changes in the high value cuts which logically should be used for steaks and roast.

CHAPTER II

REVIEW OF LITERATURE

Public concern over the world food situation during 1974 and 1975 and the high cost of concentrate feeds raised questions regarding extensive use of grain for livestock production in the United States. Considerable reexamination of feed inputs as alternate finishing systems resulted. It has been estimated that 86% of the dry matter required to produce beef comes from non-grain sources. Of that 14% from grain, only 1.5% is used in the breeding herd, the remaining 12.5% being used to finish cattle for slaughter (Pope and Schake, 1975).

There are two alternate systems involving the use of larger quantities of forage, as means of reducing grain input for production. One method of lowering grain input would be to develop all the weight and flesh possible by grazing, feeding concentrates on grass or feeding harvested roughage before the cattle are placed on finishing rations, and a second would be to lower the level of grain in the feed mixture during the finishing period in drylot.

Grain feeding of cattle is not new, it has taken place in the U.S. for nearly a century. The practice started first in the corn belt and increased with the advent of plentiful grain. One may ask, why finish cattle on grain? First, we are one of the few countries in the world, outside of Canada with grain available for large scale cattle feeding. Because we can intensify beef production by drylot fattening, the U.S. and Canada are the only countries which can produce nearly 400 pounds of beef yearly per cow unit maintained (Pope and Schake, 1975).

The heavy use of grain enormously increases daily gains of cattle during the feedlot phase, shortens the production cycle by 6 months to 1 year, greatly improves the carrying capacity of the nation's cow herds, and supplies the U.S. consumer with about 120 pounds carcass beef each year. This beef is of much higher quality than the people of any other nation enjoy. Among the most obvious reasons beef cattle are fattened in large numbers in the U.S. is because the American public has developed a tremendous affinity for fed beef. To illustrate, beef consumption in the U.S. rose from about 55 pounds per person in the early 1950's to 117 pounds in 1974. Moreover, the proportion of U.S. Choice beef, usually indicative of grain feeding, almost doubled during that period.

Although relatively good gains can be achieved on high quality forage by grazing, as hay or as silage as the sole source of feeding it is well recognized that an additional source of energy is needed to produce a finished animal with a high dressing percentage and a high grading carcass in a reasonable feeding period.

The ultimate test of a management system for beef cattle is the quality of the meat. If the product is unacceptable to the consumer then the feeding-management system is unacceptable and the consumer as well as the producer suffers losses.

Harrison et al. (1978) studied the quality and yield characteristics of 38 crossbred steer carcasses to measure the effects of 4 nutritional regimes. One group of steers was slaughtered at the end of the summer grazing period (grass-fed), 1 after 49 days in the feedlot on a high concentrate ration (short-fed), 1 group after 98 days in the feedlot on a high concentrate ration (long-fed). Marbling scores and

quality grade increased with length of feeding. Cattle fed 98 days on either high grain or forage ration had an average quality grade of low choice. Carcasses from grass-fed steers barely graded good. Fat thicknesses were lowest for carcasses from grass and short-fed cattle and highest for carcasses from long and forage-fed cattle. The Ribeye of carcasses from grass-fed cattle was smaller than from short and long-fed cattle, but did not differ significantly from carcasses of forage-fed cattle. Weight gain during grain feeding for 49 days possibly resulted from increased muscle size, whereas gain differences from 49 to 98 days may be attributed to increased fat disposition. Kidney, pelvic and heart fat (KPH) generally increased with length of feeding. KPH percentages were less for carcasses from grass and short-fed cattle than for carcasses from forage-fed cattle. KPH percentages did not differ between carcasses from short and long-fed cattle. Carcass weight increased with length of feeding. Yield grades did not differ significantly between carcasses from grass and short-fed cattle or between carcasses from forage and long-fed cattle. Yield grade of carcasses from short-fed cattle tended to be lower than that of carcasses from grass-fed cattle because of larger ribeyes in the short-fed carcasses.

Palatability responses favored those cattle fed the longest time on feed and the highest plane of nutrition. Taste panel responses to loin steaks tended to be more desirable for all characteristics with longer feeding. Steaks from grass-fed beef were less tender than those from long and forage-fed beef. Steaks from short-fed beef were less tender than those from long and forage-fed beef. Steaks from short-fed beef were less tender than those from long-fed carcasses, but were similar to steaks from forage-fed regime. The observed tenderness

differences are likely attributed in part to differences in external fat which affects rate of chill. Flavor of steaks from long and forage-fed beef was rated more desirable than that of steaks from grass and short-fed beef. Higher marbling levels in long and forage beef likely contributed to this observation. Flavor of fat became more desirable as feeding period increased. Steaks from forage-fed cattle were juicier than those from grass and short-fed cattle. No significant differences in the juiciness were noted among longissimus muscle steaks from grass, short and long-fed beef or between steaks from long and silage-fed beef. Grain finished carcasses were slightly fatter and chilled more slowly than grass finished carcasses. This study indicates that carcasses from cattle fed a high quality ration for a certain period of time will be of acceptable palatability regardless of marbling level or quality grade.

Cundiff et al. (1966) fed 4 different groups of steers the same ration and corn silage free choice. The steers were finished at 4 different time increments (28, 56, 84, and 112 days). Feed efficiency and average daily gain decreased with length of the feeding period. A longer feeding period improved carcass grade, dressing percentage, rib-eye area and fat thickness. A feeding period of 84 days was necessary before the carcasses averaged choice. In general, as feeding time increased a larger percentage of the feed consumed was converted to fat and less to muscle.

Young et al. (1960) conducted an experiment using heifer and steer calves to produce, by two methods, slaughter yearling cattle with similar market grade. The calves were divided into two lots of heifers and two lots of steers. All cattle received a basal ration containing

a definite amount of alfalfa-brome hay, corn silage full-fed, and .25 lb of 44% soybean meal per cwt. body weight. One group of steers and 1 group of heifers received a "limited fed" ration of ground shelled corn, adjusted at each 14-day weight period for changes in body weight. The other groups of steers and heifers in "delayed full-fed" lots, received no corn the first 98 days while thereafter they were given a full feed of ground shelled corn until slaughter, when the cattle graded low choice or higher. With corn silage being full-fed, delaying the feeding of corn for 98 days, followed by full feeding steers for 184 days and heifers for 162 days did not appear to alter the total gain, feed efficiency, yield or quality of carcasses, as compared with continuous limited feeding of corn to steers during 275 days and heifers 231 days. There were no consistent differences due to treatment in the amount of fat in the 9-10-11 rib cut. These tests indicate that when corn silage properly supplemented, is full-fed to fattening calves, similar total amounts of ground shelled corn may be either limited-fed on the basis of body weight continuously after weaning, or full-fed after a strong growing period to produce a choice carcass from yearling steers. Quantities of corn for limited feeding and timing of full feeding may be adjusted for desired marketing dates, as well as for silage and hay in the feed supply.

Wood and School (1962) conducted a study using steers to determine the response to various combinations of brome grass-alfalfa soilage and corn feeding during the forage growing season followed by the full feeding of corn for finishing. The rations fed consisted of (1) all soilage, (2) 20 parts soilage: 1 part concentrate, (3) 10 parts soilage: 1 part concentrate, (4) 5 parts soilage: 1 part concentrate, (5) 3 parts

soilage: 1 part concentrate and (6) 2 parts soilage: 1 part concentrate. Rate of gain increased as the level of corn feeding increased. The increase in gain was linear and 1 pound of corn replaced 8.9 pounds of soilage (on an as fed basis). Estimated slaughter grades were higher for steers fed higher levels of corn during the soilage feeding period. The steers fed all soilage required 88 days longer to reach market than the steers fed the 2:1 ratio of soilage to concentrate. The results of this study would indicate that one can expect an increase in rate of gain as the level of corn is increased to a 2:1 ratio of good quality alfalfa-bromegrass soilage to concentrate. In the production of finished cattle, the feeding of corn has advantages by increasing rates of gain and grade as well as shortening the time the steers are on feed.

Dinius et al. (1978) fed high concentrate diets for varying periods to steers that had been fed forage in the feedlot to evaluate animal performance and to determine whether carcass characteristics and meat palatability would differ from that of steers fed the forage diet. There were no significant differences in daily live weight gain among treatments, but these data are tenuous because experimental periods were relatively short and because gastrointestinal tract fill as a percentage of live weight most likely decreased for the steers that were switched from hay to concentrate whereas that of steers continuously fed hay probably changed little. Calculated daily carcass gain was higher for steers fed concentrate than for those fed hay, and daily carcass gain tended to increase as period of feeding concentrate increased. Dressing percentage increased as the interval of feeding concentrate increased as did marbling. In this study cattle fed concentrate for 9 weeks produced carcasses that graded low choice whereas

those fed concentrate for less time graded good. Grain feeding improved carcass quality two-thirds of a grade in this study. Fat deposition increased with length of the period that cattle were fed concentrate as evidenced by increased fat thickness, percentage of kidney, pelvic and heart fat and USDA yield grade. The highest yield grade was 3.3, therefore waste fat was not excessive. Although the length of the period that concentrate was fed influenced carcass composition, few differences were detected in cooking or palatability characteristics. Degree of doneness, tenderness, juiciness and connective tissue were similar among all treatments. They did not, however, find less connective tissue and greater overall palatability with meat from steers fed grain. Whereas feeding concentrate for 3 weeks did not influence total extractible lipids, feeding concentrate for 9 weeks substantially increased extractible lipids. Cattle gained carcass weight rapidly when shifted to the concentrate diet, and such economically important traits as dressing percentage and quality grade were improved by feeding concentrate. Quality measures of lean tissue and taste panel evaluations of the meat were expected to improve with concentrate feeding, but did not.

Skelley et al. (1978) investigated the carcass characteristics and palatability of beef from steers fed 10 rations comparing corn silage, urea treated corn silage and coastal bermuda grass pellets. In addition to the different roughages, other components in various rations were corn, urea, sulfur and cottonseed meal. The steers fed coastal bermuda grass pellets and corn had the highest slaughter weight, carcass weight and loin weight, while those steers fed urea-treated corn silage and cottonseed meal had the lower weight. These observations are in agreement with those of Bryant et al. (1965), Hammes et al. (1964)

and Edwards et al. (1973), who reported that corn fed to steers on pasture or silage increased gains and increased final carcass weight. The steers fed on coastal bermuda grass pellets and yellow corn produced carcasses with the greatest amount of external fat and consequently the highest and least desirable yield grade. These reports tend to agree with those of Edward et al. (1968) and Schupp et al. (1976). The steers fed corn silage, corn and urea produced carcasses with the greatest amount of marbling and were among those with the highest quality grades. The steers fed rations without corn had the lowest quality grades.

Bryant et al. (1965) reported that feeding corn on pasture increased quality grade almost one-third over not feeding corn on pasture. This increase was also reported by Edward et al. (1973) when corn was fed along with silage rather than when silage was fed alone. Flavor scores were lowest for steaks that came from steers produced on the two rations containing no corn. Steers fed coastal bermuda grass pellets and corn produced carcasses with longissimus steaks that were slightly less tender than those produced from steers on rations with corn silage and corn.

This disagrees with Schupp et al. (1976) who finished steers on grass, grass on grain and at different intervals in drylot and reported that the retail sales and subsequent tenderness, flavor and juiciness rating were similar among treatment groups both from a consumer panel and a laboratory panel. Edwards et al. (1968) and Malphurs et al. (1962) also found these similarities in steers fed grain on pasture and those steers finished in drylot.

Hammes et al. (1964) found no significant differences in quality grades of steers finished on high corn silage rations and those finished

on high grain diets. Schupp et al. (1976) also reported similar grades from steers finished on grass, grain on grass and for different periods in drylot.

Bowling et al. (1978) collected data on the economics of production as well as on market ability quality and consumer acceptance of beef produced by various grain to forage ratio management systems. One hundred Santa Gertrudis steer calves were used in this study. Steers were slaughtered as calves, yearlings and as 2-year-olds after periods on grass alone, grain on grass, or in drylot. The steers fed grain reached slaughter weight and grade 100 to 230 days sooner, were higher in USDA quality grade, dressed higher and yielded lower percentages of primal cuts than steers finished on forage management systems. Steers grown on grass and then fed concentrates for 98 days before slaughter produced much more protein than did steers grain-fed 125 or 255 days after weaning, or steers which were grazed or fed grain on grass as either long-yearlings or 2-year-olds. These investigators concluded that the best management system to conserve grain and yet produce an adequate supply of high quality beef would incorporate maximum growth and frame development on forages followed by short-term (100-200) drylot feeding. Management practices of this nature would allow maximum protein production and greater assurance of acceptable palatability with only small losses in cutability. Steers from grass or grain on grass were approximately 6 months older if slaughtered at comparable weight and grade than those fed in drylot after grazing and were lower and more variable in palatability.

Skelly et al. (1978) stated that animals finished on high forage rations should receive added concentrates, such as corn, up to 1% of

body weight in order to insure choice grade and the most desirable palatability ratings.

The economical production of beef cattle that yield a high percentage of highly acceptable retail cuts with a minimum amount of fat trim is of utmost importance to the beef industry. To improve total production efficiency, information on the influence of nutrition, mature size, and rate of growth on carcass composition and palatability is needed.

Waldman et al. (1971) studied the carcass composition and growth of Holstein steers reared on various nutritional regimes and observed that the percentage of carcass protein decreased slightly from birth to 590 kg live weight, but fat was deposited at a greater rate by cattle fed high energy rations compared to those fed a lower energy level.

New genetic resources are being sought in an effort to improve efficiency of beef production and to meet consumer demands for more and leaner meat. European beef breeds such as the Charolais and Limousin have been imported extensively for these purposes. In addition, dual-purpose and dairy steers have been identified as sources of lean beef. Large breed differences for growth rate, feed efficiency and carcass composition have been demonstrated while little variation due to breed was associated with palatability characteristics.

Prior et al. (1977) have suggested interactions between both energy density and protein concentration in the diet and breed type. Some investigators have observed that high energy density in the diet appeared to accelerate fat deposition to a greater extent in small-type steers than larger-type, and that high protein concentrate in the diet resulted in greater fat deposition in the larger-type steers.

Ferrel et al. (1978) fed Angus, Hereford, Shorthorn, Angus-Hereford and Shorthorn reciprocal crosses and 1/2 and 3/4 Charolais steers to measure the effects of genotype, dietary energy density and protein levels in terms of growth rate, feed efficiency, and carcass characteristics. These breeds represented steers differing in growth rate and body composition. Most of the increase in carcass weight due to increase energy density of the diet apparently resulted from increased carcass fat. There were no differences in amount of carcass protein or edible product attributable to energy intake. Breed group affected all carcass traits measured. Carcasses from large-type steers were heavier and contained greater amounts of protein and edible product than carcasses from smaller-type steers. Rate of gain favored the larger-type steers, but feed efficiency was similar between the two types. Protein and edible product per unit of feed intake was greater in the larger, faster growing steers than in smaller-type earlier maturing steers.

Cole et al. (1964) in an investigation to determine the yield of wholesale cuts and separable muscle, fat, and bone of Zebu, British and dairy cattle found that the left side of the carcasses as a percent of carcass and untrimmed loin, as a percent of left side did not vary significantly among years. The only significant differences among the samples of breeds for percent forequarter and hindquarter were between Jersey and Brahms. Quarters from the left side of Jerseys were equal in weight, but forequarters of other breeds were heavier than hindquarters. Brahman sides had the highest percent forequarter (50.9), followed by Angus (50.7). Percent separable muscle of the left side of the carcasses was significantly least for British-type steers and identical for Zebu and dairy types, with more than 1/2 of the side

weight being muscle in all breeds. Among breeds, Angus and Herefords had the least percent muscle and these two breeds did not differ significantly. Brahmans and Holsteins had the highest proportion of separable muscle. Brahmans, Holsteins and Jerseys had the thinnest fat cover over the ribeye. A large kidney knob contributed to the low percent separable muscle in relation to external fat thickness in the Jersey breed. Among breeds, Angus were fattest (34.3%) followed by Herefords (31.3%). This showed a significant difference in separable fat between these two breeds, and they differed significantly from all others. Holstein sides were least fat (22.1%), but there were no significant differences between Holstein and Brahmans. The Zebu and the Jerseys did not differ significantly. Among breeds, Angus sides had lower percent bone (12.8) than Hereford sides (14.1) and both breeds were lower in bone content than the other five breeds. The Jersey breed had the highest percent bone (17.6%) followed by Holstein (16.2%). The two British breeds had the least moisture and Holstein and Brahman breeds the most. Hereford and Angus ether extract means were highest of all breeds, with Angus sides being significantly higher in ether extractable components (33.6%) than Hereford sides (30.0%). Holstein and Brahman ether extract means were lowest (21.0% and 23.1%, respectively). Jerseys were the only breed which had a greater ether extract content than separable fat content, which may have been due to a high degree of marbling throughout most muscle. The British-type cattle had a lower percent of their left side in untrimmed round, chuck, and foreshank, but a higher percent in flank, plate and brisket than the other two types. 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 least percent flank and brisket. Among breeds, Angus had the lowest percent round, loin and chuck, but were highest in all the minor wholesale cuts except foreshank. Differences between Angus and Hereford cut-out were significant for all cuts except rib, chuck and brisket. The Zebu breeds were similar in most wholesale cut means differing significantly only in percent chuck and plate. Brahman had the highest percent chuck and lowest percent plate of all breeds. Holsteins had significantly higher percent round, chuck, and foreshank, but lower percent flank and kidney fat than Jersey. Holstein sides cut out a higher percent of round and chuck than Hereford sides. These data indicate that among the samples of breeds studied, fat had a depressing effect on yield of the major wholesale cuts and separable muscle.

Garret (1971) conducted two comparative slaughter experiments in which he compared the net efficiency of energy utilized by Holstein and Hereford cattle. The Hereford was 20 and 12% more efficient in converting feed energy to energy stored as fat and protein in the two trails. The gains made by beef steers contained more fat and consequently more energy than comparable gains by the dairy steers. The difference in efficiency seemed to be related to the fat component of the animal and of the gained tissue.

Koch et al. (1976) studied the composition and quality characteristics of steer carcasses obtained from 14 breed combinations. The animals were compared to a constant age, constant weight, and constant percentage of fat in the longissimus muscle. There was a positive association between growth rate of breed groups and percentage of retail product or bone. A negative association was observed between growth rate of breed groups and percentage of fat trim. A negative association

between growth rate and percentage of fat in the longissimus resulted in breed groups attaining the same percentage of fat in the longissimus at significantly different average carcass weights. Conformation and marbling attributes of quality grade differed significantly among breed groups. Tenderness differences among breed groups were small. Breed group means for taste panel tenderness and marbling were positively associated. Within breed groups the desirable influence of increased marbling associated with the time on feed was essentially counteracted by the undesirable influence of increased age. Breed groups did not differ significantly in flavor or juiciness scores.

Lipsey et al. (1978) selected 46 steers of different breed and type which consisted of 16 Hereford-Angus and reciprocal crosses (HxA-AxH), 14 Gelbveigh (Gelb), and 16 Maine-Anjou (MA) sired steers from Hereford and Angus crossbred cows to represent cattle with differing maturing rates. The objective was to determine if cattle fed to the same energy efficiency endpoint, once maintenance was accounted for, are similar in carcass composition, feedlot performance and quality grade. Gelb and MA crosses were fed an average of 70 days longer, averaged more than 94 kg heavier at slaughter, and gained an average of .21 kg more per day than HxA-AxH. Hereford-Angus and reciprocal crosses (HxA-AxH) were more than 1.4 kg of DM per kilogram gain less efficient than MA and Gelb on a gross basis. Average daily gain and gross efficiency were significantly related by both pooled and within-breed analyses. Faster gaining cattle were more efficient when fed to the same NEP efficiency endpoint. HxA-AxH carcasses showed no advantage in quality grade over MA and Gelb, although HxA-AxH averaged .48 cm more backfat and .68 poorer yield grade than MA and Gelb. MA and Gelb had a higher percentage of carcass lean than HxA-AxH. These researchers

suggest that steers of differing maturing rates fed to the same NEP efficiency endpoint did not exhibit the same growth and efficiency performance even though quality grade traits were similar.

Lush (1928) found that correlation between measurements of feeder steers and subsequent gains, dressing and percentage and values of dressed beef are low, but statistically significant.

Black et al. (1938) used beef, dual purpose and dairy steers to study the correlations of body measurements to animal performance and carcass characteristics. They found that the correlations indicated that wither height is one of the best measurements of performance. They also concluded that slaughter grade was a better measurement of beef type than any ratio of measurements.

Gregory et al. (1962) found that experienced appraisers can subjectively estimate group means for carcass weight, fat thickness at the 12th rib, percent kidney fat, ribeye area, cutability and carcass grade with reasonable accuracy.

Tallis et al. (1959) used Hereford steers to study 10 linear body measurements. The measurements were taken in duplicate by two investigators. Results of the study indicated that heart girth, circumference at navel, length of body, width of chest, depth of chest, and height at hooks and withers had the highest steer components and the lowest investigator, interaction and error components. The ratios of weight to height and weight to length were calculated and correlated with dressing percentage, ribeye area and edible portion of the animal. In both steer and heifer data, the two ratios were positively correlated with ribeye area and negatively correlated with edible portion. These correlations were positively correlated with dressing percentage in steers only.

Orme et al. (1959) using the data from 31 long yearling steers found that live animal measurements and carcass measurements were all highly repeatable with the exception of spring of ribs, width of pins, and length from the 13th rib to the hooks.

Cook et al. (1951) took body measurements of 157 milking short-horn steers. Slaughter grade, carcass grade, and dressing percentage were taken under comparable conditions on all the animals. Results indicated that steers of lower height at the withers and at the floor of chest and steers that were shorter in body length, tended to have a higher dressing percentage than more rangy steers. Steers with larger circumference of foreshank tended to make slightly higher slaughter grades. Steers that were wide in the shoulders tended to make slightly higher slaughter and carcass grades than those that were narrow. There seemed to be a tendency for steers with a higher average daily gain to have a higher dressing percentage than those with lower average daily gains.

Intramuscular fat, popularly referred to as marbling has often been implicated as a contributing factor to beef palatability and is the most important component of the USDA beef grading system.

Francis et al. (1977) stated that research finds no clear-cut relationship between marbling and beef palatability, yet consumers place confidence in well marbled meat and pay a demand related price.

Parrish (1974), and Smith and Carpenter (1974) reported low relationships between marbling and tenderness.

Romans et al. (1965) found steaks containing moderate degrees of marbling to be juicier than steaks possessing slight marbling.

Parrish (1974) summarized research reports relating to marbling and beef palatability and concluded that marbling had a strong relationship to juiciness and flavor.

Walter et al. (1963) reported that marbling did not exert any significant effect on tenderness, flavor or juiciness scores.

Smith et al. (1976) and Merkel and Pearson (1975) have indicated that subcutaneous fat may act as a regulator of tenderness. It has been proposed that thick layers of fat act as an insulating barrier and allows for a very gradual decline-in muscle temperature during chilling thus preventing cold shortening. The amount of external fat and marbling could exert a sizeable influence in determining the optimum storage period under vacuum packaging conditions to maximize palatability and minimize shelf-life problems.

Francis et al. (1977) conducted a study using steaks prepared in a typical consumer like manner to determine whether consumers could differentiate beef of two marbling levels. Eight hundred and six consumers rated 95 slight-plus and 95 typical-modest marbled ribeye steaks from Angus, Hereford x Angus, Holstein and Shorthorn steers of similar ages. Differences between the 2 marbling levels were not consistent. The most important factor contributing to variations in palatability scores was order of sampling, which was randomly assigned by session. In these sessions in which modest-marbled steaks were tasted first, they were given about 2 units average preference over the slightly-marbled steaks. If slightly-marbled steaks were tasted first they received a slightly lesser preference but still almost 2 units. Of those indicating a difference, 56% favored samples tasted first, regardless of marbling level. Apparently, the initial taste sensation

overshadowed the effect of marbling. This suggests that slight marbling gives adequate palatability.

Jennings et al. (1978) selected the carcasses from 50 Hereford and Hereford-Angus cross steers and heifers for 4 categories: >1.52 cm fat thickness-modest or above marbling; >1.52 cm fat thickness-slight or below marbling; <1.02 cm fat thickness-slight or below marbling; and, <1.02 cm fat thickness-modest or below marbling. The objective of the study was to evaluate simultaneously the effect of variations in both fat thickness and marbling on palatability traits. Regardless of the amount of external fat, loin steaks possessing modest or above marbling had lower shear values, and higher tenderness and juiciness ratings than steaks containing slight or lower marbling, although mean palatability scores were in the acceptable range for both palatability traits. Carcass characteristics and measurements were low in their relationship to tenderness attributes with marbling scores having the highest correlation. Within the various selection categories, increases in marbling over the range included in the study or above modest were associated with improvements in tenderness, while the opposite was true for marbling scores of slight or below.

Both USDA and the Army requires Utility grade as a minimum standard of beef in patties. But in a 1976 study, the USDA had judged this beef to be tough and generally unacceptable due to the quantity of connective tissue still remaining in the product after it had been ground. In 1978 the Beltsville research team studied the effectiveness of processing the offending tissue. They also studied the effects on palatability of other elements in the ground beef process including methods of grinding, patty size, storage and type and amount of fat.

It was found that proper treatment can make a difference: that cutter-canner cow meat-even bull meat-can produce ground beef patties that score as high with taste panelists as patties made from Choice beef trimmings. This becomes important when you look at the size of the ground beef market and the fact that, although the major source for lean ground meat is mature animals, some purchase specifications for ground beef do not permit its use in their formulation. USDA contacted 12 firms to learn about their sources of raw material for ground beef. Utility was the most frequent grade of cow used, but several processors used cutter and canner grade beef. Four firms imported frozen beef from Australia, New Zealand and South America. When used, frozen beef comprised 20-40% of the total formulation. While some companies used beef from the entire carcass, others used forequarter and hindquarter meat with loins and ribs removed. Still others used Utility chucks, shanks, and plates. Use of frozen meat had few practical effects on palatability or cooking properties.

A study conducted by the USDA utilized chucks as the lean source and Choice plates, Choice trimmings, Choice flanks, kidney and brisket trimmings as the fat source to determine the effects of fat source and level on the acceptability of ground beef. Treatments were formulated to contain 16±, 20±, 24±, and 28±% of fat with the meat ground through a 0.32 cm plate in the final stage. Results show that scores for ground beef flavor intensity, connective tissue and degree-of-doneness as well as cooking loss percentages were not significantly different depending on fat source or level. The type of fat did not affect the quality of ground beef, but as the percentage of fat increased from 16 to 30%, tenderness and juiciness also increased, while Instron work

decreased. Because total cooking losses were not noticeably different among the different fat levels in the study and ground beef with higher fat levels cost less, the researchers surmised that among products with less than 30% fat, the one with the greatest level of fat may be the best bargain.

Researchers also tested storage characteristics using patties made from utility chucks with the following fat sources: Choice plates, Choice trimmings, 50% Choice trimmings/50% kidney fat, or 50% brisket fat/50% kidney fat. In general they found that type of fat did not affect the palatability or cooking characteristics of stored ground beef. The main problem detected after 3 months was a decrease in flavor intensity and development of off-flavor. USDA scientists concluded that acceptable patties could be made with any of the formulations previously mentioned, but that the fat level should be at least 20% to enhance palatability and that frozen patties should not be stored over 3 months to avoid development of off-flavor.

Blumer (1963) investigated and summarized many of the previous studies concerning the relationship of marbling or fat to the palatability of beef and concluded that the composition of the ration to beef animals influences the rate of fat deposition within the muscles and also the composition of the fat. It is well known that the caloric intake controls the rate and quantity of fat deposition. While the ration fed to beef animals does not influence the fat composition as greatly as it does with hogs, there is evidence to indicate that the ration does have some influence upon fat composition. Blumer further concluded that the most fruitful research shows the relationship between marbling and panel flavor would appear to be through separation,

isolation and identification of the flavor compounds of beef. Much work has been done on both the volatile and non-volatile fractions of beef and much is known, but more is needed. When the compounds of the flavor complex are all known in their proper proportions, only then may the role of fat be known. Therefore, palatability effects concerning fat should be studied not only on the basis of total quantitative fat content of the meat, but also upon the possible influence of fat composition.

CHAPTER III

MATERIALS AND METHODS

For this study 60 steer calves (30 Angus and 30 Hereford) averaging 216 kg pounds were purchased in East Tennessee Feeder Calf Sales.

The calves were trucked to The University of Tennessee Experiment Station Farm at Knoxville, where they were weighed and measurements were taken for height, length, depth, width and fat thickness. After the stress of weaning and marketing was overcome the calves were then taken to the Grassland Unit of The University of Tennessee Plateau Experiment Station at Crossville, Tennessee, where they were wintered on stockpiled fescue and hay from November 1978 to April 1, 1979. On April 1, 1979, prior to the initiation of summer grazing, the steers were weighted, measured for wither height, the subcutaneous fat over the 12th rib was estimated ultrasonically and they were implanted with 36 mg of Ralgio. They grazed on spring and summer pasture from April 1, 1979 until July 31, 1979 (122 days). The pasture consisted of orchard grass, fescue and clover.

At the end of the grazing period, weights were taken along with wither height and backfat measurements. The calves were also subjectively appraised for frame size, genetic features, body type and age (Table 1). At this time the steers were assigned to 6 groups of 10 steers each, on the basis of weight, breed and genetic features and body type similarities predicting rate of maturity.

One group of 10 steers (5 Hereford and 5 Angus) were transported to The University of Tennessee Meat Laboratory where they had access

TABLE 1. MEAN SQUARE AND R^2 VALUES FOR
VARIABLES IN MODEL 1.

SOURCE	DEPENDENT VARIABLES				
	df	YG	BF	MDG	TOTEE
DOF	5	4.1351*	231.7067*	82.5900*	524.8199*
EOAFR	1	.2841	28.5709	.0108	.1759
EOAFR $\times$ DOF	5	.2484	3.4576	5.1036	16.1427
BRD	1	.5773	4.0248	64.0445*	12.6490
DOF $\times$ BRD	5	.2212	17.0266	3.7833	26.9836
EOAFR $\times$ BRD	1	.0308	8.1304	.9033	3.9787
EOAFR $\times$ DOF $\times$ BRD	5	.3948	13.9596	1.8648	3.4994
ERROR	36	.2218	13.2571	6.3106	21.0084
R^2		76.42	74.18	70.06	79.17

* Indicates significant ($P < .01$) variables

to water (no feed) for approximately 24 hours prior to slaughter. Weights were taken immediately prior to slaughter to obtain a final live weight.

The 50 remaining steers were transferred to the 70-N unit of the Plateau Experiment Station at Crossville where they were allotted into their assigned feedlot pens. A ration of whole shelled corn, ad libitum plus 1.1 pounds of Tend-R-Leen (with rumensin included) per head per day was fed after a 14-day period of adjustment to the feedlot ration.

One group of steers was slaughtered after 28 days on full feed and 1 group at 28-day intervals thereafter through 140 days. Those animals not being slaughtered at the end of each 28-day interval continued to be weighed and measured at 28-day intervals. Subjective appraisals and weights were taken on all steers to be slaughtered on the day of slaughter.

The carcasses were weighed, and chilled for 48 hours postmortem. They were subsequently ribbed for assessment of quality and quantity indicators. The left side of each carcass was broken into wholesale cuts according to the procedure of Wellington (1953). Those cuts deemed most logical for fabrication into ground beef included the brisket, chuck, plate, ribends, flank, loin flap, foreshank and hindshank, were separated into bone, connective tissue and edible portion (lean and fat). Weights were taken of the intact wholesale cuts and of the components of the intact cuts after they were fabricated.

Each cut was ground through a 12mm and a 3mm plate and representative samples were retained for fat determination. All cuts from each carcass were then subsequently mixed together and samples were retained for fat analyses.

The samples retained for fat determination were first frozen in liquid nitrogen, then placed in a waring blender and powdered. Duplicate powdered samples from each cut weighing approximately 2 grams each were then dried in a vacuum oven at 100° C for 3 hours to remove the moisture. These samples were cooled in a desiccator for 4 hours and weighed to determine moisture content by change in weight. The samples were then placed on a Goldfish ether extract apparatus and extracted in ether for 4 hours. The solid portion of the samples were discarded and the ether was reclaimed. The remaining fat and ether were placed in a drying oven for 1 hour. The beakers containing the ether extract were cooled in desiccators, weights were taken, and the percentage ether extract was calculated by the change in weight.

Those duplicate samples showing more than 5% error were discarded and reextracted until the error came within the 5% range.

Loin and inside round steaks were evaluated for juiciness, tenderness, flavor, overall acceptability and flavor desirability by a 10-member trained sensory evaluation panel. The panelists independently rated each sample and assigned scores on an 8-point descriptive scale for juiciness, tenderness, flavor intensity, flavor desirability and overall acceptability using an 8-point hedonic scale (8 = extremely juicy, extremely tender, extremely intense beefy flavor and extremely desirable; 1 = extremely dry, extremely tough, extremely intense milky flavor and extremely undesirable, respectively). Warner Bratzler shear force measurements were taken on the steaks, also. Before panelist evaluations, each steak was wrapped in polyethylene coated freezer paper, frozen and stored at -30° C. Steaks were thawed for 24 hours in a 5 to 7 C cooler prior to cooking. Each steak was broiled to an

internal temperature of 70 C on a preheated farberware broiling unit at approximately 250° C. Steaks were wrapped in aluminum foil to insure warm samples for panelist. Warner Bratzler shear steaks were allowed to cool to 25° C. Four (2.5 X 1.3 cm i.d.) cores were removed and sheared in duplicate (total of 8 shear measurements per steak) on a Warner Bratzler shear force machine. Palatability steaks were weighed, boned and cut into 1.3 X 1.3 X 1.9 cm cubes. Cubes were randomly selected and served hot to each of the 10 member trained sensory evaluation panelists.

CHAPTER IV

STATISTICAL METHODS

In phase 1 of the analyses models were selected containing live animal and carcass measurements. The analysis of variance was used to analyze the data (Steel and Torrie, 1960). Those independent variables having no significant influence ($P > .05$) on any of the dependent variables were dropped from the models and other independent variables were substituted in the models. Those variables having no significant relation were again deleted.

Mean square values were calculated to determine which independent variables had significant relationships. The R-square values were calculated to determine how much of the variability of the dependent variable was due to each significant independent variable.

In phase 2 of the analyses a new model was selected which included the dependent variables in the first and second set of models plus additional dependent variables from the ether extract determinations. The independent variables included those which had previously shown significant influence.

The analysis of variance was again used to analyze the data and mean square and R-square values were calculated to determine which independent variables were significant and the extent of their significance on the dependent variables.

The model for phase 3 of the analyses included the sensory evaluation panel variable taken from scores received on steaks from the loin and those received from steaks from the round, as the dependent variables. The independent variables included some of the independent

variables that had previously shown significant influence plus some of the previous dependent variables, as independent variables. The data was analyzed using analysis of variance, mean square values and R-square values as had been calculated for the other models.

For all models the independent variables were added in a sequential manner and regression analysis was performed for the independent variables and the dependent variables which were significantly related.

CHAPTER V

RESULTS AND DISCUSSION

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

$$Y = \text{DOF} \quad \text{EQAFR} \quad \text{DOF} \times \text{EOAFR} \quad \text{BRD} \quad \text{BRD} \times \text{DOF} \\ \text{BRD} \times \text{EOARR} \quad \text{BRD} \times \text{DOF} \times \text{EOAFR}$$

$$\text{where } Y = \text{YG} \quad \text{BF} \quad \text{BDG} \quad \text{TOTEE}$$

The model was selected to determine if yield grade (YG), carcass backfat (BF), degree of marbling (MDG) and total ether extract (TOTEE) were significantly related to days on feed (DOF), breed (BRD), estimated overall frame score (EOAFR), $\text{EOAFR} \times \text{DOF}$, $\text{DOF} \times \text{BRD}$, $\text{EOAFR} \times \text{BRD}$ and $\text{EOAFR} \times \text{DOF} \times \text{BRD}$.

Table 1, page 26, gives the mean square values and points out those independent variables significantly related. The total R^2 values for the model are also shown in Table 1.

Yield grade, backfat and total ether extract were highly influenced ($P < .01$) by days on feed only. Degree of marbling was highly influenced ($p < .01$) by days on feed and breed. Yield grade had linear and cubic responses with days on feed (Figure 1). Backfat and total ether extract increased linearly with days on feed, while degree of marbling had linear and cubic responses with days on feed and breed (Figure 2). These results are in agreement with those of Harrison et al. (1978), Dinius et al. (1978) and Cundiff et al. (1966), who also noted that marbling scores, quality grades and fat thickness increased with length of feeding.

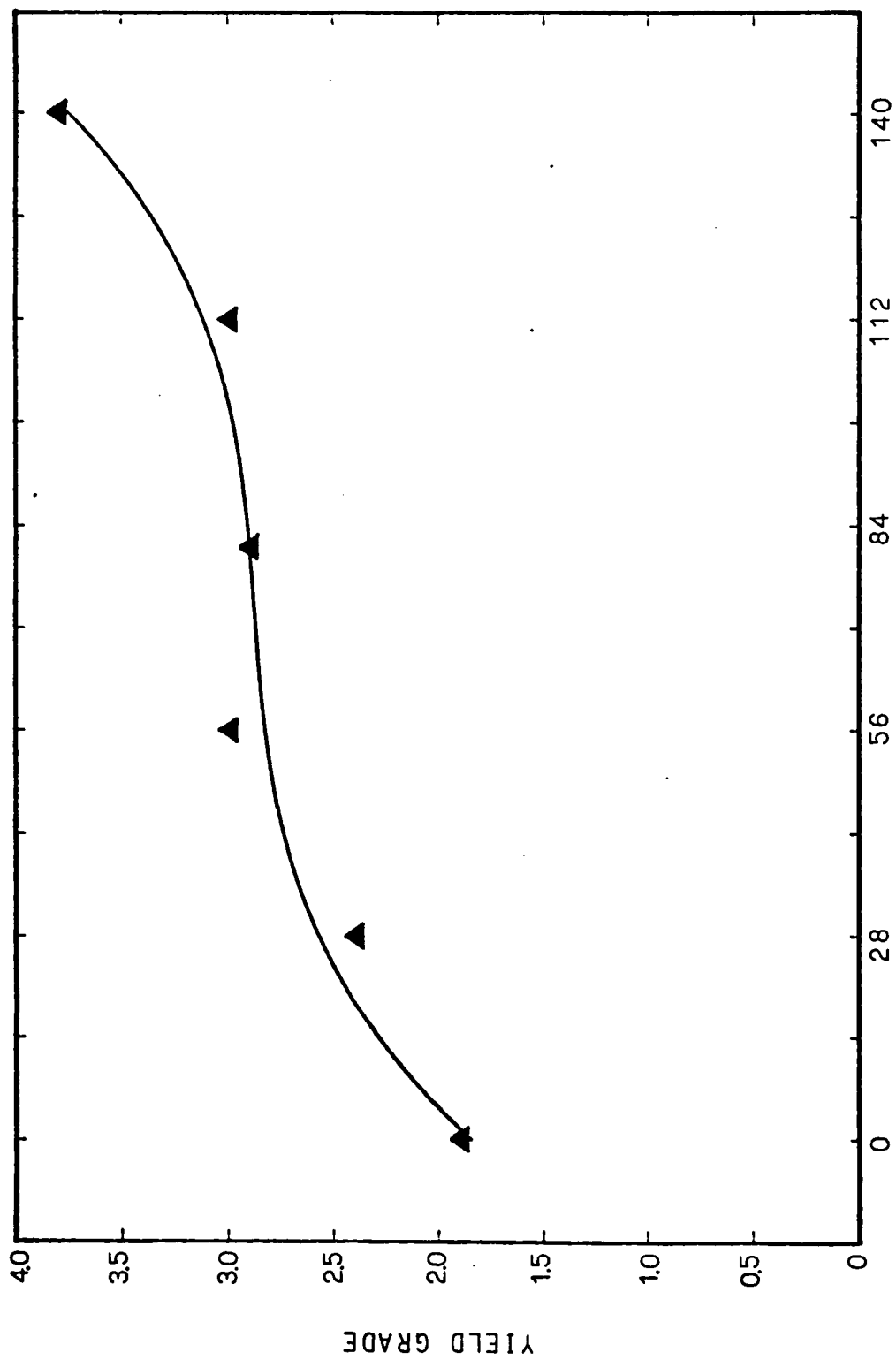


Figure 1. Cubic response of yield grade of Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

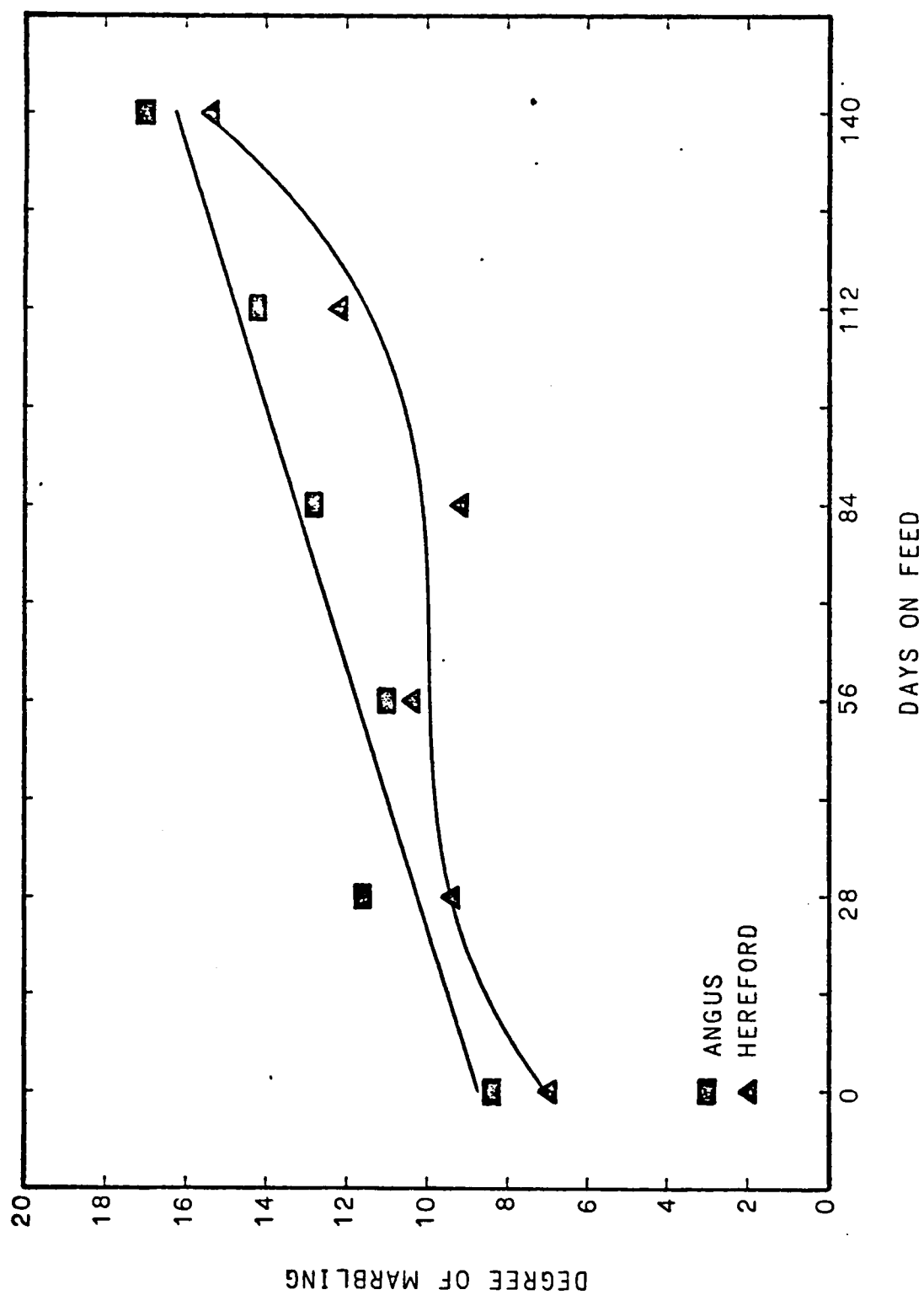


Figure 2. Linear response of degree of marbling of Angus steers and cubic response of degree of marbling of Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

There were significant differences in the degree of marbling between Angus and Hereford carcasses for all feeding periods except during the 56-day interval (Table 2).

Table 3 gives the mean square and coefficient of determination values for the variables that were significantly related. With yield grade as the dependent variable, 61.03% of the variability was due to days on feed. Days on feed accounted for 62.67 and 72.28% of the observed variability in backfat and total percentage fat, respectively. With degree of marbling as the dependent variable 54.42% of the observed variability was due to days on feed and 8.44% was due to breed effect.

A new model was selected (Model 2) which included the dependent variables from Model 1 and those independent variables that were significantly related (DOF, BRD); in addition backfat measurements off grass (BFOG), wither height measurements off grass (WHTOG) and their interaction with DOF and BRD were substituted in the model as independent variables.

YG, BF and TOTEE were highly significantly related to BFOG. WHTOG did not significantly influence any of the dependent variables. However, WHTOG*DOF was related ($P < .05$) to YG. TOTEE had a significant relation to DOF*BRD. MDG was unrelated to BFOG, WHTOG or any interactions (Table 4).

BFOG accounted for an additional 9.13% of the variability in YG, and WHTOG*DOF accounted for an additional 7.21% of the variability. BFOG accounted for an additional 9.02% of the variability in BF. BFOG and DOF*BRD accounted for an additional 3.24 and 4.22% of the variability in TOTEE, respectively (Table 5).

TABLE 2. DIFFERENCES IN DEGREE OF MARBLING
BETWEEN BREEDS

Days on Feed	Breed	Degree of Marbling
0	A	8.4 a
	H	7.0 b
28	A	11.6 c
	H	9.4 d
56	A	11.0 e
	H	10.4 e
84	A	12.8 f
	H	9.2 g
112	A	14.2 h
	H	12.2 i
140	A	17.0 j
	H	15.4 k

Marbling scores with the same superscript are not significantly different ($P < .05$)

A=Angus

H=Hereford

TABLE 3. MEAN SQUARE AND R^2 VALUES OF SIGNIFICANT
VARIABLES IN MODEL 1 ONLY

Dependent Variable	Source	df	MS	R^2
YG	DOF	5	4.1351	61.03
BF	DOF	5	231.7067	62.67
TOTEE	DOF	5	524.8199	72.28
MDG	DOF	5	82.5900	54.42
	BRD	1	64.0445	8.44

TABLE 4. MEAN SQUARE AND R^2 VALUES FOR
VARIABLES IN MODEL 2

SOURCE	bf	DEPENDENT VARIABLE			
		YG MS	BF MS	MDG MS	TOTEE MS
DOF	5	4.1351*	231.7067*	82.5900*	524.8199*
WHTOG	1	.2084	7.0732	.1140	.3062
BFOG	1	2.8872*	159.7902*	8.7032	126.3693*
WHTOGxDOF	5	.4887*	2.3544	6.3448	7.8653
BFOGxDOF	5	.1406	7.7639	6.2376	17.2750
BRD	1	.5043	9.0544	35.2466*	11.3408
DOFxBRD	5	.0804	3.4006	4.5404	40.1067*
WHTOGxBRD	1	.3258	38.1608*	1.5960	20.7497
BFOGxBRD	1	.0026	.0000	2.1078	.6143
WHTOGxBFOG	12	.1253	15.5630	4.1324	10.6003
xDOFxBRD					
ERROR	22	.1919	10.0805	7.4059	17.8825
R^2		87.54	88.00	78.53	89.16

TABLE 5. MEAN SQUARE AND R^2 VALUES FOR
SIGNIFICANT VARIABLES IN MODEL 2

Dependent Variable	Source	df	MS	R^2
YG	DOF	5	4.1351	61.03
	BFOG	1	3.0906	9.13
	WHTOGxDOF	5	.4887	7.21
	ERROR	47	.1630	
BF	DOF	5	231.7067	62.67
	BFOG	1	166.8264	9.02
	ERROR	50	9.9569	
MDG	DOF	5	82.5900	54.42
	BFOG	1	54.1500	7.14
	ERROR	53	5.5047	
TOTE	DOF	5	524.8199	72.28
	BFOG	1	126.3693	3.24
	DOFxBRD	5	40.1067	4.22
	ERROR	47	15.3816	

With yield grade as the dependent variable, there were linear and quadratic responses ($P < .05$) with DOF, BFOG and WHTOG $\times$ DOF. BF had a linear response with DOF (Figure 3), BFOG and WHTOG $\times$ BRD. TOTEE displayed a linear relationship with DOF, BFOG and DOF $\times$ BRD.

Another model (Model 3) was selected which included the 8 other extract values from the cuts used in fat determination (brisket, chuck, loin-flap, plate, ribend, foreshank and hind shank) as dependent variables. The independent variables included those used in Model 2. All the dependent variables were influenced ($P < .01$) by DOF whereas flank ether extract (FLKEE) was the only variable related to WHTOG. All the variables, except hind shank ether extract were influenced ($P < .01$) by BFOG. Only the plate ether extract (PTEE) was influenced ($P < .05$) by BFOG $\times$ DOF, and ribend ether extract (REDEE) was the only variable influenced by breed. Brisket ether extract (BRKEE), plate ether extract, loinflap ether extract (LFEE) and hind shank ether extract (HSKEE) were influenced ($P < .05$) by WHTOG $\times$ BRD (Table 6).

Table 7 indicates the mean square and coefficient of determination values of the significant variables only. DOF, BFOG and WHTOG $\times$ BRD accounted for 61.49, 4.62 and 2.42% of the variability in BRKEE, respectively. DOF accounted for 75.24 and BFOG accounted for 1.57% of the variability in chuck ether extract (CKEE). DOF, BFOG, BFOG $\times$ DOF and WHTOG $\times$ BRD accounted for 75.53, 4.11, 3.64 and .69% of the variability in PTEE, respectively. DOF, BFOG and WHTOG $\times$ BRD accounted for 52.53, 9.33 and 1.64% of the variability in LFEE, respectively. DOF, WHTOG and BFOG accounted for 42.78, 2.17 and 14.22% of the variability in FLKEE, respectively. DOF, BFOG and BRD accounted for 74.18, 1.31 and

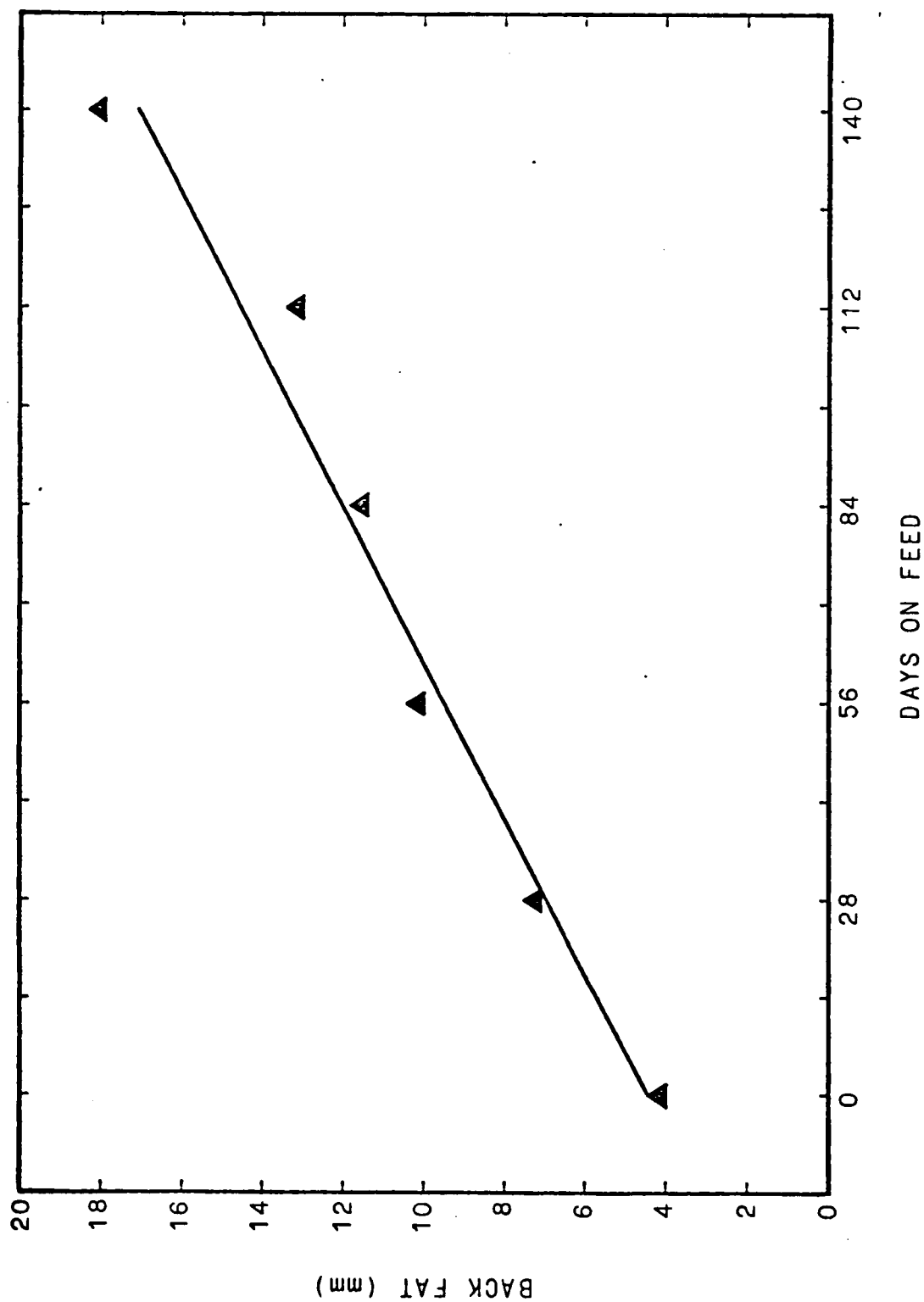


Figure 3. Linear response of back fat of Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

TABLE 6. MEAN SQUARE AND R² VALUES FOR VARIABLES IN MODEL 3.

Source	df	BRKEE MS	CKEE MS	PTEE MS	LFEE MS	FLKEE MS	REDEE MS	FSKEE MS	HSKEE MS	TOTEE MS
DOF	5	524.6039*	661.0428*	885.8087*	655.1145*	269.2700*	932.8812*	334.0709*	313.4544*	524.8199*
WHTOG	1	32.4387	2.2865	1.7297	15.0622	68.3497*	12.5034	2.9062	12.8681	.3062
BFOG	1	197.0344*	78.6042*	240.8350*	581.5369*	447.4402*	102.4095*	101.9690*	.0367	126.3693*
WHTOGxDOF	5	29.3719	16.5354	6.6225	28.6241	38.9504	14.8467	8.4933	14.3332	7.8653
BFOGxDOF	5	2.3974	15.0851	21.3585*	9.1651	8.3427	30.1295	27.2404	15.1324	17.2750
BRD	1	28.6450	31.4847	13.6337	49.4506	20.7902	101.6086*	12.0421	2.4993	11.3408
DOFxBRD	5	6.6619	12.7823	18.3015	36.1404	36.6049	28.9679	38.6766	9.9206	40.1067*
WHTOGxBRD	1	121.2066*	29.0291	53.5975*	181.6095*	13.2410	2.2773	32.9889	117.7360*	20.7497
BFOGxBRD	1	39.9549	.2064	9.7540	33.2152	2.4246	1.1661	5.8702	27.4616	.6143
WHTOGxBFOG	12	35.3293	25.3187	33.3452	58.7357	28.6108	26.9367	15.1544	40.4544	10.6033
xDOFxBRD										
ERROR	22	27.6049	19.1049	17.4443	46.5801	22.0966	32.3141	16.7589	31.6052	17.8825
R ²		85.76	90.43	93.46	83.57	84.56	88.69	86.59	75.37	89.16

*Indicates significant variables (P<.05)

TABLE 7. MEAN SQUARE AND R^2 VALUES FOR
SIGNIFICANT VARIABLES IN MODEL 3.

Dependent Variable	Source	df	MS	R^2
BRKEE	DOF	5	524.6039	61.49
	BFOG	1	197.0344	4.62
	WHTOGxBRD	5	103.4063	2.42
	ERROR	50	25.0953	
CKEE	DOF	5	661.0428	75.24
	BFOG	1	69.1314	1.57
	ERROR	48	18.8023	
PTEE	DOF	5	885.8087	75.53
	BFOG	1	240.8350	4.11
	BFOGxDOF	5	42.7059	3.64
	WHTOGxDOF	1	40.6721	.69
	ERROR	45	20.6656	
LFEE	DOF	5	655.1145	52.53
	BFOG	1	581.5369	9.33
	WHTOGxBRD	1	102.0595	1.64
	ERROR	50	44.4190	
FLKEE	DOF	5	269.2700	42.78
	WHTOG	1	68.3497	2.17
	BFOG	1	447.4402	14.22
	ERROR	52	24.7193	
REDEE	DOF	5	932.8812	74.18
	BFOG	1	82.6542	1.31
	BRD	1	94.5535	1.50
	ERROR	52	27.8198	
FSKEE	DOF	5	334.0709	60.77
	BFOG	1	104.5483	3.80
	ERROR	47	20.0509	
HSKEE	DOF	5	313.4746	55.32
	WHTOGxBRD	1	52.8281	1.87
	ERROR	51		

Note: Degrees of freedom may not total up to 59 due to insignificant variables being dropped from the model

1.50% of the variability in REDEE, respectively. DOF accounted for 60.77 and BFOG accounted for 3.80% of the variability in FSKEE. DOF and WHTOG*BRD accounted for 55.32 and 1.87% of the variability in HSKEE, respectively.

Although other variables were found to be related to the percentages of the extractable fat of the various cuts, days on feed was the most common and the most highly attributing variable. Table 8 includes the mean extractable fat changes by length of the feeding period. The changes in extractable fat of the brisket, chuck, plate and total all indicate significant linear relationships with days on feed (Figure 4). The change in extractable fat of the plate also indicated a significant quadratic response.

The fourth model was selected to determine if the palatability attributes for juiciness, tenderness, flavor, overall acceptability and flavor desirability were significantly related to DOF, BRD, MDG, BF and the interactions of these variables.

The sensory evaluation scores for steaks from the loin (Table 9) indicate that all the attributes were influenced ($P < .01$) by DOF, except juiciness. Tenderness increased linearly with days on feed up to 56 days. From 56 to 84 days tenderness tended to decrease slightly but the linear increase was resumed from 112 through 140 days on full feed. This may be due to protein turnover. Flavor increased linearly throughout the feeding period. Overall flavor desirability was unchanged from 0 to 28 days, increased from 28 to 56 days, remained unchanged from 56 to 84 days and increased again from 112 through 140 days on feed. Overall acceptability tended to increase linearly for all time periods on full feed except from 56 to 84 days, at which time the

TABLE 8. PERCENT EXTRACTABLE FAT CHANGE BY LENGTH OF FEEDING PERIOD

Days on Feed	CUTS								
	Brisket	Chuck	Plate	Loinflap	Flank	Ribend	Foreshank	Hindshank	Total
0	26.61	13.56	20.80	21.32	26.81	20.28	7.39	8.96	17.27
28	33.39	17.85	31.64	27.16	23.40	31.67	11.91	13.18	22.36
56	36.32	22.52	35.69	34.20	27.46	37.32	14.16	15.33	27.76
84	42.32	26.45	40.12	38.80	28.54	39.27	15.14	16.44	29.07
112	42.15	30.35	44.21	39.62	34.54	43.40	20.95	22.24	33.52
140	46.54	35.66	46.48	42.09	37.24	47.64	23.90	23.90	37.16

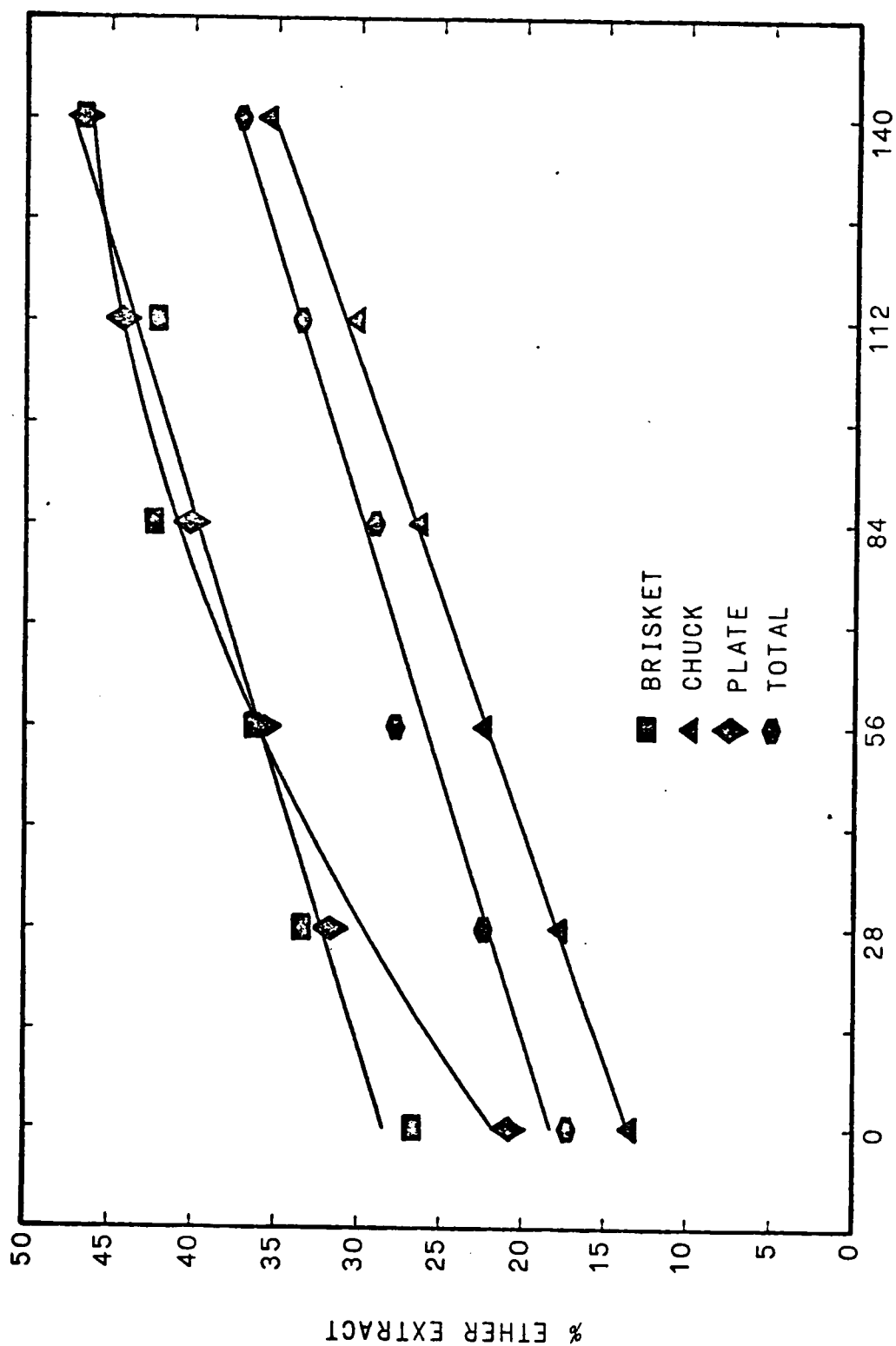


Figure 4. Linear response of the percent extractable fat of the brisket, chuck and total and the linear and quadratic responses of plate of Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

TABLE 9. TASTE PANEL SCORES - LOIN

Days on Feed	ATTRIBUTES				
	Juiciness	Tenderness	Flavor	Overall Flavor Desirability	Warner- Bratzler Shear Force
0	5.2	4.2	4.3	4.3	8.9
28	5.0	5.1	4.5	4.3	8.4
56	5.6	5.4	5.1	5.0	8.4
84	5.8	5.1	5.2	5.0	8.1
112	5.8	5.5	5.7	5.7	6.8
140	5.8	5.7	5.8	5.8	6.5

1=Extremely dry, extremely tough, extremely milky flavor, extremely undesirable flavor, extremely unacceptable

8=Extremely juicy, extremely tender, extremely beefy flavor, extremely desirable flavor, extremely acceptable for juiciness, tenderness, flavor and overall acceptability, respectively

Warner Bratzler Shear Force is measured in pounds per square inch.

sensory panel scores remained constant. Warner Bratzler shear force values for loin steaks decreased linearly with days on feed from 8.9 at 0 days to 8.4 at 28 days on feed, was unchanged from 28 to 56 days and decreased from 8.4 to 8.1 from 56 to 84 days, respectively. At 112 days the force had decreased to 6.8 and down to 6.5 by 140 days.

Presented in Table 10 are sensory panel scores and Warner Bratzler shear force values for inside round steaks. The juiciness attribute increased from 0 day on feed to 28 days going from a score of 4.6 to 5.0 for days 0 and 28, respectively. There was a slight decrease in juiciness down to 4.9 at day 56. At day 84 juiciness increased up to 5.3, but then decreased to 5.1 for days 112 and 140. Tenderness increased from 3.5 to 4.0 from day 0 to day 28, respectively. Then there was a decrease back to 3.5 at day 56 on full feed. From that point, tenderness increased to 3.6, 3.8, and 3.9 for days 84, 112 and 140, respectively. Flavor decreased from 4.4 to 3.8 from day 0 to day 56. There was a slight increase from 4.4 at day 84 to 4.8 at day 140. Overall flavor desirability decreased from 3.9 at 0 days on full feed to 3.4 at 56 days. From 84 days to 140 there were slight increases from 3.8 to 4.2, respectively. Overall acceptability tended to increase from 3.7 at day 0 to 3.9 at day 28. Then there was a decrease down to 3.4 at day 56. From day 84 to day 140 there were slight increases in overall acceptability from 3.8 to 4.1, respectively. The Warner Bratzler shear force decreased from 9.5 to 9.3 at days 0 and 28, respectively. The force required increased to 10.0 at day 56 and reached its highest peak of 10.8 at 84 days of full feeding. The force then declined to 9.8 and 8.9 for days 112 and 140, respectively.

TABLE 10. TASTE PANEL SCORES - ROUND

Days on Feed	ATTRIBUTES					Warner- Bratzler Shear Force
	Juiciness	Tenderness	Flavor	Overall Flavor Desirability	Acceptability	
0	4.6	3.5	4.4	3.9	3.7	9.5
28	5.0	4.0	4.1	3.7	3.9	9.3
56	4.9	3.5	3.8	3.4	3.4	10.0
84	5.3	3.6	4.4	3.8	3.8	10.8
112	5.1	3.8	4.5	4.0	3.9	9.8
140	5.1	3.9	4.8	4.2	4.1	8.9

1=Extremely dry, extremely tough, extremely milky flavor, extremely undesirable flavor, extremely unacceptable

8=Extremely juicy, extremely tender, extremely beefy flavor, extremely desirable flavor, extremely acceptable for juiciness, tenderness flavor, and overall acceptability, respectively

Warner Bratzler Shear Force is measured in pounds per square inch.

For steaks obtained from the loin, Table 11 lists the mean square and R^2 values for each model and the variables having significant relationships have been pointed out. The juiciness attribute was not significantly related to any of the independent variables. Tenderness, flavor, overall acceptability and flavor desirability attributes were all significantly related to days on feed (DOF). Tenderness and overall acceptability were also influenced ($P < .05$) by BF*DOF, MDG*BRD and BF*BRD. Flavor desirability was influenced ($P < .05$) by MDG*BRD and BF*BRD.

Table 12 indicates the mean square and R^2 values of those independent variables that expressed significant influence on the sensory panel scores.

Although the juiciness attribute was not significantly influenced by any of the independent variables, the R^2 values indicate that DOF, DOF*BRD, BF*DOF and MDG*BRD accounted for 15.98, 10.44, 7.61 and 3.59% of the variability in juiciness, respectively. DOF, BF*DOF, MDG*BRD and BF*BRD accounted for 14.29, 26.76, 3.52 and 4.48% of the variability in tenderness, respectively. The flavor attribute was influenced by DOF only, which accounted for 33.85% of the variability. DOF, BF*DOF, MDG*BRD and BF*BRD accounted for 24.93, 15.86, 2.11 and 8.28% of the variability in overall acceptability respectively. MDG*BRD influence on flavor desirability approached significance but the R^2 value indicated that the interaction did not account for any of the variability. DOF and BF*BRD accounted for 35.55 and 4.34% of the variability in flavor desirability, respectively.

Table 13 indicates the mean square and R^2 values of the sensory panel scores of steaks taken from the round (semimembranosus) and those

TABLE 11. MEAN SQUARE AND R^2 VALUES FOR VARIABLES
IN MODEL 4. (FOR STEAKS FROM THE LOIN)

SOURCE	df	JA MS	TA MS	FA MS	OVA MS	FDA MS
DOF	5	1.3605	2.8171*	4.0938*	3.2945*	4.7665*
BRD	1	.0304	1.0667	.0217	.2386	.0436
MDG	1	.0062	1.5621	1.8891	1.8231	1.7330
BF	1	.3221	.0848	.0376	.0179	.0862
DOF x BRD	5	.8887	.9190	.3159	.8661	.6027
MDG x DOF	5	.2577	2.0214	.4910	.8909	.4048
BF x DOF	5	.5641	4.1040*	1.2823	1.7642*	1.0014
MDG x BRD	1	1.2538	6.2882*	1.6997	4.8386*	2.7852*
BF x BRD	1	.0019	6.1490*	1.3789	4.3645*	2.5789*
MDG x BF x DOF x BRD	12	.6224	.7279	.6782	.4444	.7601
ERROR	22	.8245	1.1547	.7331	.6987	.7641
R^2		57.40	74.24	73.12	76.73	74.92

JA=Juiciness Attribute
 TA=Tenderness Attribute
 FA=Flavor Attribute
 OVA=Overall Acceptability
 FDA=Flavor Desirability Attribute

TABLE 12. MEAN SQUARE AND R^2 VALUES FOR SIGNIFICANT
VARIABLES IN MODEL 4. (FOR STEAK FROM THE LOIN)

Dependent Variable	Source	df	MS	R^2
JA	DOF	5	1.3605	15.98
	DOF $\times$ BRD	5	.8887	10.44
	BF $\times$ DOF	5	.6483	7.61
	MDG $\times$ BRD	1	1.5287	3.59
	ERROR	40	.6551	
TA	DOF	5	2.8171	14.29
	BF $\times$ DOF	5	5.2760	26.76
	MDG $\times$ BRD	1	3.4713	3.52
	BF $\times$ BRD	1	4.4126	4.48
	ERROR	44	1.0803	
FA	DOF	5	4.0938	33.85
	ERROR	54	.7320	
OVA	DOF	5	3.2945	24.93
	BF $\times$ DOF	5	2.0952	15.86
	MDG $\times$ BRD	1	1.3927	2.11
	BF $\times$ BRD	1	5.4699	8.28
	ERROR	44	.6858	
FDA	DOF	5	4.776	35.55
	BF $\times$ BRD	1	2.9070	4.39
	ERROR	49	.7842	

TABLE 13. MEAN SQUARE AND R^2 VALUES FOR VARIABLES
IN MODEL 4. (FOR STEAKS FROM THE ROUND)

Source	df	SJA MS	STA MS	SFA MS	SUA MS	SFDA MS
DOF	5	.3767	.5531	.6015	.9768*	.2229
BRD	1	1.1588	.0973	3.7401*	2.1320*	.8705
MDG	1	.1328	.0161	.0563	.0469	.0755
BF	1	.0895	2.9818*	.6196	.2194	.0166
DOFxBRD	5	.5669	.6503	.6964*	.5196	.2859
MDGxDOF	5	.2537	.1199	.3523	.1453	.0948
BFxDOF	5	1.3856*	.2547	.2314	.1384	.1202
MDGxBRD	1	1.5894	.3706	.1243	.3807	.7608
BFxBRD	1	.4012	.3087	1.2622*	.8587	1.5929*
MDGxBF	12	.3968	.5142	.6902	1.8594	.3070
xDOFxBRD						
ERROR	21	.4598	.3726	.2502	.3167	.2401
R^2		68.55	69.50	81.72	76.65	67.81

S=Semimenbranosus muscle from the round

FA, JA, TA, OUA, FDA=Same as for loin steaks

variables showing significant influence have been pointed out. Overall desirability was the only variable influenced ($P < .01$) by DOF. Juiciness was the only variable influenced ($P < .05$) by BF*DOF and tenderness was influenced by BF only. Flavor was the only variable influenced ($P < .05$) by DOF*BRD. Flavor and overall flavor desirability were both influenced by BRD. Overall acceptability was influenced ($P < .05$) by BF*BRD only.

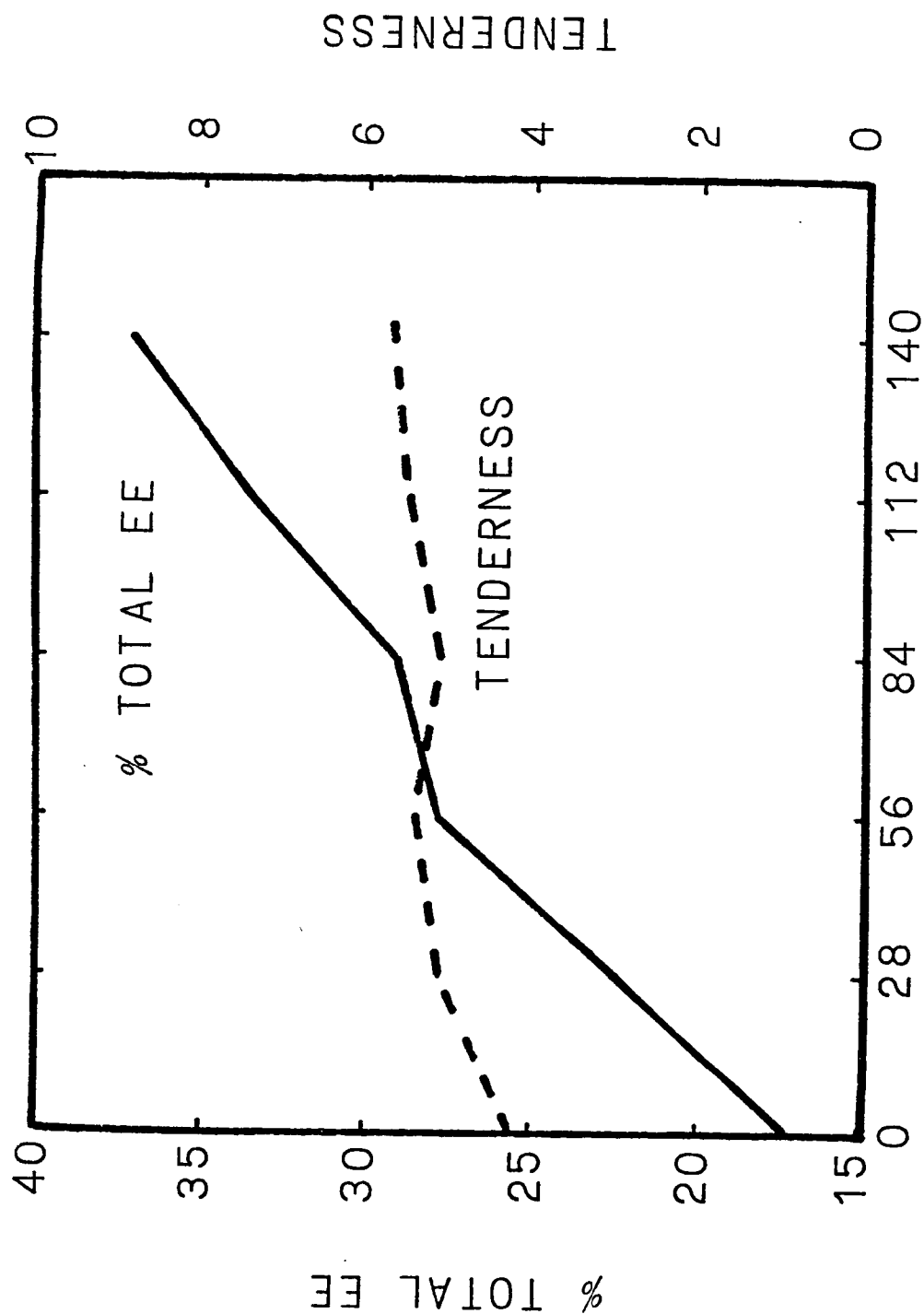
Table 14 indicates the mean square and R^2 values of the significant variables. BF*DOF accounted for 22.56% of the variability in juiciness and BF accounted for 11.62% of the variability in tenderness. BRD, DOF and BF*BRD accounted for 13.01, 12.11 and 4.39% of the variability in flavor, respectively. DOF accounted for 17.14 and BRD accounted for 7.4% of the variability in flavor desirability. BF*BRD accounted for 10.17% of the variability in overall acceptability.

These results are in agreement with the findings of Harrison et al. (1978) who concluded that sensory panel responses to steaks from the longissimus muscle flavored those from steers fed the longest length of time and the highest plane of nutrition. Bryant et al. (1965) and Skelley et al. (1978) also found palatability attributes to favor those steaks from steers fed the longest time. In contrast Dinus et al. (1978) and Schupp et al. (1976) reported similar palatability scores regardless of the length of feeding.

To illustrate how time on feed changes the fat level of ground beef from the total of the 8 cuts and the eating quality of steaks from the loin, Figures 5, 6, and 7 displays the TOTEE values with the palatability scores of tenderness, flavor desirability and overall acceptability, respectively.

TABLE 14. MEAN SQUARE AND R^2 VALUES OF SIGNIFICANT
VARIABLES IN MODEL 4. (FOR STEAKS FROM THE ROUND)

Dependent Variable	Source	df	MS	R^2
SJA	BFxDOF	5	1.3856	22.56
STA	BF	1	2.9313	11.62
SFA	BRD	1	3.7401	13.01
	DOFxBRD	5	.6964	12.11
	BFxBRD	1	1.2622	4.39
SFDA	DOF	5	.9768	17.14
	BRD	1	2.1320	7.48
SOVA	BFxBRD	1	1.5929	10.17



DAYS ON FEED

Figure 5. Total percentage of extractable fat change in ground beef and the sensory tenderness score of loin steaks from Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

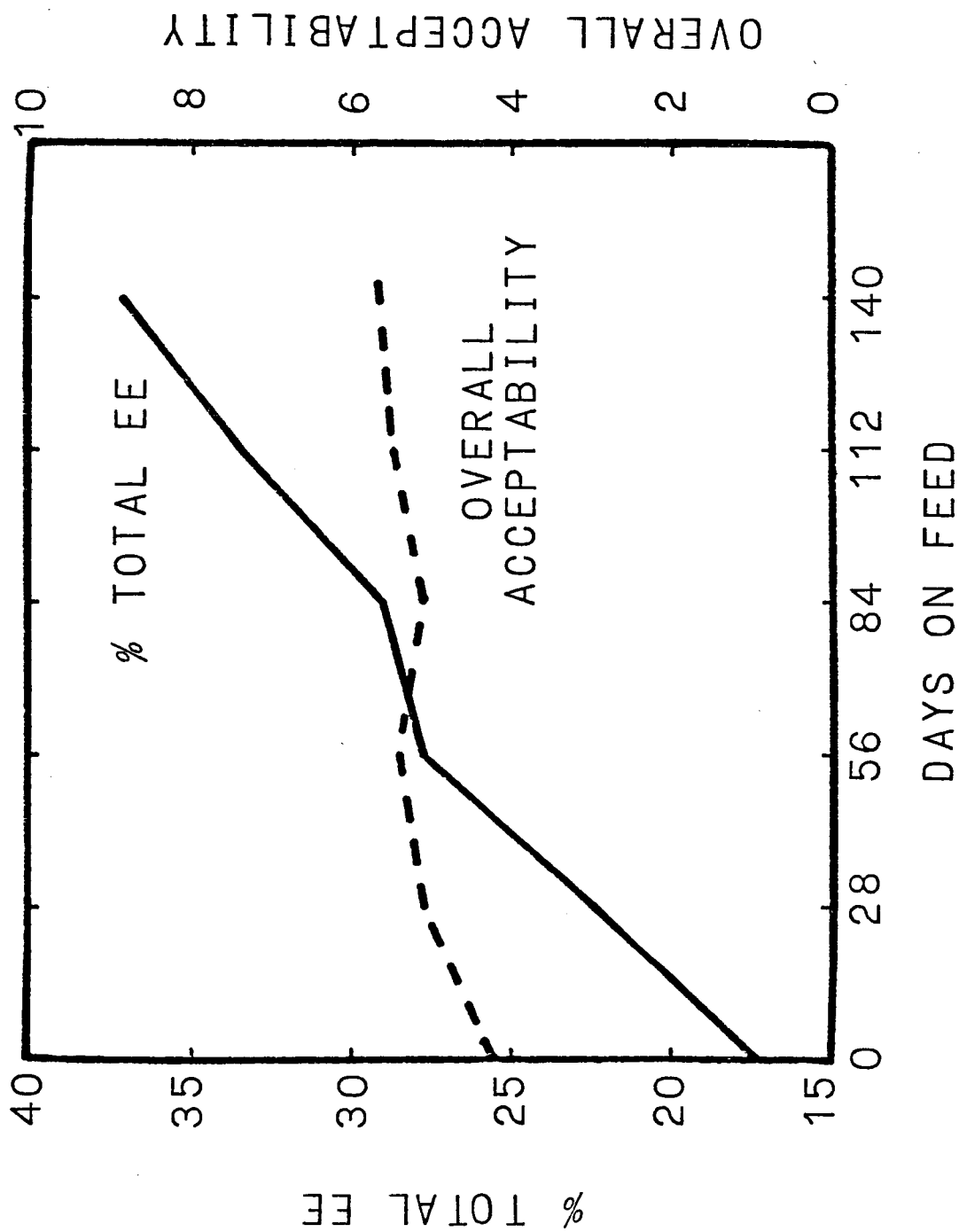


Figure 7. Total percentage of extractable fat change in ground beef and the sensory overall acceptability score of loin steaks from Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

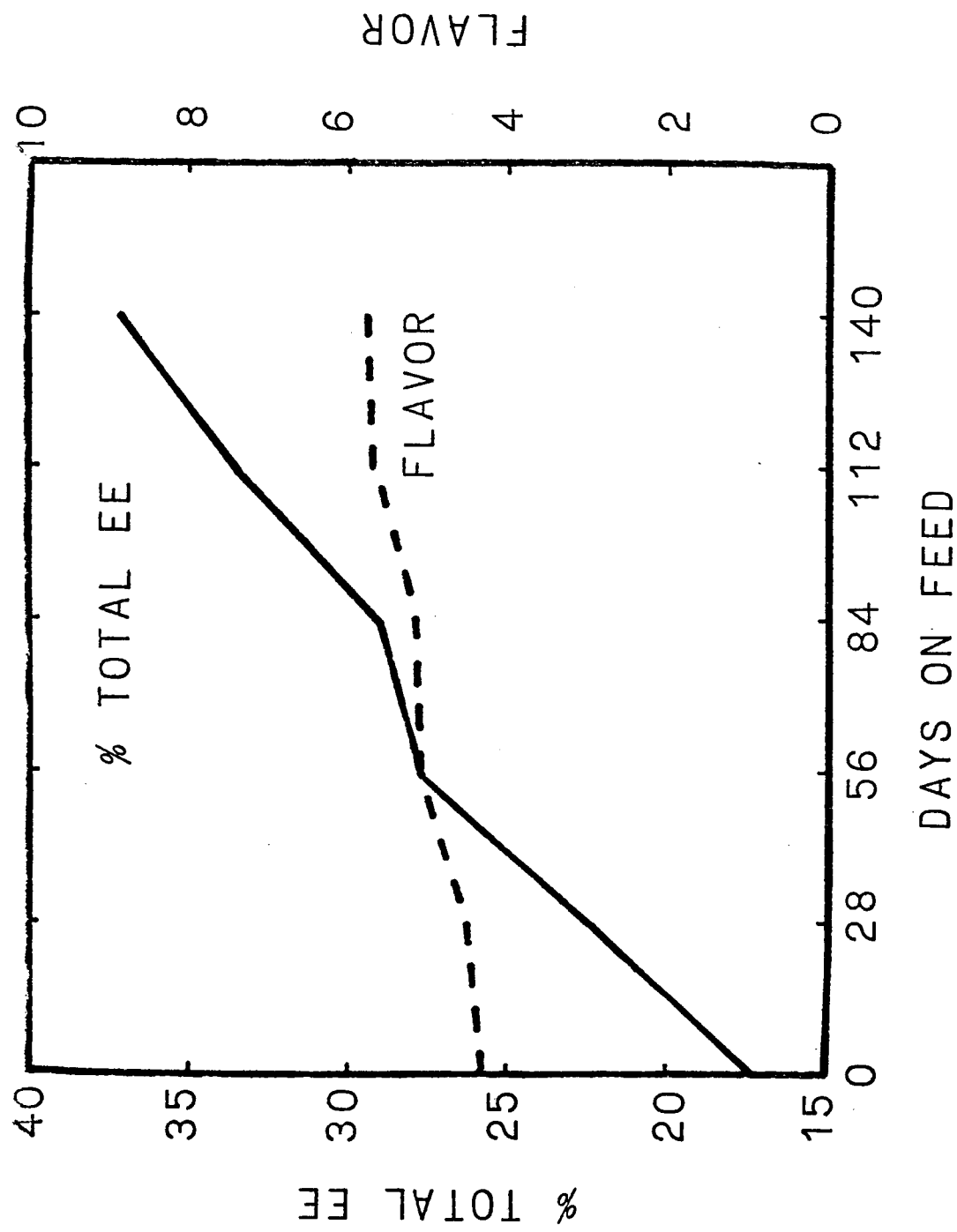


Figure 6. Total percentage of extractable fat change in ground beef and the sensory flavor score of loin steaks from Angus and Hereford steers serially slaughtered after varying intervals of feed-lot finishing.

At present, USDA requires that ground beef contain not less than 14% and not more than 28% fat. However, in 1976 USDA studied the effect of fat content of ground beef on the eating quality and concluded that ground beef should be at least 20 and not more than 30% fat to insure optimum palatability and economic value.

Results of this study revealed that the average percent TOTEE of the cuts used for ground beef reached 29% at 84 days on feed and increased to 37.16% by 140 days on feed. At 84 days on feed the sensory panel scores for tenderness, flavor and overall acceptability for steaks taken from the loin were 5.1, 5.0 and 5.1, respectively, and increased to 5.7, 5.8 and 5.7 for tenderness, flavor and overall acceptability, respectively.

CONCLUSION

Based on samples from Hereford and Angus steer carcasses, these data indicate that the percentage fat in all ground beef cuts and sensory flavor, tenderness and overall acceptability of cooked loin steaks was acceptable after a grain finishing period of 56 to 84 days.

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