PHYSICAL AND CHEMICAL CARCASS CHARACTERISTICS AS INFLUENCED BY CONCENTRATE LEVEL, BREED TYPE AND FAT THICKNESS ENDPOINT

by

Mario F. Ochoa

A Thesis Submitted to the Faculty of the

DEPARTMENT OF ANIMAL SCIENCE

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 8 1

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department of the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Mario F. Silva

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

J. A. Marchello
J. A. MARCHELLO
Professor of Animal Science

7/24/80
Date

ACKNOWLEDGMENTS

The author is sincerely grateful to his major professor, Dr. John A. Marchello, for his helpful guidance, invaluable suggestions and friendship throughout his graduate program and during the preparation of this thesis. This manuscript could not have been possible without his helpful encouragement. A special thanks is extended to Dr. Tony Mata, who gave me food for thought and many words of advice, which will always be remembered.

The author is also grateful to Marianne McDaniel and Marianne Daley for their help and cooperation throughout the laboratory analyses of this study.

A special and sincere thanks to my mother, Lydia; father, Mannix; brother, Charlie; and sister, Olivia for their patience, understanding, encouragement and moral support during this study.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

ABSTRACT

One hundred twenty steers were randomly selected from Angus X Hereford, Santa Gertrudis, Beefmaster, Limousin X Hereford and Brahma-Hereford-Angus-Charolais cross breeds.

The cattle were fed four different diets consisting of low, medium low, medium high or high concentrate levels (39, 52, 67 and 80% concentrate, respectively) and were slaughtered at 10, 13 or 15 mm of fat thickness over the 12th rib.

Carcass data were obtained and Longissimus muscle samples collected and analyzed for amount of intramuscular fat and fatty acid composition of the fat.

No significant ($P<.05$) differences in fatty acid composition were observed between diets or breeds. Cattle fed the high and medium high concentrate levels possessed more ($P<.05$) unsaturated intramuscular fat than cattle fed the low concentrate diet. Cattle fed to 13 or 15 mm of backfat had significantly ($P<.05$) more C18:1 and less C18:2 than cattle fed to 10 mm of backfat. Carcasses from the cattle fed the high concentrate diet were significantly ($P<.05$) heavier and had larger ribeyes than those fed the low and medium low concentrate diets. Limousin X Hereford cattle were significantly ($P<.05$) leaner and lower in quality grade and yield grade than the other breed types. Cattle fed to 15 mm of backfat were significantly ($P<.05$) heavier, higher in marbling and quality grade and fatter than cattle fed to 10 or 13 mm of backfat.

INTRODUCTION

Within the past decade many changes in the beef industry have occurred. In the past when the U. S. had a grain surplus, farmers preferred to market their products through animals, and as a consequence, greater profits were enjoyed. Overfinishing of beef animals was not a major concern. However, as the energy shortage occurred along with the increase in use of grain for human consumption, the problem of overfinishing beef cattle became an important issue. Consequently grain in diets of feeder cattle may be reduced in order to meet human demands for grain. This in turn may cause more grass and other harvested roughages to be used for growing and finishing feeder cattle.

Other changes which have occurred in the agricultural industry have been those regarding production goals of ranchers. Management systems practiced today involve producing animals which will maximize profits. Concentrated efforts have been to develop animals in which the rate of maturity is increased. In these animals fat deposition occurs early and shortens the period of time required for marketing.

In order to insure carcass quality, a certain amount of fat is necessary, but should not exceed 10 mm of subcutaneous fat. Thus compositional changes which favor cattle that have higher percentages of lean to fat will better meet production needs of today as compared to the more finished beef of the past.

Concentrate feeding has been well studied and proved to be influential on carcass physical as well as chemical characteristics. However, no definite slaughter endpoint or concentrate diet has been established which satisfies the production goals for all types of feeder cattle, thus showing a need for researching these areas.

The purpose of this study was to determine the effects of concentrate level, breed type and fat thickness endpoint on carcass physical and chemical characteristics.

LITERATURE REVIEW

Rumen Function

The breakdown of nutrients taken in by ruminants is mainly due to the work of symbiotic microorganisms located in the rumen. Most of the organic matter consumed by ruminants exists as insoluable polysaccharides of which cellulose is the most important. By the use of microorganisms as digestive agents, ruminants can digest cellulose into valuable and utilizable precursors of body constituents.

Microbes also break down dietary fat and produce an altered end product during fat digestion, which may have an effect of body composition. Various studies have shown that ruminants receiving normal dietary addition of 5 and 10% fat, either of a highly saturated or unsaturated form, generally do not have large changes in the composition of body fat stores (Edwards et al. 1961, Erwin, Steiner and Marco 1963, Roberts and McKirby 1964, Dryden and Marchello 1973). The small change of body fat stores is mainly due to the hydrogenation of the dietary lipid by rumen microorganisms. This metabolical process in the ruminant is the most important feature which prevents large differences in body fat stores to be prominant (Reiser 1951, Garton, Lough and Vioque 1961, Ulyatt et al. 1966). Erwin et al. (1963) have described that both protozoa and bacteria hydrogenate the unsaturated fatty acids of the diet.

Body Fat Condition

Fat is laid down in different depot sites in the animal; around the viscera and kidney (internal fat), between the muscles (intermuscular), beneath the skin (subcutaneous), and in the form of marbling between muscle bundles (intramuscular) (Forrest et al. 1975).

The contribution of the various fat depots to the total fat content of the body has been reported by Kempster et al. (1976). The greatest contributor to total fat was intermuscular fat (49.5% pooled within group, CV = 6.0%) followed by subcutaneous fat (29.5%, CV = 10.8%) while kidney and pelvic fat was (16.4%, CV = 19.3%) and considered the most variable. No results were given for intramuscular fat; however, Cramer et al. (1973b) reported about 25% of the total fat in "chemical mature" cattle is intramuscular.

Weight Effects

It has been suggested by McMeekan (1940, 1941) that in a specific muscle there are certain limits to muscle fiber size which are defined by age and these limits cannot be exceeded despite a prolonged high plane of nutrition. Any weight gain in the mature bovine after these limits are reached must be due solely to fat deposition (Moulton, Trowbridge and Haigh 1923).

Haecker (1920) designed a study to determine the composition of gain from 47 kilograms (kg) to various weights up to 685 kg. If the total gain from 47 kg to 458 kg was considered, fat content accounted for a third of the gain in weight. As the final weight increased to 685 kg, fat accounted for approximately 40% of this increase in weight.

Johnson, Butterfield and Prior (1972) studied the proportions of intermuscular, subcutaneous, intramuscular and kidney fat which made up total side fat. Results show that the two major contributors to total side fat weight are intermuscular and subcutaneous depots. These workers reported that 74% of the total fat in the bovine carcass was found in these two depot sites.

Age

Hiner and Bond (1971) studied growth differences in separable lean and fat for Angus calves from 6 to 36 months slaughtered at 6 month intervals. The animals were fed 3 diets which consisted of (1) full fed, (2) restricted and (3) fed diet 2 then full fed for 6 months. Results show that the largest ratio increase of all muscles, lean and fat weights occurred during the growth period of 6 to 12 months in all diets.

Moulton et al. (1923) found that the mature bovine grows some during fattening, but 76.5% of the weight increase is fat. Callow (1950) reported that cows fatten more slowly than steers, and that with cows only 58.2% of the increase is due to fat as compared to 71.5% for 2 1/2 year old fattening steers. Fat deposits appear first as internal fat, with increasing age and adequate calorie intake, intermuscular is then deposited as is subcutaneous fat, and lastly fat is deposited in the form of marbling (Andrews 1958 and Zinn 1964).

Studying intramuscular fat, Ramsey, Cole and Sliger (1967) reported that this particular fat increased with maturity up to 30 months of age, after this intramuscular fat content varied little with increasing age.

Clemens et al. (1973), studying carcass data from bulls and steers slaughtered at 9, 12, 15, 18 and 24 months of age found that bulls did not deposit sufficient fat in Longissimus muscle to grade choice until they approached 24 months of age. In turn, steers graded choice at about 15 months of age.

Cramer et al. (1973a) found that Herefords and Holsteins begin to deposit intramuscular fat at accelerated rates at about 15 months of age; whereas Angus increased the rate of deposition at about 9 months of age.

Breed Effects

Body type, usually designated by breed, influences growth rate and mature body size which in turn dictates composition at a given weight or stage of physiological maturity. Usually beef cattle are earlier maturing and capable of becoming fat at younger age than dairy cattle (Carrol et al 1964).

Brungardt (1972) indicated that cattle of different growth and maturity rates should be compared at a certain level of fatness of compositional endpoint on the growth curve.

Kidwell and McCormick (1956) found that if beef breeds are compared to dairy breeds on age constant or weight basis, dairy cattle are lower in percentage of total fat and higher in percentage of total protein.

Hankes (1974), who worked with steer calves from Hereford cows breed to Hereford, Angus, Holstein or Jersey bulls, found that no major differences in carcass composition related to breed exist when fed to the same degree of finish. However, Koch et al. (1976) found considerable breed variation in the carcass fat depots even when adjustments were made for carcass weight differences.

Prior et al. (1977) researched the composition of different biological types of cattle; Angus X Hereford (small), and Charolais X Chianina-Hereford or Charolais X Chianina-Angus (large). Results showed that rates of fat deposition tended to be faster in small type cattle than large type cattle. They attributed this response to different respective stages of physiological maturity or stage development at time of slaughter. Furthermore, if relative chemical composition is a valid estimate of physiological maturity, the large type cattle had not reached the same degree as the small type; however, if degree of marbling is used as an indicator of physiological maturity, the two types of cattle were similar.

Cramer et al. (1973b) also determined fat distribution differences among three types of cattle; Herefords, Angus and Holsteins. Slaughter weights were selected to provide carcasses with approximately 30% fat. Considerable variation existed in percentage of carcass fat, but the average for all breeds was 30.4%. The Holsteins had approximately 4% less fat than the other two breeds, while the Herefords and Angus differed by only .5%.

Effect of Nutritional Regimen on Intramuscular Lipid

The amount of intramuscular lipid present, especially in the *Longissimus* muscle, is an important feature in cattle. Under present

USDA grading standards (1976) the value of carcasses is due in part to the degree in intramuscular lipid present. The effect of different nutritional regimens is controversial, although all cattle are not fed in the same manner, the same feedstuffs, or to the same weight. Other factors such as biological type and environmental all play a part in determining to what extent this trait is present.

In a study conducted by Waldman, Tyler and Brungardt (1971), feeding 171 male Holstein calves under a high and medium energy level, Longissimus muscle extraction of lipid of the 13th costal rib did not differ significantly ($P>.05$) in terms of nutritional regimen until animals reached 455 and 590 kg live weights. The design called for animals to be slaughtered at 91, 227, 341, 455 and 590 kg weights. The animals on the high energy diet slaughtered at 455 and 590 kg exhibited significantly ($P<.05$) higher levels of lipid in the Longissimus muscle than the animals slaughtered at same weight on medium energy diet (7.64% and 38.98%, respectively).

Clemens et al. (1973) found that by feeding a high and low dietary energy level consisting of 8.25% ground corn, 12.5% pelleted (brome and alfalfa) hay, 5% protein supplement and 65.0% ground corn, 35.5% pelleted hay with protein supplement, to 9, 12, 15, 18 and 24 month old cattle, differences in ether extract of the 8th rib were present. The results indicated that animals on the high energy diet had more lipid present in the intramuscular area regardless of age.

In a similar experiment conducted by Arthaud et al. (1977) using similar ration and age groups, ether extract of the Longissimus muscle at the 12th rib showed similar results when comparing high energy diets to low energy diets.

Skelly et al. (1978) fed 300 steers over a 3 year period using 10 different rations. A portion of the Longissimus muscle near the second lumbar vertebrae was removed and subjected to ether extraction. Results indicated were that no significant ($P>.05$) difference of ether extract at this position of the Longissimus existed.

Bowling et al. (1978) did work on 100 steer calves under 10 management systems of beef production, and found the Longissimus muscle of the 9, 10 and 11th rib cut to be higher in ether extract content when going from grass feed to grain feed.

Trenkel et al. (1978) studied the growth of the Longissimus muscle of cattle on two diets. One diet was 80% corn and the other was 48% corn. One group of cattle was full fed and the other group was limited fed, to reduce growth rate by 33%. The animals were slaughtered at 110, 220, 360 and 500 kg average live weight. Results showed that amount of lipid extracted increased ($P<.05$) in the limited fed animals at 500 kg and this process was not found in the 360 kg cattle. The limited fed cattle tended to be somewhat later maturing with respect to lipid deposition in the muscle. Implications from this study were that intramuscular fat in cattle is influenced by age as well as body weight.

Effect of Plane of Nutrition on Fatty Acid Composition of Fat

The major fatty acids in adipose tissue of cattle are C18:1, followed by C16:0 and C18:0 according to Waldman (1968). According to

Hilditch (1956), these three fatty acids account for over 90% of the total acids in bovine depots, and the proportion of oleic acid must determine the softness or firmness of the mixed fats.

Methods of altering the fatty acid composition in ruminant tissue has been studied by feeding diets which contain different types of fat added to the diet.

Church et al. (1967) reported that feeding animal tallow to steers tended to increase the saturation of depot fat, but feeding DES had no significant influence on fatty acid composition.

Dryden et al. (1973) reported that the depot fat of steers became less saturated as the animal aged and that feeding 6% animal fat tended to promote more saturated depot fat. Tailhead fat from cattle which were fed 6% safflower oil contained higher ($P<.05$) C18:2 levels than those fed 6% animal fat or the control basal diet. The animal fat treatment tended to elevate quantities of C14 and C18 and lower the levels of C18:1 and C18:2 as compared to the control. The 6% safflower oil supplemented group had less C16 and more C18:1, C18:2 and C18:3; however, these results were not significant ($P>.05$).

Skelly et al. (1973) reported that feeding corn silage and Vitamin A has no effect on depot fat composition, whereas feeding raw soy beans tended to decrease the saturation of fat.

Feeding high grain diets results in a more unsaturated fat than feeding high-forage diets (Cabezas et al. 1965, Miller et al. 1967 and Rumsey et al. 1972) indicates that feeding steers on all concentrate diet increased the total unsaturated acids by 20% over feeding the all-forage diet. Most of the increased unsaturation was due to increased concentrations of oleic acid at the expense of palmitic and stearic acids.

Miller et al. (1967) did work on sheep fed a high-roughage and high concentrate diet to determine their effects on fatty acids of variout tissues. Results show that higher levels of C18:0 were found in the tissues of lambs receiving a high-roughage ration. There was also a consistently higher content of C18:1 in the tissues of lambs fed a high-concentrate ration.

Cabezas et al. (1965) found that rations containing higher percentages of corn (72%) which were fed to cattle resulted in more C18:1 and less C16:0 with a higher ($P<.05$) degree of unsaturation in the subcutaneous fat, than cattle fed diets containing 31 or 62% dried citrus meal or 36% corn.

Tove and Matrone (1962) reported that the tallow from sheep fed purified diets contained considerably less stearic acid and more oleic acid than the tallow from sheep fed natural diets. Similar results were reported by Oltjen and Williams (1974) regarding fatty acid patterns of fat depots in steers fed a purified diet when compared to steers fed a natural diet.

Nutritional Regimen and Yield Grade Factors

Factors used in determining yield grade of cattle are based on various carcass traits. Nutritional regimen may have an influence on these variables, thus causing a difference between type of diets.

Guenther et al. (1965) fed a high and moderate plane of nutrition and slaughtered cattle of both feeding regimens at weaning weights of 125 and 205 kg. Influences on yield grade factors were noticed from feeding the different diets. The animals on the high plane of nutrition yielded carcasses which were heavier than their moderate-level mates. Ribeye area was affected by changes in animal age and carcass weight. The ribeye area was larger in those animals fed the high level diet and were also fatter than animals on the moderate level diet.

Stuedman et al. (1968) fed steer calves five different levels of nutrition; very restricted (1); restricted (2); normal (3); high (4) and very high (5). The calves were fed from birth to 8 months of age. A random sample of calves from each of five groups were slaughtered at 8 months and the remaining calves were then fed a finishing ration to a weight of 430 kg. Data showed that the calves slaughtered at 8 months of age had higher carcass weights with an increasing level of nutrition while carcasses of cattle fed to a constant weight showed no difference. At 8 months of age, the cattle on the high level of nutrition also had more fat thickness and larger ribeyes. At constant market weights, cattle exhibited no difference in ribeye area or fat thcikness. Implication from this study is that growth indicates a definite pattern regarding the effect of nutritional level on growth of bone, muscle and fat. As nutritional level is decreased, bone development is reduced by the least amount, followed by muscle and fat. The results were reported to be similar with those of McMeekan (1940, 1941) and Palsson and Verges (1952).

Prior et al. (1977) fed 75 head of cattle three different dietary energy densities (low, LE; medium, ME; and high, HE) (2.9, 3.1 or 3.2 Mcal ME/kg dry matter, respectively), and three dietary levels of crude protein (LP = 10, MP = 11.5 or HP = 13% of dry matter). In looking at biological type (large vs. small), results show that increased dietary energy intake increases carcass weight ($P<.05$) in both types of cattle without influencing any other carcass trait at adjusted constant carcass weight. Large type cattle showed larger ribeyes, less backfat and better yield grades than small type cattle. Implications are that heavier carcass weight resulted from increased dietary energy intake in small type cattle is largely due to more fat deposition. By increasing the level of protein in the ration, results show no significant ($P>.05$) alteration in carcass traits in small type cattle and results agree with those of Epley (1971). In turn large type cattle fed the highest crude protein yielded carcasses with higher fat thicknesses and yield grades when compared to carcasses of cattle fed LP or MP ration. The results were attributed in part to differences in protein metabolism between type of cattle or differences in protein source and/or digestability between treatments.

Bowling et al. (1977) did work on thirty pairs of carcasses (one forage-finished and one grain-finished). Results show that there is no difference in carcass weight or yield grade when comparing rations; however, significantly larger ($P<.05$) ribeyes, kidney, pelvic and heart fat (%) and higher fat thicknesses values were observed with carcasses from cattle fed the grain finishing diet.

Cross and Dinus (1978) studied the effects of forage diets on carcass characteristics using two experiments. The first experiment consisted of comparing alfalfa hay to dehydrated alfalfa meal, ground vs.

ground and pelleted alfalfa; no Monensin vs. Monensin; no implant vs. hormonal implant. Results showed that the diets in experiment one did not affect chilled carcass weight, fat thickness or estimated kidney fat. The yield grade and ribeye area were significantly increased ($P<.05$) when hormonal implants were used and results are attributed to the additive affect of Monensin and implant. In experiment two, steers were fed ground alfalfa or orchard hay and each supplemented with formaldehyde-protein-lipid or animal fat which made up 6% of each diet. Results in experiment two show that animals fed ground alfalfa produced significantly heavier ($P<.05$) carcasses than those fed orchardgrass hay. Type of lipid (animal fat or protected) had a significant ($P<.05$) effect only in the ground alfalfa group with the protected lipid diet having heavier carcasses. Other than carcass weight, addition of protected lipid produced no significant ($P>.05$) effects on carcass traits. Cattle fed ground alfalfa diets produced carcasses with significantly more (P.>05) fat thickness, higher estimated kidney fat, larger ribeye areas and yield grades than steers fed the orchard grass diet.

Nutritional Regimen and Quality Grade

Intramuscular fat or marbling is an important factor in determining the grade and ultimately, meat palatability of beef in the United States. The influence of feed has a slight effect on the amount of marbling but is mainly a function of maturity although variation is observed from one animal to another. As animals advance in age, fat content will increase at an increasing rate, regardless of nutritional regimen, provided that the animal is in positive energy balance.

In a study conducted by Guenther et al. (1965), using half-rib Hereford steer calves (225 g) to determine the effect of plant nutrition on growth and development from weaning to slaughter weight. The cattle were fed a moderate and high plane of nutrition and slaughtered at weaning, 125 kg and 205 kg. Results show that when compared by diets on weight constant basis, carcasses of cattle fed the high level of nutrition had better grades.

Lofgreen (1968) in determining body composition using low, medium and high energy diets and slaughtered at 125 kg and 205 kg, found that differences in marbling scores were small and not influenced by nutrition.

Skelly et al. (1978) conducted a 3 year study with 100 steers, each year feeding 10 different rations and slaughtering heaviest steers at 196 day feeding periods and others slaughtered at seven day intervals for a total of five slaughter periods. Results show steers fed corn silage, corn and urea produced carcasses with highest quality grade. Steers fed rations without corn produced carcasses with lowest quality grades.

Bryant et al. (1965) reported that the carcass garde of steers not fed corn on pasture averaged one-third grade less than for steers fed corn on pasture.

Hammes et al. (1964) stated that cattle fed high corn silage rations produced carcasses grading high Good to low Choice; not significantly different ($P > .05$) from cattle fed conventional high-grain fattening ration.

Edwards et al. (1973) fed cattle corn silage and cottonseed meal with and without added corn in the diet. Results reported were that corn raised the final grade by one-third of a grade from high Good to low Choice.

Cross and Dinus (1978) finished beef cattle using forage diet of alfalfa, hay vs. meal, ground vs. pelleted with Monensin and hormonal implants and added protected fat or animal fat. The cattle fed the hay rather than the meal had significantly ($P<.05$) more marbling (small+ vs. small-), and higher quality grade (Choice- vs. Good+). The ground hay significantly ($P<.05$) increased marbling score compared with pelleted hay, but did not affect quality grade. Carcasses of cattle fed with Monensin did not significantly ($P>.05$) alter marbling or quality grade; however, carcasses of steers with hormonal implant had significantly ($P<.05$) higher quality grades.

Breeds and Carcass Lipid

Different breeds of cattle have shown the ability to fatten at an earlier time than others. The use of the beef cow as a red-meat source over the dairy cow has caused agriculture to develop beef cattle in which the rate of maturity has been increased. In such animals fat deposition occurs early in life and thus shortens the period required for making animals ready for market (Marchello 1979).

In a study conducted by Kidwell and McCormick (1956) they found that if beef breeds are compared to dairy on age or weight constant basis, dairy cattle are lower in percentage of total fat.

Carroll et al. (1964) found that carcass characteristics of Hereford were fatter than Holsteins at similar physiological age but had no more ($P>.01$) fat in the loin muscle than Herefords.

Hanks et al. (1974), using steer calves (Hereford cows bred to Hereford, Angus, Holstein or Jersey bulls) found no major difference in carcass composition related to breed when fed to the same degree of finish. However, Koch et al. (1976) found considerable breed variation in the carcass fat depots even when adjusted carcass weight differences were made. He found that Charolais X Hereford, Simmental X Hereford and Limousin X Hereford had less fat at the 12th rib than Hereford, Angus X Hereford, Jersey X Hereford or South Devon X Hereford at constant weight and age.

Adams et al. (1973) made carcass measurements of steers produced by Hereford dams sired by Simmental, Limousin, Angus, Hereford and other bulls and found that fat thickness measures of Angus and Hereford crosses were significantly ($P\leq.05$) greater than those for the other breeds. These same breeds also exhibited higher fat percentages than the others.

Kempster et al. (1976) gathered data from 643 steer carcasses of 15 breed types to determine the distribution of total fat (TF) between subcutaneous (SF), intermuscular (IF), kidney knob and channel (KKCF) fat. Carcasses of the Angus cross group contained markedly higher proportion of subcutaneous fat than the other groups of cattle. There were also a large differences ($P<.50$) between breeds for KKCF and IF. One interesting result is that dairy type cattle deposited higher proportions of their total fat as KKCF and intermuscular fat and a lower proportion subcutaneously as compared to beef cattle. Similar results have been reported by Butterfield (1965), Callow (1962) and Pomery and Williams (1974).

Dickerson et al. (1972) compared seven breeds of sheep for carcass characteristics and found only minor differences in carcass traits.

Jones et al. (1978) compared growth and carcass characteristics of bulls from Hereford crossbreds (HC), beef synthetic (SY, crossbred by artificial insemination) and dairy crossbred (DC). Results showed that the HC bulls had the fattest carcasses and the SY and DC carcasses were approximately the same in composition at each slaughter weight used.

Lohman (1971) stated that variation in carcass composition for cattle was primarily due to variation in degrees of fatness and the relative differences in fat content (as much as 50%) occurred between breedtypes at a given carcass weight.

Breeds and Fatty Acid Composition

In general, fat in animals seems to be more saturated than fat of plants. According to Hilditch (1956), three fatty acids (palmitic, oleic and stearic) account for 90% of the total acids in bovine depots fats. The degree of saturation of tissue lipids increase as cattle develop (Leat and Embleton 1970). Management and nutritional factors may also influence the saturated:unsaturated ratio in cattle subcutaneous fat (Waldman et al. 1965, Terrell et al 1969, Church et al. 1976, Dryden et al. 1973 and Skelly et al. 1973).

Feeding high grain diets resulted in a more unsaturated fat deposition than feeding a high forage diet (Cabezas et al. 1965, Miller et al. 1967 and Rumsey et al. 1972) and by feeding an all concentrate diet, unsaturation may be increased up to 20% over an all forage diet (Rumsey et al. 1972). Most of the increase in unsaturation is due to increased concentration of oleic acid at the expense of palmitic and stearic acid.

Little research has been conducted to determine the effect of different treatments on the fatty acid composition in depot fats of different breeds. One of the few studies that did compare fatty acid composition of different breeds was conducted by Rumsey et al. (1972). Samples of depot fat were taken from 22 Angus and 22 Shorthorn cows selected from a long term breeding experiment. The cows were pastured year round and during the months of December through mid-April cattle received supplemental hay, silage and protein. In each breed, a growth selection line was established from the same genetic base as that for four highly inbred lines. The sampling plan was to obtain fat from lactating cows, two young ($\leq$ 4 years), and two old ($\geq$ 6 years) in each line breed; and from four young and four old in each growth selection line. Sixteen inbred Angus and fourteen inbred Shorthorns were sampled. Results showed that Shorthorns had higher ($P<.05$) levels of C14 than both inbred (2.33% vs. 1.87%) and growth lines (2.4% vs. 1.56%) when compared to the Angus breed. Significant ($P<.05$) line within breed differences for the inbred cattle were obtained for C18, C16, C16:1 and levels of unsaturation. Variation among inbred lines within breeds for

C18 was greater ($P<.05$) for the younger vs. older cows. Conclusions were that lines or families having specific differences in fatty acid composition could be developed and maintained in line with conventional breeding programs.

Hecker (1972) studied fat composition changes with growth and various other factors associated with growth in 27 animals of Hereford, Angus and Holstein breeds. In terms of fatty acid composition, there was no general breed differences demonstarted in reference to muscle, subcutaneous or serum fat.

Carcass Characteristic Differences between Breed

Differences that exist among animals of different breeds, under similar conditions, are due to the genetic make-up of each breed. Variation among animals is due to the genetic expression of each individual. The proportion of phenotypic variation that exists in a population due to heredity is termed heritability (Lasley 1972). Heritability estimates for traits associated with carcasses vary considerably. For fat thickness values as low as 11% (Behrens et al. 1955) and as high as 57% (Dinkel and Bush 1973) have been reported. For carcass fat trim, values such as 42% (Cundiff et al. 1969) and 39% (Dinkel and Bush 1973) have been given. Carcass grade heritability estimates have been reported to range from 16 to 84% (Lasley 1972). Estimates for area of Longissimus muscle have been reported to be 70% (Lasley 1972). It's evident from these values that heredity in an important factor in determining carcass characteristics for all breeds.

British Breed Differences

The separation and classification of different breeds is generally named as to the place of origin and each fall into a specific category. The British breeds consist of Hereford, Angus, Shorthorn and Lincoln Red. The French breeds consist of Charolais and Limousin. The other class of interest is that of the Zebu category and consists of Brahman, Brahman Cross and Santa Gertrudis.

Considering the purebreds of British origin it has generally been found that Angus and Shorthorn exceed Herefords in marbling and carcass grade (Damon et al. 1960, Butler et al. 1962, Gregory et al. 1966, Gaines et al. 1967, Lasley et al. 1971 and Scarth et al. 1973).

Gregory et al. (1966) researched animals from different calf crops and found each year all steers were slaughtered at the end of the 252 day feeding period.

Results show that Angus had larger (P>.05) ribeyes followed by Hereford then Shorthorn breeds. Carcass grade was higher (P<.05) for Angus and Shorthorns than Herefords. Actual cutability percent was higher (P<.05) for Herefords than Angus or Shorthorns and these results were attributed to less fat trim present in Herefords. Damon et al. (1960) also reported that Herefords had higher precent lean and less fat than Angus or Shorthorns.

Scarth, Kauffman and Bray (1973) analyzed data from 2,503 steers shown at the International Quality Beef Show in Chicago from 1956 through 1967 for Shorthorn, Angus and Hereford breeds. Results showed no significant difference (P>.05) between carcass weights. Angus steers had significantly ($P<.05$) larger ribeyes, followed by Herefords and Shorthorns. These results are similar to those found by Gregory et al. (1966) and Kauffman et al. (1968). Fat thickness/100 Kg of carcass with carcass weight held constant, show that Herefords had lower ($P<.05$) values than Angus than Shorthorns. Gregory et al. (1966) reported similar results; however, Jeremiah et al. (1970) and Gains et al. (1967) reported very small differences among these breeds for fat thickness. Marbling score was reported to be higher ($P<.05$) for Angus followed by Shorthorns than Herefords.

British and French Crossbreds

By breeding the purebred of one breed to another, heterosis will result. The combination of desired characteristics may be produced depending on the heritability of the traits being considered. Gregory et al. (1966) and Gaines et al. (1967) have reported significant ($P<.05$) heterosis effects for carcass traits associated with growth such as ribeye size and carcass weight. Carcass traits not directly related to growth such as cutability, grade and palatability have been reported to have small heterosis effects (Kincaid 1962).

O'Mary et al. (1979) considered carcasses of steers from Angus cows sired by Angus and Charolais bulls. The crossbred steers were fed 30 days longer to reach comparable compositional endpoints as purebreds. Carcasses of the crossbreds were heavier ($P<.05$) than those of purebreds, partly due to longer feeding. The Angus steer carcasses were fatter, more marbled and graded higher ($P>.05$) than crossbred carcasses. The crossbreds showed significantly ($P<.01$) higher cutabilities and larger ribeyes than purebreds. Conclusions for this study were that crossbreds involving these particular breeds require more than 30 days to reach similar compositional endpoint as purebred.

Adams et al. (1973, 1977) did considerable research on Herefords crossed with Angus, Simmental, Lomousin, Charolais and other breeds. The large framed breed crosses of Simmental, Limousin and Charolais displayed the ability to yield heavier carcasses than Hereford purebreeds or Angus crosses. Angus X Herefords and Herefords show the ability to marble, quality and yield grade higher than Simmental, Limousin or Charolais crosses. Simmental, Charolais and Limousin crosses were superior in Longissimus muscle measurement over Hereford purebreeds or Angus cross. Conclusions from this study show that carcasses of larger framed breeds are leaner, while lighter carcasses of the British breeds were fatter. Similar results have been reported by Koch et al. (1976).

Other studies have also shown that British X French (Angus X Charolais) are heavier, leaner and have larger ribeyes than straight bred British (Angus) cattle while the latter are better in quality and generally fatter (Olentine et al. 1976, Martin and O'Mary 1973).

Brahman Crosses with British Breeds

Moderate amount of research has been done to investigate the effect of Brahman cross with various breeds to determine the breeding value of Brahman crossbreds. Research has shown that postweaning growth of the Brahman is less than that of the straight bred calves (Kincaid 1962 and Cartwright et al. 1964).

Studies have also shown that when slaughtered as yearlings, British bred steers have higher carcass grades and higher percentages of fat than Brahman steers who display higher percentages of lean and bone (Cundiff 1970).

Heterosis effects of carcass traits which are not related to growth rate have been reported to be low or near the average of parents, however, the effects are higher among British - Brahman cross than British straight breds (Cundiff 1970).

MATERIALS AND METHODS

General

Twenty-four animals of relatively the same age were randomly selected from each of five breed types consisting of Angus X Hereford, AXH, Santa Gertrudis, STG; Limousin X Hereford, LXH; Beefmaster, BMS; Brahma-Hereford-Angus-Charolais cross, BOG (n=120) were fed at the Chaves County Cattle Corporation feedlot in Roswell, New Mexico. An equal number of animals from each breed type were randomly assigned to each of four concentrate levels. These were low, medium-low, medium-high and high, consisting of 39, 52, 67 and 80% concentrate, respectively. Experimental diets are described in Table 1.

Three slaughter times were utilized; when the average fat thickness over the 12th rib reached 10, 13 or 15 mm. All breed types were represented within each concentrate level and fat thickness end-point. The design for the experiment for each treatment is as follows:

Concentrate Level

LOW (39%)	MEDIUM LOW (52%)	MEDIUM HIGH (67%)	HIGH (80%)
Fat Thickness 10, 13, 15	Fat Thickness 10, 13, 15	Fat Thickness 10, 13, 15	Fat Thickness 10, 13, 15

Within each pen of cattle, fat thicknesses were determined ultrasonically, using a Scanogram model 720. When the estimated

Table 1. Composition of feeds.

Item	Low	Medium Low	Medium High	High
Dry Matter	94.2	93.9	92.6	90.4
Protein[a], %	16.02	15.0	13.8	12.86
Phosphorus[a], %	.28	.32	.32	.34
Metabolizable energy[b]	2.33	2.46	2.64	2.82
Metabolizable energy[c]	2.20	2.31	2.44	2.55
Percent concentrate	39	52	67	80

[a]100% dry matter basis
[b]Megacal/kg.
[c]Megacal/kg on as fed basis.

average of each pen reached the predetermined fat thickness, the whole group was sent to slaughter.

This design resulted in some breed types having more and some having less than the predetermined average. Consequently, there was a strong breed type effect on the actual vs. the predetermined avearge for each endpoint group (Table 13).

The animals were slaughtered at a commercial packing plant, Glover Meat Packing Company, in Roswell, New Mexico. Upon slaughter, the carcasses were tagged for identification with hot carcass weight and animal number. The carcasses were then chilled for 24 hours and ribbed between the 12th and 13th ribs by the packer and evaluated by a USDA Federal Grader for quality and yield grades. Carcass data was collected and consisted of hot carcass weight, ribeye area, marbling score, fat thickness and kidney-pelvic and heart fat, for yield and quality grade computations.

Processing Carcasses

Left side forequarters were then broken down to obtain the rib and plate section (wing) by cutting between the 5th and 6th ribs. The wings were tagged with animal number and shipped to the University of Arizona by refrigerated truck. Upon arrival the rib and plate section was separated into individual wholesale cuts at 15.2 cm opposite chine bone and parallel to it. A 2.5 cm slice of the Longissimus muscle from the small end of rib was taken from each rib, identified and stored in individual plastic bags at -20 C until analyses. The analyses consisted of intramuscular lipid and moisture determinations.

Longissimus Lipid Extraction

The analysis for total extractable lipid and total moisture content was done by using the chloroform-methanol extraction following the modified procedure of Ostrander and Dugan (1961) as outlined by Wooten et al. (1979). This procedure makes it possible to determine total lipid and moisture as separate steps of the same procedure. The lipid portion was saved and stored in vials with chloroform at -20 C until esterification.

Esterification

The lipid fractions were transesterified by a modified procedure described by Marchello et al. (1971) and stored in vials at -20 C until thin layered.

Thin Layer

To further purify the methylesters of lipid fraction for minimum baseline drift and maximum repeatability of chromatograph procedures, a thin layer procedure was applied. The procedure called for spotting approximately 200 ul of the chloroform-lipid mixture on 20 x 20 cm pre-activated (1 hr at 100c) and precoated (0.25 mm silica gel f-254, e. merck ag., Darmstadt, Germany) thin layer plates. The plates were developed in a filter-paper lined tank with a solvent of petroleum ether (30 to 70 C), diethyl ether, and acetic acid (80:10:1) (Bowyer et al. 1963). After development, the plates were lightly sprayed with 0.05% (w/v) solution of rhodamine 6G in ethyl alcohol (Skipski et al. 1967) and viewed under ultraviolet light for spot identification and marking according to appropriate standards. The fatty acid ester bands were identified using standards. The bands were then eluted from the silica gel with 3 ml of petroleum ether, 3 ml diethyl ether and 3 ml diethyl ether after mixing and centrifugation at 1,500 rpm to pack silica gel.

Gas Liquid Chromatography

The fatty acid esters were separated by a Bechman GC-5 gas chromatograph and detected by flame ionization. Dual 1.83 mm (3.2 mm O.D.) coiled, stainless steel columns, packed with 100-120 mesh ...

chromosorb W (HP) as the stationary phase and 5% silar 5 CP as the liquid phase were used. The carrier gas (nitrogen) flow was 25 ml/min and column temperature was 165 C. Identification of the methyl esters was by comparing retention times with a standard solution of known composition. The weight percent of each methyl ester was calculated by use of a disc integrater on the recorder.

Statistical Treatment of Data

All data were anlyzed by analysis of variance according to Nie et al. (1975). Duncan's multiple range test and main treatment interactions were performed to compare treatment means. Because numerous significant ($P<.05$) interactions were observed between the main effects tested (diet, breed and fat thickness endpoints), the Longissimus fatty acids were analyzed by nesting diets within breeds, breeds within diets, diets within fat thickness, fat thickness within diets, breeds within fat thickness, and fat thickness within breeds. The same procedure was applied to quality and yield grade factors along with percent lipid when carcass data were compared by treatments. No adjustments were made for carcass weight differences.

RESULTS AND DISCUSSION

Longissimus Fatty Acid Composition

Dietary Effects

Fatty acid data of ribeye muscles as influenced by diet are presented in Table 2. The amount of lipid in Longissimus muscle was not influenced ($P<.05$) by concentrate level. Similar results have been reported by Hornstein et al. (1967), Rumsey et al. (1972) and Skelly et al. (1978). Other diets such as addition of protected lipid or feeding of animal fat have also been reported not to influence amount of intramuscular lipid (Cross and Dinus 1978). Cattle fed the MH concentrate level had the highest amount of intramuscular lipid followed by cattle fed the LO, HI and ML concentrate level (4.68, 4.60, 4.49 and 4.38%, respectively).

Major fatty acid analysis shows no significant ($P>.05$) difference between diets, except for the IsoC16 fatty acid which was greater ($P<.05$) in ribeye samples of cattle fed low concentrate when compared to medium low, medium high and high concentrate diets (1.45% vs. 0.75, 0.75 and 0.69%, respectively).

Others (Skelly et al. 1978, 1973, and Sumida et al. 1972) have also reported little differences in body fatty acid composition as influenced by diet.

Diet did influence the amount of unsaturation within the Longissimus muscle. Ribeye samples of cattle fed the MH and HI concentrate

Table 2. Means for the major fatty acids by concentrate level.

Fatty Acid	Concentrate Level[a]			
	LO	ML	MH	HI
Lipid, %*	4.60	4.38	4.68	4.49
C14	3.44	3.05	3.21	4.09
C14:1	.93	.73	.64	.77
C15	1.07	.53	.61	.72
Iso C16	1.45[c]	.75[b]	.75[b]	.69[b]
C16	31.60	31.75	31.15	31.30
C16:1	2.82	2.74	3.04	2.92
C17	1.12	.99	1.08	1.00
Iso C18	1.52	.71	.87	.95
C18	16.91	18.47	17.10	15.84
C18:1	35.09	36.91	38.12	37.82
C18:2	4.02	3.31	3.57	3.60
% Sat.	57.27[c]	56.10[b,c]	55.23[b]	54.39[b]
% Unsat.	42.73[b]	43.90[b,c]	44.77[c]	45.61[c]

[a]LO = low concentrate; ML = medium low concentrate; MH = medium low concentrate; HI = high concentrate.

[b,c]Values within same line having unlike superscripts differ significantly ($P<.05$).

*Percent lipid in Longissimus muscle.

diets exhibited significantly ($P<.05$) higher proportions of unsaturation than intramuscular lipid of cattle fed the LO concentrate diet (44.77 and 45.61% vs. 42.73%, respectively). Cabezas et al. (1965) reported similar results. They attributed these findings to the development of specific microflora in the rumen by use of high concentrate diets. The metabolism of the microflora must have been different enough to cause an increase in the degree of unsaturated fat made available for absorption.

Waldman et al. (1968) reported that the percent of unsaturated fatty acid in subcutaneous beef fat increased as cattle increased in weight and fatness. Results in Tables 2 and 11 show that as the concentrate level of the diet was increased, hot carcass weight increased and so did the percent of unsaturated fatty acids. This implies that as cattle receive higher levels of concentrate which produce heavier carcasses, alterations in the nature or type of fat occur. Link et al. (1970) reported similar results which showed increased unsaturation during growth, but attributed genetics and environment to such findings. In contrast, Reiser and Reddy (1956), Reiser and Chaudburg (1959) and Hornstein (1967) reported that triglyceride fatty acid composition was comparatively unaffected by differences in age, weight or dietary fatty acids on depot fat.

Breed Effects

Lipid content and fatty acid composition of the ribeye muscle as influenced by breed type are presented in Table 3. Beefmasters (BMS), Santa Gertrudis (STG), Brahma-Hereford-Angus-Charolais cross (BOG) and Angus X Hereford (AXH) had significantly ($P<.05$) greater amounts of

Table 3. Means for the major fatty acids by breed.

Fatty Acid	Breed[a]				
	LXH	BMS	STG	BOG	AXH
Lipid, %*	3.20[b]	4.74[c]	4.69[c]	4.96[c]	4.88[c]
C14	3.04	3.46	3.33	3.86	3.37
C14:1	.62	.71	.70	.77	1.07
C15	.56	.65	.64	.89	.99
Iso C16	.99	.76	.72	1.20	1.11
C16	30.49	31.60	32.27	30.60	32.12
C16:1	2.92	2.96	2.74	3.10	2.57
C17	1.12	.98	1.00	.92	1.27
Iso C18	.92	.84	.56	1.31	1.54
C18	17.76	17.32	17.52	15.95	16.86
C18:1	36.93	36.84	37.20	37.94	36.40
C18:2	4.58	3.72	3.29	3.43	2.85
% Sat.	55.40	55.80	55.19	55.10	57.24
% Unsat.	44.60	44.20	44.81	44.90	42.76

[a]Breeds refer to: AXH = Angus Hereford; BMS = Beefmaster; STG = Santa Gertrudis, LXH = Limousin Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[b,c]Values within same line having unlike superscripts differ significantly ($P<.05$).

*Percent lipid in Longissimus muscle.

ribeye lipid than Limousin X Hereford (LXH) breed. Koch et al. (1976) found similar results for LXH cattle when compared to Hereford, Angus, Hereford X Angus, Limousin X Hereford, Charolais X Hereford and other breeds. O'Mary et al. (1979) also found breed differences. Their results showed Angus cattle to possess more Longissimus fat than Angus X Charolais.

Fatty acid profiles from all breeds were similar and no significant ($P>.05$) differences existed. Results agree with those of Hecker (1972); however, Sumida et al. (1972) reported significant ($P\leq.05$) line within breed differences for C16 of subcutaneous fat but concluded that real breed differences probably do not exist. Further evaluation of the data in Table 3 reveals that AXH breed tended to be more saturated, although not significantly ($P>.05$) when compared to LXH, BMS, STG and BOD breeds.

Effects of Fat Thickness Endpoints

Lipid content and fatty acid data by fat thickness are presented in Table 4. The Longissimus muscle of cattle fed to 15 mm of fat thickness possessed significantly ($P<.05$) more intramuscular lipid than cattle fed to 10 mm of fat thickness (4.91 vs. 4.07%, respectively), while carcasses of the 13 mm fat thickness were intermediate (4.64%) and not significantly ($P>.05$) different to other values. Scarth et al. (1973) found that fat thickness increased with increasing age along with amount of intramuscular fat. Dinus and Cross (1978) also found similar results which suggest that as fat thickness increases, intramuscular lipid increases.

Table 4. Means for the major fatty acids by fat thickness endpoints.

Fatty Acid	Fat thickness[a]		
	10 MM	13 MM	15 MM
Lipid %*	4.07[b]	4.64[bc]	4.91[c]
C14	3.58	3.16	3.47
C14:1	.86	.69	.72
C15	.93	.62	.57
Iso C16	1.24[c]	.71[b]	.70[b]
C16	30.85	31.28	32.44
C16:1	2.96	2.81	2.84
C17	1.19	.99	.93
Iso C18	1.48[c]	.72[b]	.70[b]
C18	17.10	17.64	16.69
C18:1	35.43[b]	37.95[c]	37.89[c]
C18:2	4.30[c]	3.38[b]	3.00[b]
% Sat.	56.10	55.57	55.60
% Unsat.	43.90	44.43	44.40

[a]Fat thickness endpoint refers to live back fat measurement between 12th and 13th ribs.

[b,c]Values within same line having unlike superscripts differ significantly ($P < .05$).

*Percent lipid in Longissimus muscle.

Fatty acid data reveal that Longissimus muscle of the 10 mm backfat cattle had significantly ($P<.05$) larger percentages of Iso-C16, Iso C18 and C18:2 when compared to 13 or 15 mm backfat group. There was also a lower ($P<.05$) C18:1 proportion in 10 mm cattle than 13 or 15 mm cattle (35.43% vs. 37.95% and 37.89%, respectively).

In looking at fat thickness and its relationship to composition, Skelly et al. (1973) made a general conclusion that amount of external fat seems to have little relationship to the exact composition of various body fats, revealing that no precise relationship can be established in fatty acids of body fat when cattle are fed to different degrees of finish. However, data in Table 4 indicate that as cattle are taken to a greater fat thickness, Longissimus lipid C18:1 increases at the expense of C18:2.

Breed Effects within Dietary Treatment

Results for breeds within concentrate level for fatty acids of Longissimus muscle are presented in Table 5. LXH cattle displayed a lower ribeye fat content when compared to other breeds within all concentrate levels, although differences were not significant ($P>.05$). Similar results have been reported by Koch et al. (1975) for the LXH cattle when compared to Herefords, Angus, Limousin, South Devon and Jersey straight breds and crosses.

For the LO concentrate diet, BOG cattle exhibited a significantly ($P<.05$) larger proportion of Iso C16 and Iso C18 than STG, BMS, or LXH cattle. Within the ML concentrate diet the only difference between breeds was the larger ($P<.05$) proportions of C18 in the BMS and LXH

Table 5. Means of fatty acids for breeds[a] within concentrate[b] level.

Fatty Acids	LO					ML				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Lipid*, %	5.15	5.02	4.73	3.32	4.71	4.18	4.90	4.64	3.04	4.89
C14	3.20	3.55	3.07	3.00	5.53	2.66	3.20	3.07	3.36	2.90
C14:1	1.43	.45	.76	.70	1.80	.66	.90	.83	.60	.50
C15	1.33	.50	.85	.63	2.87	.68	.80	.45	.50	.30
Iso C16	1.60[c]	.40[c]	1.20[c]	1.28[c]	3.80[d]	.52	1.10	.71	.96	.50
C16	30.98	33.95	33.55	27.65	27.47	33.54	30.38	31.46	30.42	33.97
C16:1	2.18	2.23	2.85	3.03	4.10	2.34	3.38	2.78	2.84	2.20
C17	1.28	.73	1.00	1.35	1.57	.90	1.18	1.10	.92	.53
Iso C18	2.20[d]	.33[c]	1.17[c]	.88[c]	4.33[c]	.72	.60	.64	1.04	.60
C18	17.40	20.23	16.37	17.00	13.67	17.12[c,d]	15.98[c]	19.56[c]	19.08[d]	18.63[c,d]
C18:1	34.23	34.73	35.55	39.28	29.43	38.30	39.13	35.75	36.32	37.30
C18:2	4.08	2.80	3.64	5.20	5.43	2.48	3.40	3.57	3.96	2.50
% Sat.	57.65	59.90	57.16	54.45	57.32	57.27	53.23	57.08	55.60	56.33
% Unsat.	42.35	40.10	42.84	45.55	42.68	42.73	46.77	42.93	44.40	43.67

Table 5, Continued.

Fatty Acids	MH					HI				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Lipid*, %	5.66	4.97	4.48	3.50	4.97	4.52	3.86	5.09	2.86	5.25
C14	3.93	2.80	2.93	2.90	3.74	3.78	3.57	4.89	2.75	3.37
C14:1	1.28	.95	.44	.55	.52	1.02	.60	.80	.70	.43
C15	1.23	.90	.44	.57	.38	.86	.43	.87	.60	.37
Iso C16	1.60	.75	.44	.83	.58	.92	.60	.64	1.00	.33
C16	30.75	29.75	31.26	32.42	30.28	32.70	34.23	29.99	30.55	30.90
C16:1	3.13	2.45	3.03	3.03	3.26	2.66	2.77	3.22	2.55	2.73
C17	1.70	1.55	.79	1.17	.86	1.30	.77	1.00	1.00	.77
Iso C18	2.45	.70	.51	.72	.56	1.10	.73	1.06	1.35	.27
C18	15.90	18.50	17.86	17.40	15.61	16.92	15.30	15.15	17.05	16.10
C18:1	36.23	38.30	38.41	36.32	41.14	36.38	37.20	38.00	35.60	41.73
C18:2	2.78	3.45	3.84	4.12	3.06	2.30	3.70	3.86	6.30	2.97
% Sat.	57.32	55.32	54.91	55.98	52.95	56.72	52.30	54.07	55.62	53.78
% Unsat.	42.68	44.68	45.09	44.02	47.05	43.28	47.70	45.93	44.38	46.22

[a]Breeds refer to: AXH = Angus X Hereford; BMS = Beefmaster; STG = Santa Gertrudis; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[b]LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate

[c,d]Values within same line and concentrate level having unlike superscripts differ significantly ($P<.05$)

*Lipid % = Percent lipid in Longissimus muscle.

cattle than in STG cattle (19.56 and 19.08% vs. 15.98%, respectively). There was no significant ($P>.05$) interaction of breed within concentrate level for MH or HI concentrate diets. From these data, it can generally be concluded that little interaction exists between breed within concentrate level for Longissimus muscle lipid fatty acid composition.

Dietary Treatment within Breed

The comparison of concentrate level within breed for fatty acid content of the Longissimus is presented in Table 6. There were no significant ($P>.05$) differences in fatty acids due to concentrate level within the AXH, STG, LXH or BOG breeds. Within the BMS breed, those on the HI concentrate level displayed higher ($P<.05$) C14 levels as compared to the other three concentrate levels. Also, a higher ($P<.05$) content of C18 in the ML concentrate level was noted when compared to LO and HI concentrate diets (19.56% vs. 16.37 and 15.15%, respectively). The MH and HI concentrate diets increased ($P<.05$) the C18:1 level within the BOG breed when compared to the LO concentrate diet (41.40 and 41.73% vs. 29.43%, respectively). While the ML diet value was intermediate (37.30) and not significantly ($P>.05$) different from the other diets.

There was also a significant ($P<.05$) interaction of diets within breed for percent unsaturation of the Longissimus lipid. Within the STG breed the cattle fed the HI concentrate level were more ($P<.05$) unsaturated when compared to cattle on LO concentrate level (47.70% vs. 40.10%, respectively). Again, evidence exists that with feeding a high level of concentrate, degree of unsaturation of intramuscular lipid increased.

Table 6. Means of fatty acids for concentrate[a] levels within breed[b].

Fatty Acids	AXH				STG				BMS			
	LO	ML	MH	HI	LO	ML	MH	HI	LO	ML	MH	HI
Lipid*, %	5.15	4.18	5.76	4.52	5.02	4.90	4.67	3.86	4.73	4.64	4.48	5.09
C14	3.20	2.66	3.93	3.78	3.55	3.20	2.80	3.57	3.07[c]	3.07[c]	.293[c]	4.89[d]
C14:1	1.43	.66	1.28	1.02	.45	.90	.95	.60	.76	.83	.44	.80
C15	1.33	.68	1.23	.86	.50	.80	.90	.43	.85	.45	.44	.87
Iso C16	1.60	.52	1.60	.92	.40	1.10	.75	.60	1.20	.71	.44	.64
C16:0	30.98	33.54	30.75	32.70	33.95	30.38	29.75	34.23	33.55	31.46	31.26	29.99
C16:1	2.18	2.34	3.13	2.66	2.23	3.38	2.45	2.77	2.85	2.78	3.03	3.22
C17	1.28	.90	1.70	1.30	.73	1.18	1.55	.77	1.00	1.10	.79	1.00
Iso C18	2.20	.72	2.45	1.10	.33	.60	.70	.73	1.17	.64	.51	1.06
C18:0	14.40	17.12	15.90	16.92	20.23	15.98	18.50	15.30	16.37[c]	19.56[d]	17.81[c,d]	15.15[c]
C18:1	34.23	38.30	36.23	36.38	34.73	39.13	38.30	37.20	35.55	35.75	38.41	38.00
C18:2	4.08	2.48	2.78	2.30	2.80	3.40	3.45	3.70	3.64	3.57	3.84	3.86
% Sat.	57.75	57.27	57.32	56.72	59.90[d]	53.23[c]	55.32[c,d]	52.80[c]	57.16	57.08	54.91	54.07
% Unsat.	42.35	42.73	42.68	43.28	40.10[c]	46.77[d]	44.68[c,d]	47.70[d]	42.84	42.93	45.09	45.93

Table 6, Continued.

Fatty Acids	LXH				BOG			
	LO	ML	MH	HI	LO	ML	MH	HI
Lipid*, %	3.32	3.50	3.03	2.86	4.71	4.88	4.97	5.25
C14	3.00	3.36	2.90	2.75	5.53	2.90	3.74	3.37
C14:1	.70	.60	.55	.70	1.80[d]	.50[c]	.52[c]	.43[c]
C15	.63	.50	.57	.60	2.87[d]	.30[c]	.38[c]	.37[c]
Iso C16	1.28	.96	.83	1.00	3.80	.50	.58	.33
C16:0	27.65	30.43	32.42	30.55	27.47	33.97	30.28	30.90
C16:1	3.03	2.84	3.03	2.55	4.10	2.20	3.26	2.73
C17	1.35	.92	1.17	1.00	1.57	.53	.86	.77
Iso C18	.88	1.04	.72	1.35	4.33[d]	.60[c]	.56[c]	.27[c]
C18:0	17.00	19.08	17.40	17.05	13.67	18.63	15.62	16.10
C18:1	39.28	36.32	36.32	35.60	29.43[c]	37.30[c,d]	41.40[d]	41.73[d]
C18:2	5.20	3.96	4.12	6.30	5.43	2.50	3.06	2.97
% Sat.	54.45	55.60	55.98	55.62	57.32	56.33	52.95	53.78
% Unsat.	45.55	44.40	44.02	44.38	42.68	43.67	47.05	46.22

[a]LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[b]Breed refers to: AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus Charolais cross.

[c,d]Values within same line and breed having unlike superscripts differ significantly ($P<.05$).

*Lipid % = Percent lipid in Longissimus muscle.

Fat Thickness Endpoints within Concentrate Level

The data for fatty acid of Longissimus muscle by fat thickness within concentrate level is presented in Table 7. As was expected, regardless of concentrate level fed, cattle fed to a greater fat thickness endpoint had larger ($P>.05$) amounts of lipid in the ribeye.

Few fatty acid differences ($P<.05$) were noted due to fat thickness endpoints within diet. Within the LO concentrate level, cattle fed to 13 mm of backfat had higher ($P<.05$) proportions of C18:1 than cattle fed to 10 or 15 mm of backfat (40.91% vs. 30.22 and 34.56%, respectively). There was also a higher ($P<.05$) level of C18:2 within the LO concentrate level for cattle fed to the 10 mm backfat when compared to cattle fed to the other backfat thicknesses (5.79% vs. 2.63 and 3.29%, respectively). There were no general trends observed within any of the diets for fatty acids between the various fat thickness endpoints.

Concentrate Levels within Fat Thickness Endpoints

Table 8 presents the data for lipid content and fatty acid composition by concentrate level within fat thickness endpoints. No differences existed ($P>.05$) in percent lipid in the Longissimus between concentrate levels within each of the fat thickness endpoints; however, cattle at the 15 mm endpoint tended to have more fat in the ribeye muscle than cattle in the 10 or 13 mm groups.

Within the 10 mm fat thickness group, cattle fed the low concentrate diet had larger ($P>.05$) proportions of C15 and Iso 16, and smaller ($P<.05$) proportions of C18:1 than cattle fed ML, MH or HI concentrate

Table 7. Means for the major fatty acids by fat thickness[a] endpoints within concentrate[b] level.

Fatty Acid	LO			ML			MH			HI		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Lipid*, %	4.28	4.55	5.00	3.80	4.19	5.15	4.32	4.86	4.86	3.50[c]	4.93[d]	5.09[d]
C14	4.02	2.99	3.19	2.98	3.02	3.18	3.33	3.03	3.24	4.08	3.88	4.26
C14:1	1.30	.56	.87	.74	.81	.63	.80	.49	.58	.58	.97	.83
C15	1.85	.53	.64	.64	.60	.30	.76	.44	.56	.43	1.05	.80
Iso C16	2.43[d]	.81[c]	.87[c]	.89	.66	.70	1.05	.50	.58	.53	.95	.66
C16	30.35	30.22	35.17	31.66	31.39	32.35	31.65	31.55	30.06	29.54	32.32	32.51
C16:1	3.01	2.59	2.86	2.95	2.72	2.50	2.92	3.23	3.04	2.98	2.78	2.95
C17	1.42[d]	.88[c]	1.00[c,d]	1.13	.95	.85	1.25	.88	1.04	.91	1.37	.84
Iso C18	2.75[d]	.63[c]	.90[c]	.84	.60	.71	1.24	.50	.73	1.07	1.38	.49
C18	16.87	17.18	16.61	18.25	19.19	17.74	16.47	17.93	17.14	16.86	15.10	15.26
C18:1	30.22[c]	40.91[d]	34.56[c]	36.32	36.84	37.76	37.00	37.46	40.31	38.29	36.18	38.53
C18:2	5.79[d]	2.63[c]	3.29[c]	3.55	3.24	3.13	3.89	3.96	2.74	3.96	3.98	2.90
% Sat.	59.35[d]	54.72[c]	58.03[c,d]	55.93	56.26	56.10	55.58	55.24	54.91	53.53	56.15	53.64
% Unsat.	40.65[c]	45.28[d]	41.97[c,d]	44.07	43.74	43.90	44.43	44.76	45.09	46.48	43.85	46.36

[a]Fat thickness endpoints refer to live backfat measurement between 12th and 13th ribs.

[b]LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[c,d]Values within same line and concentrate level having unlike superscripts differ significantly ($P<.05$).

*Percent lipid in Longissimus muscle.

Table 8. Means for the major fatty acids by concentrate[a] level within fat thickness[b] endpoint.

Fatty Acid	10 mm				13 mm				15 mm			
	LO	ML	MH	HI	LO	ML	MH	HI	LO	ML	MH	HI
Lipid*, %	4.28	4.19	4.32	3.50	5.00	3.80	4.86	4.93	4.54	5.15	4.86	5.09
C14	4.02	2.98	3.33	4.08	2.99	3.02	3.03	3.88	3.19	3.18	3.24	4.26
C14:1	1.30	.74	.80	.58	.56	.81	.49	.97	.87	.63	.58	.83
C15	1.85^{d}	.64^{c}	.76^{c}	.43^{c}	.53	.60	.44	1.05	.64	.30	.56	.80
Iso C16	2.43^{d}	.89^{c}	1.05^{c}	.53^{c}	.81	.66	.50	.95	.87	.70	.58	.66
C16	30.35	31.66	31.65	29.54	30.22	31.39	31.55	32.32	35.17	32.35	30.06	32.51
C16:1	3.01	2.95	2.92	2.98	2.59	2.72	3.23	2.78	2.86	2.50	3.04	2.95
C17	1.42	1.13	1.25	.91	.88	.95	.88	1.37	1.00	.85	1.04	.84
Iso C18	2.75	.84	1.24	1.07	.63	.60	.50	1.38	.90	.71	.73	.49
C18	16.87	18.25	16.47	16.86	17.18^{c,d}	19.19^{d}	17.93^{c,d}	15.10^{c}	16.62	17.74	17.14	15.26
C18:1	30.22^{c}	36.32^{d}	37.00^{d}	38.29^{d}	40.91	36.84	37.46	36.18	34.56	37.76	40.31	38.53
C18:2	5.79	3.55	3.89	3.96	2.63	3.24	3.96	3.98	3.29	3.13	2.74	2.90
% Sat.	59.35^{d}	55.93^{c}	55.38^{c}	53.53^{c}	54.72	56.26	55.24	56.15	58.03^{d}	56.10^{c,d}	54.91^{c,d}	53.64^{c}
% Unsat.	40.65^{c}	44.07^{d}	44.43^{d}	46.48^{d}	45.28	43.74	44.76	43.84	41.97^{c}	43.90^{c,d}	45.09^{c,d}	46.36^{d}

[a]LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[b]Fat thickness endpoint refers to live back fat measurement between 12th and 13th ribs.

[c,d]Values within same line and fat thickness endpoints having unlike superscripts differ significantly ($P < .05$).

*Percent lipid in Longissimus muscle.

diets. Within the 13 mm fat thickness endpoint, cattle on the ML diet had larger (P<.05) proportions of C18 than cattle on the HI concentrate diet (10.19% vs. 15.10%) while cattle fed the LO and MH concentrate diet were intermediate and not significantly different from other diets (17.18 and 17.93%, respectively). There was no significant (P>.05) difference in fatty acids content between diets within the 15 mm backfat group.

Within the 10 and 15 mm fat thickness groups, as the concentrate level was increased, the percent unsaturation also increased and was significantly (P<.05) different between LO and HI concentrate diets within both backfat groups.

Fat Thickness Endpoint within Breed

Data on the effects of body fat content within breed for fatty acid content and percent intramuscular lipid of the Longissimus are presented in Table 9. No significant (P>.05) effects were observed within breed for percent lipid; however, LXH cattle tended to have less Longissimus lipid than other breeds for each of the fat thickness endpoints. Within the STG cattle, fat thickness endpoint groups differed about 4% between minimum and maximum values for percent Longissimus lipid, while the other breeds showed only a 1.5% difference.

Few significant (P<.05) differences were observed for fatty acids for fat thickness endpoints within each breed. The C18 content was higher (P<.05) for the 13 mm fat thickness group than the 15 mm group within the BMS cattle (18.70% vs. 15.72%, respectively). Higher (P<.05)

Table 9. Means for the major fatty acids by fat thickness[a] endpoints within breed[b].

Fatty Acid	AXH			STG			BMS			LXH			BOG		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Lipid*, %	5.23	4.23	5.16	3.85	4.70	5.51	4.26	4.84	5.11	2.68	3.56	3.39	4.14	5.54	5.19
C14	3.70	3.53	2.48	3.17	4.00	2.77	3.69	2.59	4.12	2.45	3.60	3.17	5.25	3.22	3.40
C14:1	1.43	1.00	.45	.83	.58	.60	.57	.63	.98	.55	.84	.50	1.40	.46	.58
C15	1.39	.85	.43	.73	.63	.47	.63	.54	.79	.47	.80	.47	2.23	.40	.32
Iso C16	1.56	1.05	.30	.87	.48	.73	.83	.59	.85	1.10	1.06	.83	3.03	.50	.44
C16	31.03	32.78	33.30	31.48	32.93	32.97	31.14	31.61	32.17	30.62	28.18	32.28	28.75	30.36	32.32
C16:1	2.61	2.73	2.23	2.65	2.80	2.83	3.13	2.59	3.15	2.72	3.48	2.65	3.83	2.88	2.74
C17	1.56	1.05	1.03	1.32	.75	.70	.99	.98	.96	1.08	1.20	1.08	1.18	.92	.72
Iso C18	2.54[d]	1.15[c,d]	.13[c]	.58	.75	.27	1.05	.57	.88	1.13	.74	.87	2.93	.60	.74
C18	16.84	16.17	17.93	18.22	17.00	16.80	17.83[c,d]	18.70[d]	15.22[c]	17.40	16.88	18.85	12.60[c]	17.70[d]	16.88[d]
C18:1	34.28	36.75	40.13	36.75	36.80	38.63	35.71	37.80	37.20	36.25	38.82	36.03	33.35	39.84	39.70
C18:2	3.50	2.82	1.60	3.43	3.13	3.23	4.08	3.43	3.58	6.02	4.40	3.30	5.45[d]	3.10[c,d]	2.14[c]
% Sat.	58.19	57.15	56.38	54.91	55.58	55.08	56.51	55.33	55.57	55.20	54.80	56.14	55.26	55.13	54.90
% Unsat.	41.81	42.85	43.63	45.09	44.43	44.93	43.49	44.67	44.43	44.80	45.20	43.86	44.74	44.88	45.10

[a]Fat thickness endpoint refers to live back fat measurement between 12th and 13th ribs.

[b]Breed refers to: AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford -Angus - Charolais cross.

[c,d]Values within same line and breed having unlike superscripts differ significantly ($P<.05$).

*Percent lipid in Longissimus muscle sample.

levels of C18:1 were found in cattle fed to 13 and 15 mm backfat when compared to cattle fed to 10 mm of backfat for the BOG breed type (37.8 and 37.50% vs. 35.71%, respectively).

A general trend was observed for the C18:1 and C18:2 fatty acids. As cattle were fed from 10 to 13 mm of backfat the C18:1 content increased while the C18:2 content decreased in Longissimus lipid within each breed. No significant ($P>.05$) interaction was observed for fat thickness within breed for percent unsaturation of ribeye lipid.

Breeds within Fat Thickness Endpoints

Few effects of breed were observed within body fat condition (Table 10) for fatty acids and percent lipid in the Longissimus muscle. The AXH and BMS breed had larger ($P<.05$) amounts of lipid within the 10 mm backfat group when compared to the LXH cattle (5.23 and 4.26% vs. 2.68%, respectively). The LXH cattle consistently showed lower ($P<.05$) percent lipid in Longissimus muscle within each fat thickness endpoint when compared to the other breeds. It is evident from these data that physiological maturation of this particular muscle is later for the LXH cattle. They require more time on feed to reach comparable degrees of fatness to the other breeds. If percent lipid of the Longissimus muscle is a reasonable measure of maturity, it can be implied that concentrate feeding to later stages of development or to alternate endpoints may be better means by which to put LXH at a similar physiological stage of development as the earlier maturing breeds. Once it is understood when the LXH cattle reach the same developmental stage as these other breeds, slaughter endpoint for LXH could be established.

Table 10. Means for the major fatty acids by breeds[a] within fat thickness[b] endpoints.

Fatty Acid	10 mm					13 mm					15 mm				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Lipid*, %	5.23^{d}	3.85^{c,d}	4.26^{d}	2.68^{c}	4.14^{c,d}	4.23	4.70	4.84	3.56	5.53	5.16	5.51	5.10	3.38	5.19
C14	3.70	3.17	3.69	2.45	5.25	3.53	4.00	2.59	3.60	3.22	2.48	2.77	4.12	3.17	3.40
C14:1	1.43^{d}	.83^{c,d}	.57^{c}	.55^{c}	1.40^{c,d}	1.00	.56	.63	.84	.46	.45	.60	.98	.50	.58
C15	1.39^{c,d}	.73^{c}	.63^{c}	.47^{c}	2.23^{d}	.85	.63	.54	.80	.40	.43	.47	.79	.47	.32
Iso C16	1.56	.87	.83	1.10	3.03	1.05	.48	.59	1.06	.50	.30	.73	.85	.83	.44
C16	31.03	31.48	31.14	30.62	28.75	32.78	32.93	31.61	28.18	30.36	33.30	32.97	32.17	32.28	32.32
C16:1	2.61	2.65	3.13	2.72	3.83	2.73	2.80	2.59	3.48	2.88	2.23	2.83	3.15	2.65	2.74
C17	1.56	1.32	.99	1.08	1.18	1.05	.75	.98	1.20	.92	1.03	.70	.96	1.08	.72
Iso C18	2.54	.58	1.05	1.13	2.93	1.15	.75	.57	.74	.60	.13	.27	.88	.87	.74
C18	16.84	18.22	17.33	17.40	12.60	16.17	17.00	18.70	16.88	17.70	17.93	16.80	15.22	18.85	16.88
C18:1	34.28	36.75	35.71	36.25	33.35	36.75	36.80	37.80	38.82	39.84	40.13	38.63	37.20	36.03	39.70
C18:2	3.50	3.43	4.08	6.02	5.45	2.82	3.13	3.43	4.40	3.10	1.60	3.23	3.58	3.30	2.14
% Sat.	58.19	54.91	56.51	55.20	55.26	57.15	55.58	55.33	54.80	55.13	56.38	55.08	55.57	56.14	54.90
% Unsat.	41.81	45.09	43.49	44.80	44.74	42.85	44.43	44.67	45.20	44.88	43.63	44.93	44.43	43.86	45.10

[a]Breeds refer to: AXH=Angus X Hereford; STG - Santa Gertrudis; BMS = Beefmaster; LXH - Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[b]Fat thickness endpoint refers to live back fat measurement between 12th and 13th ribs.

[c,d]Values within same line and fat thickness endpoints having unlike superscripts differ significantly ($P<.05$).

*Percent lipid in Longissimus muscle sample.

Few significant ($P<.05$) fatty acid differences were observed between breeds within fat thickness endpoints. Only minor fatty acids (C14:1 and C15) were different ($P<.05$) between breeds within the 10 mm backfat group.

One interesting observation that was noted although not significant ($P>.05$) was that the AXH breed consistently displayed a larger portion of its Longissimus fatty acids in the saturated form compared to the other breed types' endpoint. Studies regarding pigs have related rapid deposition of fat during growth to a more highly saturated fat being deposited (Elson et al. 1963, Kauffman et al. 1964 and Sink et al. 1964). This may explain why Angus X Hereford cattle had a more saturated fat compared to the other breeds in this study.

Carcass Quality and Yield Grade Characteristics

Dietary Effects

The effect of concentrate level on carcass characteristics are presented in Table 11. Feeding different concentrate levels had little influence on marbling score or quality grade. Carcass quality grades were in the Good category regardless of diets fed. The marbling scores were higher for the carcasses of the cattle fed the ML and MH concentrate diet, when compared to carcasses of cattle fed the LO and HI concentrate diets, although differences were not significant ($P>.05$). Results were similar to those of Lofgreen (1968) and Garrett (1974) who reported little difference in quality grade and intramuscular fat content between cattle fed varying levels of concentrate. Visual evaluation of carcasses yielded the above mentioned marbling scores which were analogous with percent

Table 11. Means for carcass data by concentrate[a] level.

Item	Concentrate[a] Level			
	LO	ML	MH	HI
Hot carcass wt., Kg	270[c]	277[cd]	291[d,e]	305[e]
Marbling[b]	10	11	11	10
Quality grade	Good-	Good	Good	Good-
Ribeye area, cm^2	75.2[c]	75.9[c]	77.1[c]	81.1[d]
Fat thickness (mm)	9.9[c]	9.9[c]	10.9[c,d]	11.9[d]
Yield grade	2.5	2.6	2.6	2.7
Cutability %	51.2	51.0	50.9	50.7

[a]LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[b]Marbling refers to 10 = slight$^-$; 11 = slight^o; 12 = slight$^+$

[c,d,e]Values within same line having different superscripts differ significantly ($P<.05$).

lipid values for Longissimus muscle. Since marbling scores or amount of lipid within the ribeye were not influenced by varying levels of concentrate, results suggest that quality grade is independent of amount of concentrate in the diet.

For yield grade and its factors, carcasses of cattle fed a HI and MH concentrate level had significantly ($P<.05$) higher hot weights than cattle fed the LO concentrate level (305 and 291 kg vs. 207 kg, respectively). Results were similar to Bowling et al. (1978), Prior et al. (1977), Arthaud et al. (1977), who reported heavier carcasses which were fed high levels of concentrate in comparison to low levels of concentrate. Increasing dietary energy appears to accelerate rate of weight gain. Cattle receiving higher concentrate levels yielded heavier carcasses.

Ribeye areas were also larger ($P<.05$) for cattle fed the HI concentrate diet when compared to the cattle fed the MH, ML and LO concentrate (81.1 cm^2 vs. 77.1, 75.9 and 75.2 cm^2, respectively). High concentrage feeding stimulated faster development of the ribeye and of hot carcass weight when compared to lower concentrate feeding. Similar results were reported by Bowling et al. (1977), and indicated that carcasses finished on feeding regimens which incorporated the greatest concentrations of energy were heavier and had greater muscle mass. Conversely, Trenkle et al. (1978) found that weight of the Longissimus was increased ($P<.005$) with an increase in body weight but was not affected by level of feeding.

Fat thickness measurements of subcutaneous fat did not differ ($P>.05$) between cattle on the LO, ML and MH concentrate levels (9.9 and 10.9 mm). Cattle fed the HI concentrate diet had significantly ($P<.05$) more fat over the 12th rib than cattle fed the LO and ML concentrate diet (11.9 mm vs. 9.9 mm). Overall feeding higher levels of concentrate to cattle produced carcasses which had greater amounts of backfat. Similar results have been reported by others (Bowling et al. 1978, Arthaud et al. 1977 and Guenther et al. 1965). As a result of fat thickness values, yield grades and cutability precents followed similar trends, however, results here were not significant ($P>.05$)

Dietary energy does not seem to influence the marbling scores, however, greater subcutaneous fat thickness values for higher concentrate diets suggests that total physiological processes exert a fine control between subcutaneous and intramuscular fat deposition.

Breeds Effects

Carcass data by breed type are listed in Table 12. Several carcass physical characteristic differences were noticed. Cattle of the STG and BOG breed had greater (P>.05) hot carcass weights than AXH, BMS or LXH cattle. Cole et al. (1963) found that cattle containing at least 37% Brahman breeding had significantly (P<.05) lower hot carcass weights and carcass grades than Santa Gertrudis or Brahman - British crosses, while the latter two groups did not differ significantly.

The LXH cattle had significantly (P<.05) lower hot carcass weights than all other breeds except for the AXH cattle. This seems unreasonable since Limousin cattle are larger type cattle, and Angus and Hereford are generally considered smaller type cattle. It would seem more appropriate that cattle of the LXH breed would have had carcass weights comparable to those of larger type (BOG, STG) cattle. Contrary to results concerning hot carcass weight of LXH cattle compared to AXH cattle, Adams et al. (1977) found that LXH cattle had higher (P<.05) hot weight than either Hereford or Angus X Hereford cattle, while being almost similar (1.1 kg difference) to Hereford X Charolais cattle. Koch et al. (1976) also found similar results concerning above mentioned breeds and hot carcass weights.

Table 12. Means for carcass data by breeds[a].

Item	Breeds[a]				
	AXH	STG	BMS	LXH	BOG
Hot carcass wt., Kg	$267^{c,d}$	315^{e}	282^{d}	252^{c}	314^{e}
Marbling[b]	13^{e}	$11^{d,e}$	10^{d}	8^{c}	$11^{d,e}$
Quality grade	Choice-^{e}	Good^{d,e}	Good-^{d}	Standard^{c}	Good^{d,e}
Ribeye area, cm^2	75.9	78.48	76.5	77.1	79.1
Fat thickness (mm)	13.2^{e}	$10.9^{d,e}$	$9.7^{c,d}$	7.6^{c}	13.0^{e}
Yield grade	2.8^{e}	2.8^{e}	2.5^{d}	2.0^{c}	3.1^{e}
Cutability %	50.6^{c}	50.4^{c}	51.3^{d}	52.4^{e}	50.0^{c}

[a]AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[b]Marbling refers to: 7 = traces^{-}; 8 = traces^{o}; 9 = traces^{+}; 10 = slight^{-}; 11 = slight^{o}; 12 = slight^{+}; 13 = small^{-}; 12 = small^{o}; 13 = small^{+};

[c,d,e]Values within the same line having unlike superscripts differ significantly ($P<.05$).

Differences in marbling scores and quality grades by breed were similar to hot carcass weight. There was no difference in these particular traits between AXH, BOG and STG cattle; however, the LXH cattle marbled less ($P<.05$) and quality graded lower ($P<.05$) than all the other breeds. The highest quality grade was Choice- for the AXH cattle while the lowest was Standard from the LXH cattle. Similar results were reported by Koch et al. (1976) between the same breeds.

Ribeye areas were found not to be significantly ($P>.05$) different between breeds. Larger ribeyes were reported for the large framed cattle (BOG, LXH, STG) when compared to small framed cattle (AXH, BMS). Similar results were reported by Adams et al. (1973) considering LXH and AXH breed.

Fat thickness values between breeds differed significantly ($P<.05$). AXH and BOG cattle possessed greater ($P<.05$) amounts of fat over the 12th rib than BMS or LXH cattle (13.2 and 13.0 mm vs. 9.7 and 7.6 mm) while the STG (10.9 mm) cattle were intermediate and different only from the LXH cattle. The LXH cattle were leaner ($P<.05$) than all other breeds. This in part may account for the lower ($P<.05$) carcass weights when compared to the other breeds. Fat thickness values could have been lower, possibly because LXH cattle require more energy for maintenance at this age, consequently the feed intake is used as an energy source until maturity is reached at a later age. Since Limousin cattle are late maturing, their developmental processes probably proceed to later chronological ages, as compared to the early maturing cattle. Maturity rates would then account for the differences in fat thickness between the different breed types. Willham (1974) suggested that fat deposition is primarily related to differences in maturity rates among different groups. Improper experimental design could have also caused differences in fat thicknesses due to breed type treatment. Since an average value using all breeds within each diet was used for backfat endpoint, some breeds attained the designated fat thickness endpoint while others, especially the LXH breed, did not.

Yield grades between cattle of the varous breed types were found to be significantly ($P<.05$) different. BOG, AXH and STG cattle had higher ($P<.05$) values when compared to BMS and LXH cattle (3.1, 2.8 and 2.8 vs. 2.5 and 2.0, respectively). The LXH cattle were significantly ($P<.05$) lower in yield grade than all other breeds and thus higher ($P<.05$) in percent cutability. This can be attributed to lower carcass weights and fat thicknesses in the carcasses of the LXH cattle. Similar results have been reported for LXH cattle when compared to Hereford and Angus crosses by Adams et al. (1973).

Effects of Fat Thickness Endpoints

Carcass data by fat thickness endpoints are listed in Table 13. As expected, cattle fed to greater fat endpoints yielded heavier ($P>.05$) carcasses. Cattle fed to the 15 mm backfat endpoint had significantly ($P<.05$) heavier carcasses than either 10 or 13 mm backfat cattle (309 kg vs. 285 and 263 kg, respectively). Cattle fed to 10 mm of fat thickness had significantly ($P<.05$) lighter carcasses than all other endpoints.

Marbling scores and quality grades were also significantly ($P<.05$) different ($P<.05$) between backfat endpoints. Cattle fed to 15 mm of backfat had higher ($P<.05$) marbling scores and quality grades than cattle fed to 10 or 13 mm of backfat. An average marbling score of $Slight^{+}$ and quality grade of high Good was attained for 15 mm cattle while both 10 and 13 mm cattle had marbling scores of $Slight^{-}$ and quality grades of low Good.

Cattle fed to the 15 mm fat condition were fatter (P .05) and displayed larger ribeyes than did cattle fed to 10 or 13 mm of backfat.

Table 13. Means for carcass data by fat thickness[a] endpoints.

Items	Fat thickness endpoints[a]		
	10 MM	13 MM	15 MM
Hot carcass wt., Kg	263[c]	285[d]	309[e]
Marbling[b]	10[c]	10[c]	12[d]
Quality grade	Good-[c]	Good-[c]	Good+[d]
Ribeye area cm^2	73.9[c]	77.8[d]	79.8[e]
Fat thickness (mm)	9.4[c]	10.2[c]	12.2[d]
Yield grade	2.4[c]	2.6[c]	2.9[d]
Cutability %	51.4[d]	51.1[d]	50.4[c]

[a]Fat thickness endpoints refer to live backfat measurement between 12th and 13th ribs.

[b]Marbling refers to 10 = slight$^-$; 11 = slight^o; 12 = slight$^+$.

[c,d,e]Values within same line having unlike superscripts differ significantly ($P<.05$).

Within the 15 mm fat thickness endpoint, the actual backfat measurements averaged 12.2 mm and ribeyes averaged 79.8 cm^2, while those for the 10 and 13 mm backfat averaged 9.4 and 10.2 mm for fat thickness and 73.9 and 77.8 cm^2 for ribeyes, respectively.

Yield grade values were similar, however, cattle fed to the 15 mm fat condition had significantly ($P<.05$) higher yield grades than those fed to 10 or 13 mm of fat thickness (2.9 vs. 2.4 and 2.6, respectively). As a result, cutabilities favored the leaner 10 and 13 mm fat condition cattle.

Since the amount of finish is a function of time, these data indicate that feeding cattle to 15 mm of backfat, regardless of time, can definitely be beneficial in improving carcass quality traits at the expense of cutability percentages. Although quality attributes were significantly different ($P<.05$) between 10 and 15 mm of backfat, implications are that feeding cattle to 15 mm of fat thickness is not a beneficial practice for feedlot cattle, because quality differences were only within the Good grade category. If quality is the only determining factor in choosing when to slaughter cattle, feeding to 10 mm of fat thickness is just as advantageous as feeding to 15 mm of fat thickness. However, if weight is the determining element for slaughter time, cattle fed to 15 mm of fat thickness possessed significantly heavier ($P<.05$) carcass with higher quality grades than those fed to lesser (10 or 13 mm) degrees of finish. This suggests that fat thickness may be a better endpoint for slaughter than quality grade.

Effects of Concentrate Level within Fat Thickness

The carcass data by concentrate level within fat thickness is presented in Table 14. Few significant ($P<.05$) differences were noted for the carcass traits between diets within any fat thickness endpoint. Hot carcass weight was influenced by HI concentrate diet only within the 15 mm endpoint when compared to LO and ML concentrate diet. This suggests that at greater degrees of finish, feeding a HI concentrate or high energy diet increases weight gain.

Table 14. Means for carcass data by concentrate[a] level within fat thickness[b] endpoint.

Item	10 mm				13 mm				15 mm			
	LO	ML	MH	HI	LO	ML	MH	HI	LO	ML	MH	HI
Hot Carcass Wt., Kg	251	254	269	280	266	283	291	299	291[d]	295[d]	311[d,e]	336[e]
Marbling[c]	10[e,f]	11[f]	9[d,e]	7[d]	10	9	11	11	10	12	12	12
Quality Grade	Good-[e,f]	Good-	Standard+[d,e]	Standard-[d]	Good-	Standard+	Good	Good	Good-	Good-	Good+	Good+
Ribeye Area, cm^2	73.2	72.6	74.6	75.9	73.9[d]	77.1[d]	77.1[d]	83.7[e]	78.5	77.1	78.5	85.6
Fat Thick-ness (mm)	8.3	8.6	10.7	10.2	10.4	8.4	11.2	11.4	11.2	12.2	10.9	14.7
Yield Grade	2.2	2.4	2.4	2.5	2.7	2.4	2.7	2.5	2.6	2.9	2.8	3.2
Cutability %	51.8	51.4	51.3	51.2	50.8	51.5	50.8	51.2	51.0	50.2	50.5	49.7

[a] LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[b] Fat thickness endpoint refers to live animal measurement between 12th and 13th ribs.

[c] Marbling: 7 = traces$^-$; 8 = traces^o; 9 = traces$^+$; 10 = slight$^-$; 11 = slight^o; 12 = slight$^+$.

[d,e,f] Values within same line and fat thickness endpoints having unlike superscripts differ significantly ($P<.05$)

Marbling score and quality grade were influenced (P<.05) within the 10 mm endpoint only by concentrate level. They were higher (P<.05) for the LO and ML diets as compared to the HI diet. No explanation can be given for this occurrence.

Ribeye areas were significantly (P<.05) influenced by concentrate level within the 13 mm endpoint.. Ribeyes were larger for the cattle fed the HI concentrate diet as compared to the other three diets. General tendencies observed were that within all fat thickness endpoints ribeye areas tended to be larger for the cattle fed the HI concentrate diet.

Concentrate Level within Breed Type

Carcass data by concentrate level within breed type is presented in Table 15. Few significant differences (P<.05) were observed. Within the BMS breed, cattle fed the HI concentrate diet had significantly (P<.05) heavier carcasses than cattle fed the LO, ML and MH diets (307 kg vs. 259, 279 and 285 kg, respectively). A general trend was observed within all breeds, in that hot carcass weights increased (P<.05) as concentrate level increased.

There was no significant (P>.05) differences in marbling score and quality grade between diets within each breed. However, the LXH cattle tended to be lower in quality when compared to other breeds at each concentrate level. This suggests that within each breed type marbling is influenced more by the genetic makeup of the individual breed type than nutritional regimen.

Table 15. Means of carcass data for concentrate[a] levels within breed[b].

Item	AXH				STG				BMS			
	LO	ML	MH	HI	LO	ML	MH	HI	LO	ML	MH	HI
Hot Carcass Wt., Kg	252	245	280	288	292	305	327	335	259[d]	279[d,e]	285[d,e]	307[f]
Marbling[c]	13	11	12	13	11	13	12	8	10	10	11	10
Quality Grade	Choice-	Good	Good+	Choice-	Good	Choice-	Good+	Standard	Good-	Good-	Good	Good
Ribeye Area cm^2	74.6	70.6	76.5	81.8	76.5	73.9	79.8	83.1	72.6[d]	75.9[d,e]	75.9[d,e]	82.4[e]
Fat Thickness	15.2	10.9	13.4	13.2	9.7	10.9	11.4	11.4	8.4	9.1	8.9	11.7
Yield Grade	3.0	2.7	2.8	2.8	2.6	3.1	2.9	2.8	2.4	2.4	2.4	2.6
Cutability %	50.0	50.7	50.6	50.9	51.0	49.9	50.3	50.5	51.5	51.3	51.4	50.9

Table 15, Continued

Item	LXH				BOG			
	LO	ML	MH	HI	LO	ML	MH	HI
Hot Carcass Wt., Kg	243	245	255	268	311	312	312	320
Marbling[c]	7	9	8	11	12	14	10	10
Quality Grade	Standard-	Standard+	Standard	Good	Good+	Choice	Good-	Good-
Ribeye Area cm^2	73.2	80.4	77.1	77.8	83.1	77.1	76.5	79.8
Fat Thickness	5.8^d	6.9^d	7.6^d	11.7^e	12.2	11.9	14.7	13.2
Yield Grade	1.9	1.7	2.0	2.3	2.8	3.1	3.3	3.2
Cutability %	52.6	53.1	52.3	51.5	50.5	49.9	49.4	49.8

[a]LO = low concentrate; ML = medium low concentrate MH = medium high concentrate; HI = high concentrate.

[b]Breed refers to: AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais - cross.

[c]Marbling refers to: 7=traces$^-$; 8=traces^o; 9=traces$^+$; 10=slight$^-$; 11=slight^o; 12=slight$^+$; 13=small$^-$; 14=small^o; 15=small$^+$.

[d,e,f]Values within same line and Breed having unlike superscripts differ significantly ($P < .05$).

Larger ribeye areas and heavier carcasses were noted in cattle fed the HI concentrate diet when compared to cattle fed the LO concentrate within each breed, but only significant ($P<.05$) within the BMS breed.

Fat thickness results were similar to those for ribeye areas and not significant ($P>.05$) between diets. The fat thickness measurements tended to be larger in the MH and HI concentrate diets than LO or ML diets within each breed except for the AXH cattle. Data for fat thickness measurements and ribeye areas suggest that fat anabolism as well as protein anabolism were at higher rates when cattle were fed a MH or HI concentrate diet. Furthermore, this was reflected by heavier hot carcass weights at these levels of concentrate.

Similar trends were observed for yield grades. The higher concentrate levels tended to increase the yield grade within each breed type except for the AXH cattle. Opposite effects were observed here. Cattle fed the LO concentrate diet tended to be fatter and possess higher yield grades at this level of nutrition when compared to the others. It seems that fat deposition within this breed type occurred best at the LO concentrate level; however, no valid explanation is applicable. Since a lower proportion of protein and a higher amount of energy was present in the HI diet as compared to the LO concentrate diet (Table 1), results suggest that energy intake may be a more important factor in influencing carcass weight gain than is quantity of protein. A quantitative protein necessity of 11.0% and an energy comsumption of 2.61 Mcal/kg (dry matter basis) is suggested by N.R.C. (1970) in order to meet minimum protein and energy requirements. Since diets used in this study were in line with requirements of N.R.C., and deficiencies due to protein or energy were eliminated, thus making these carcass weight comparisons between dietary treatments valid.

Breed Type within Concentrate Level

Carcass data by breed type within concentrate level are presented in Table 16. Hot carcass weights for the LXH cattle were significantly ($P<.05$) lower than other breeds within each concentrate level except the HI, but a similar trend was present. The BOG and STG cattle had heavier ($P<.05$) hot carcass weights than other breeds within each concentrate level. This was expected since the above mentioned cattle can be classified as large type cattle while those of the BMS and AXH can be classified as medium to small type. As the level of concentrate fed to cattle increased, all breeds tended to increase their carcass weight regardless of biological type. Similar results were found by Prior et al. (1977) concerning biological type and feeding regimen.

Within the LO and ML diet the LXH marbling scores and quality grades were significantly ($P<.05$) lower than other breeds. The AXH, STG and BOG cattle had higher ($P<.05$) marbling scores and quality grade values than LXH or BMS cattle. Similar results were seen within the MH and HI concentrate levels for marbling scores and quality grades; however, these results were not significant ($P>.05$).

No significant ($P>.05$) difference between breeds was observed for ribeye areas within each concentrate level.

Table 16. Means for carcass data by breeds[a] within concentrate[b] level.

Item	LO					ML				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Hot Carcass Wt., Kg	$253^{d,e}$	$292^{e,f}$	$259^{d,e}$	243^{d}	295^{f}	245^{d}	305^{e}	279^{e}	245^{d}	312^{e}
Marbling[c]	13^{f}	$11^{e,f}$	10^{e}	7^{d}	$12^{e,f}$	$12^{d,e,f}$	$13^{e,f}$	$10^{d,e}$	8^{d}	14^{f}
Quality Grade	Choice-^{f}	Good^{e,f}	Good-^{e}	Standard-^{d}	Good+^{e,f}	Good+^{e}	Choice-^{e}	Good-^{d,e}	Standard^{d}	Choice^{e}
Ribeye Area cm^2	74.6	76.5	72.6	73.2	83.1	70.6	73.9	75.9	80.4	77.1
Fat Thickness (mm)	15.2^{g}	$9.7^{e,f}$	8.2^{e}	5.8^{d}	$12.2^{f,g}$	10.9	10.9	8.9	6.6	11.9
Yield Grade	3.0^{f}	$2.6^{e,f}$	$2.4^{d,e}$	1.9^{d}	$2.8^{e,f}$	$2.7^{e,f}$	3.1^{f}	2.4^{e}	1.7^{d}	3.1^{f}
Cutability %	50.0^{d}	$51.0^{d,e}$	$51.5^{e,f}$	52.6^{f}	$50.5^{d,e}$	$50.7^{d,e}$	49.9^{d}	51.3^{e}	53.1^{f}	49.9^{d}

Table 16, Continued.

Item	MH					HI				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Hot Carcass Wt., Kg	$280^{d,e}$	327^{e}	$284^{d,e}$	255^{d}	313^{e}	288	335	307	268	320
Marbling	12	12	11	8	10	13	9	10	8	10
Quality Grade	Good+	Good+	Good	Standard	Good-	Choice-	Standard+	Good-	Standard	Good-
Ribeye Area cm^2	76.5	79.8	75.2	77.1	76.5	81.8	83.1	83.1	77.8	79.8
Fat Thickness (mm)	13.5^{e}	$11.4^{d,e}$	8.9^{d}	7.6^{d}	14.7^{e}	13.2	11.4	11.7	10.2	13.2
Yield Grade	$2.8^{d,f}$	$2.9^{d,e}$	$2.4^{e,f}$	2.0^{f}	3.3^{d}	2.8	2.8	2.6	2.3	3.2
Cutability %	$50.6^{d,e}$	$50.3^{d,e}$	$51.4^{e,f}$	52.3^{f}	49.4^{d}	50.9	50.4	50.9	51.5	49.8

[a] Breed refers to: AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[b] LO = low concentrate; ML = medium low concentrate; MH = medium high concentrate; HI = high concentrate.

[c] Marbling refers to: 7 = traces$^-$; 8 - traces^o; 9 = traces$^+$; 10 = slight$^-$; 11 = slight^o; 12 = slight$^+$; 13 = small$^-$; 14 = small^o; 15 = small$^+$.

[d,e,f] Values within same line and concentrate level having unlike superscripts differ significantly (P<.05).

Fat thickness measurements were significantly (P<.05) different within two diets for breeds. For the LO concentrate diet, the AXH cattle were significantly (P<.05) fatter than STG, BMS and LXH cattle (15.2 mm vs. 9.7, 8.4 and 5.8 mm) while BOG cattle were intermediate and significantly (P<.05) fatter than the LXH cattle (2.8 mm vs. 1.9 mm, respectively). Within the MH concentrate diet BOG and AXH cattle were fatter (P<.05) than BMS or LXH cattle (14.7 and 13.5 mm vs. 8.9 and 8.4 mm, respectively), while STG cattle were intermediate and not significantly (P>.05) different to the other breeds of cattle. These results along with those observed for marbling scores indicate that BOG and STG cattle have similar maturity rates as AXH cattle.

Yield grade values for breeds within each diet were also significantly (P<.05) different. Within the LO, ML and MH diets the LXH cattle had lower yield grades than STG or BOG cattle while the AXH and BMS cattle were intermediate and significantly (P<.05) different to LXH cattle within the ML diet only. No significant (P>.05) differences in yield grade between breeds within the HI concentrate diet were observed; however, data indicates that the LXH cattle followed a trend of a lower yield grade regardless of diet.

Cutability percent results show that the LXH and BMS cattle had higher (P<.05) cutabilities in comparison to AXH, STG or BOG cattle within each diet.

Fat Thickness within Concentrate Level

Carcass data for fat thickness within concentrate level are presented in Table 17. As expected cattle fed to a greater backfat

Table 17. Means of carcass data for fat thickness[a] endpoints within concentrate[b] level.

Item	LO			ML		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Hot Carcass Wt., Kg	251	266	291	254[d]	283[d,e]	295[e]
Marbling[c]	10	10	10	12[d,e]	9[d]	12[e]
Quality Grade	Good-	Good-	Good-	Good[d,e]	Standard+[d]	Good+[e]
Ribeye Area cm^2	73.2	73.9	78.5	72.6	77.2	77.1
Fat Thickness (mm)	8.4	10.4	11.2	8.6[d]	8.4[d]	12.2[e]
Yield Grade	2.2	2.7	2.6	2.4	2.4	2.9
Cutability %	51.8	50.8	51.0	51.4	51.5	50.2
	MH			**HI**		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Hot Carcass Wt., Kg	269[d]	291[d,e]	311[e]	280[d]	299[d]	336[e]
Marbling[c]	9[d]	11[d,e]	12[e]	7[d]	11[e]	12[e]
Quality Grade	Standard+[e]	Good[d,e]	Good+[e]	Standard-[d]	Good[e]	Good+[e]
Ribeye Area cm^2	74.6	77.2	78.5	75.9[d]	83.7[e]	85.0[e]
Fat Thickness (mm)	10.7	10.9	11.2	10.2	11.4	14.7
Yield Grade	2.4	2.7	2.8	2.5[d]	2.5[d]	3.2[e]
Cutability %	51.3	50.8	50.5	51.2[e]	51.2[e]	49.7[d]

[a]Fat thickness endpoint refers to live animal measurement between 12th and 13th ribs.

[b]LO=low concentrate; ML=medium low concentrate; MH=medium high concentrate; HI=high concentrate.

[c]Marbling refers to: 7=trace$^-$; 8=trace^o; 9=trace$^+$; 10=slight$^-$; 11=slight^o; 12=slight$^+$; 13=small$^-$.

[d,e]Values within same line and concentrate level having unlike superscripts differ significantly ($P<.05$).

endpoint within each diet produced heavier carcasses. Within the LO concentrate diet, carcasses of the 13 mm fat thickness were heavier ($P<.05$) than those of the 10 mm group (266 kg vs. 251 kg), while carcasses of the 15 mm group were heavier ($P<.05$) than those of the 13 mm group (291 kg vs. 266 kg). Similar and signifcant ($P<.05$) differences were present within all other diets except the LO concentrate diet.

Marbling scores and quality grades were similar for backfat endpoints within the LO concentrate diet. Within the ML concentrate diet the 15 mm cattle had significantly ($P<.05$) higher marbling scores and quality grades than cattle of the 13 mm group, but the cattle of the 10 and 13 mm group were similar in these traits. Similar results were observed for the backfat groups within the MH and HI concentrate levels as for the ML diet; however, carcasses from the 13 and 15 mm of bacfat were significantly ($P<.05$) higher in marbling and quality grade than cattle of the 10 mm group within the HI concentrate diet. Quality grades characteristics improved when cattle were fed to a greater degree of finish within the MH and HI concentrate diets, Grades improved from USDA Standard to USDA Good as backfat thickness increased from 10 to 15 mm within MH and HI concentrates diets.

In general ribeye areas increased in size as backfat endpoint was increased within each concentrate level; however, significant ($P<.05$) differences were only present within the HI concentrate diet group.

Fat thicknesses and yield grades also increased as fat thickness endpoint increased within each diet. Significant ($P<.05$) differences for fat thickness were seen only within the ML concentrate diet, while significant ($P<.05$) differences for yield grade were present only within the HI concentrate diet.

Data suggest that there is no real benefit in quality grade or cutability in taking cattle from 13 to 15 mm of backfat regardless of diet.

Fat Thickness Endpoints within Breed Type

As was expected, cattle fed to greater thicknesses of backfat yielded carcasses that were heavier (Table 18). Within the AXH cattle, hot carcass weights increased with increasing endpoints of backfat, but lacked statistical significance ($P>.05$). For each breed, the preceeding statement was true and significant differences ($P<.05$) were noted.

Marbling scores and quality grades were not significantly ($P>.05$) affected by fat thickness within each breed. A general trend was observed that as fat thickness endpoint increased so did marbling score and quality grade within all breeds. The AXH, BOG and STG cattle all had higher ($P<.05$) marbling scores and quality grades than BMS or LXH cattle. AXH cattle tended to marble and quality grade best while LXH cattle were weaker in these particular traits in comparing all breeds.

Ribeye areas were not different ($P>.05$) within each breed as backfat endpoint increased except for LXH cattle. Within the LXH cattle, those fed to 13 or 15 mm of backfat had significantly ($P<.05$) larger ribeyes than those fed to 10 mm of backfat (80.0 and 80.6 cm^2 vs. 68.4 cm^2). This general trend was noticeable within all breeds.

Table 18. Means of carcass data for fat thickness[a] endpoints within breed[b].

Item	AXH			STG			BMS		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Hot Carcass Wt., Kg	245	268	287	302[d]	303[d]	340[e]	256[d]	287[e]	304[e]
Marbling[c]	11	13	14	10	11	13	9	10	11
Quality Grade	Good	Choice-	Choice	Good-	Good	Choice-	Standard+	Good-	Good
Ribeye Area, cm^2	72.2	75.5	76.8	76.11	78.0	77.4	72.2	75.5	78.0
Fat Thickness (mm)	12.2	12.7	15.0	8.9[d]	10.4[d,e]	13.5[e]	8.7	9.9	10.2
Yield Grade	2.6	2.7	3.2	2.5	2.8	3.3	2.2	2.6	2.6
Cutability %	50.9	50.9	49.9	51.3	50.6	49.4	51.8	51.0	51.0

Table 18, Continued.

Item	LXH			BOG		
	10 mm	13 mm	15 mm	10 mm	13 mm	15 mm
Hot Carcass Wt., Kg	219^{d}	272^{e}	268^{e}	302^{d}	291^{d}	349^{e}
Marbling[c]	7	8	10	12	10	13
Quality Grade	Standard-	Standard	Good	Good+	Good-	Choice
Ribeye Area, cm^2	68.4	80.0	80.6	76.8	76.1	80.6
Fat Thickness (mm)	6.6	7.6	8.9	12.2^{d}	10.9^{d}	16.3^{e}
Yield Grade	1.9	1.9	2.0	2.9^{d}	2.8^{d}	3.6^{e}
Cutability %	52.6	52.5	52.3	50.2^{e}	50.8^{e}	48.7^{d}

[a]Fat thickness endpoint refers to live animal measurement between 12th and 13th ribs.

[b]Breed refers to: AXH - Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Hereford - Angus - Charolais cross.

[c]Marbling refers to: 7=traces^{-}; 8=traces^{o}; 9=traces^{+}; 10=slight^{-}; 11=slight^{o}; 12=slight^{+}; 13=small^{-}; 14=small^{o}.

[d,e,f]Values within same line and breed having unlike superscripts differ significantly ($P<.05$).

Few significant (P<.05) interactions of fat thickness within breed were noted for backfat measurement and yield grade variables. The general trend was that as fat thickness endpoint increased, backfat measurement and yield grade also increased (P<.05) within all breeds.

From fat thickness data, STG, BMS and LXH cattle had not attained the designated backfat endpoints. BOG cattle reached the first and last take off endpoints but lacked finish for the intermediate endpoint. This shows that certain breeds were not ready for slaughter while other breeds were. The use of average backfat measurement within each diet for all breeds is accountable for the fact that some breed types did not attain the designated endpoints.

Breed Type within Fat Thickness Endpoints

Significant (P<.05) carcass weight differences were observed for breeds within fat thickness endpoints (Table 19). Within the 10 and 15 mm backfat group, BOG and STG cattle had significantly (P<.05) heavier hot carcass weights than AXH, BMS or LXH cattle. Similar results were attained within the 13 mm backfat group for the same breeds; however, differences were not significant (P>.05).

Marbling scores and quality grades were always lowest (P>.05) for the LXH cattle within each backfat group. BOG, AXH and STG cattle had higher marbling scores and quality grades than BMS or LXH cattle within all fat thickness endpoints. Higher marbling scores and quality grades were achieved as cattle were fed to a greater backfat thickness, regardless of breed.

Table 19. Means of carcass data for breeds[a] within fat thickness[b] endpoints.

Item	10 mm					13 mm				
	AXH	STG	BMS	LXH	BOG	AXH	STG	BMS	LXH	BOG
Hot Carcass Wt., Kg	245[d,e]	302[f]	256[e]	219[d]	302[f]	268	303	287	268	291
Marbling	11[e]	10[d,e]	9[d,e]	7[d]	12[e]	13[e]	11[d,e]	10[d,e]	8[d]	10[d,e]
Quality Grade	Good[e]	Good[d,e]	Standard+[d,e]	Standard-[d]	Good+[e]	Choice-[e]	Good[d,e]	Good-[d,e]	Standard[d]	Good-[d,e]
Ribeye Area, cm^2	73.2	77.1	73.2	69.3	77.8	76.5	79.1	76.5	81.1	77.1
Fat Thickness	12.2[e]	8.9[d,e]	8.6[d]	6.6[d]	12.2[e]	12.7	10.2	9.9	7.6	10.9
Yield Grade	2.6[e,f]	2.5[d,e,f]	2.2[d,e]	1.9[d]	2.9[e]	2.7[e]	2.8[e]	2.6[e]	1.9[d]	2.8[e]
Cutability %	50.9[d,e]	51.3[d,e,f]	51.8[e,f]	52.6[f]	50.2[d]	50.9	50.6	51.0	52.5	50.8

Table 19, Continued

Item	15 mm				
	AXH	STG	BMS	LXH	BOG
Hot Carcass Wt., Kg	$287^{d,e}$	340^{f}	304^{e}	268^{d}	349^{f}
Marbling	14^{e}	$13^{d,e}$	11^{d}	10^{d}	13^{e}
Quality Grade	Choice^{e}	Choice-^{d,e}	Good^{d}	Good-^{d}	Choice-^{e}
Ribeye Area, cm^2	77.8	78.5	79.8	81.8	81.8
Fat Thickness	15.0^{f}	$13.4^{e,f}$	$10.2^{d,e}$	8.9^{d}	16.3^{f}
Yield Grade	3.2^{f}	3.3^{f}	2.6^{e}	2.0^{d}	3.6^{f}
Cutability %	49.9^{d}	49.4^{d}	51.0^{e}	52.3^{f}	48.5^{d}

[a]Breeds refer to: AXH = Angus X Hereford; STG = Santa Gertrudis; BMS = Beefmaster; LXH = Limousin X Hereford; BOG = Brahma - Angus - Charolais cross.

[b]Fat thickness refers to live animal measurement between 12th and 13th ribs.

[c]MARBLING refers to: 7=traces^{-}; 8=traces^{o}; 9=traces^{+}; 10=slight^{-}; 11=slight^{o}; 12=slight^{+}; 13=small^{-}; 14=small^{o}.

[d,e,f]Values within same line and concentrate level having unlike superscripts differ significantly ($P<.05$)

Ribeye areas were not significantly (P>.05) different between breeds within each backfat group. The LXH cattle had the smallest (P<.05) ribeyes within the 10 mm backfat group; were largest (P<.05) in the 13 mm group and were largest (P>.05) along with BOG's in the 15 mm backfat group, when compared to the other breeds.

Fat thickness measurements were larger (P<.05) for BOG and AXH cattle when compared to other breeds within every fat thickness endpoint. LXH cattle were leaner, while BMS and STG cattle were intermediate within each fat thickness endpoint.

Yield grade values were lower (P<.05) for the LXH cattle within each backfat group, while AXH, STG and BOG had larger values, while BMS cattle were intermediate. BOG cattle had lower (P<.05) cutability percents within the 10 and 15 mm backfat endpoint, while STG cattle had lower cutabilities within the 13 mm backfat group.

GENERAL DISCUSSION

With regard to beef cattle, this study indicates that there is no genetic characteristic for each breed type studied in expressing its own particular composition of intramuscular fat. However, compositional changes in fatty acids of intramuscular fat may occur within these breed types as mediated by their diet. The use of high concentrate diets resulted in an increase in the unsaturated fatty acid fraction of the intramuscular fat. Possibly by the stimulation of enzymatic systems which desaturate fatty acids at the site of deposition or by the unsaturated plant lipids in the diet by escaping hydrogenation by rumen microflora and leading to the absorption from the intestine of unsaturated fatty acids with eventual deposition.

On the other hand, intramuscular fat content appears to be a primary function of breed type rather than diet. Increased intramuscular fat deposition is more evident in some breeds than others. Maturity rate seems to be the major responsible factor. Those cattle which are considered of British origin are known for their early maturing characteristics, while those classified as "exotics" reach maturity at later ages. This effect then could determine the rate of fat deposition in the muscle. Within this study, AXH, BOG and STG breed types possessed these early maturing traits while those cattle of LXH breed type inherited late maturing characteristics. The evidence was shown both by marbling and subcutaneous fat values. Furthermore, the subcutaneous fat thickness endpoint influenced intramuscular fat content even more than diet. However, breed type appeared to be the most important factor in the expression of degree of marbling. In turn, all quality characteristics followed these same trends for the various breed types.

Factors which contribute to carcass weight are more a function of nutritional regimen than breed type or backfat thickness endpoint. Subcutaneous fat deposition and Longissimus dorsi measurements were greater by feeding high concentrate diets and consequently heavier carcasses were produced by these High diets.

By feeding different concentrate diets or by feeding to different fat thickness endpoints, marbling score and ribeye size can be influenced. Yet no particular diet was found to be best for obtaining carcasses with optimum quality and high cutability. The AXH, BOG and STG breed types appeared to be the most desired for quality attributes, while LXH cattle were the best for improved cutability.

Overall it can be established that breed types determine the time on feed required to reach a specific carcass quality and backfat endpoint, while amount of concentrate fed would have only an effect on quality traits.

SUMMARY

This study involved 120 steers of 5 different breed types. The cattle consisted of Angus X Hereford, Santa Gertrudis, Beefmaster, Limousin Hereford and Brahma - Hereford - Angus - Charolais cross.

The cattle were fed four diets consisting of low, medium low, medium high and high concentrate diets (39, 52, 67 and 80% concentrate, respectively) to 10, 13 or 15 mm fat thickness endpoints.

Carcass data were collected and Longissimus muscle samples from the 12th rib were analyzed for percent lipid and fatty acids content.

Little variation in percent lipid or fatty acid profile was observed between diets. However, fat from cattle on the high and medium high concentrate diets were significantly ($P<.05$) more unsaturated than fat from cattle on the low concentrate diet.

The Limousin X Hereford cattle had significantly ($P<.05$) lower intramuscular lipid values than the other breeds. No significant ($P>.05$) fatty acid differences were observed between breed for intramuscular lipid, however, Angus X Hereford cattle tended to be more saturated than the other breeds.

Cattle fed to 15 mm of backfat had significantly ($P<.05$) more lipid in the Longissimus muscle than cattle fed to 10 mm of backfat. Fatty acid analysis showed that cattle fed to 13 and 15 mm of backfat had higher ($P<.05$) C18:1 and lower ($P<.05$) C18:2 proportions than cattle fed to 10 mm of backfat.

Very few significant interactions between main treatments were observed for fatty acid content of Longissimus lipid. By feeding high concentrate levels or to 15 mm of backfat, more C18:1 and greater proportions of unsaturation were present.

Cattle fed high and medium high concentrate diets yielded carcasses which were significantly ($P<.05$) heavier with larger ribeyes than carcasses of cattle fed a low concentrate diet. Marbling scores and quality grades were not influenced by diet. Fat thickness tended to be larger at higher (medium high and high) concentrate levels than lower (medium low and low) concentrate levels. Yield grades were not significantly ($P>.05$) different between diets; however, cattle fed the high concentrate diet had the highest yield grade values.

Santa Gertrudis and Brahma - Hereford - Angus - Charolais cross cattle had heavier ($P<.05$) carcasses than the other breeds. Marbling scores, quality grades, fat thicknesses and yield grades were all lower ($P<.05$) for Limousin X Hereford cattle when compared to the other breeds. Quality grade and yield grade factors tended to be higher ($P<.05$) in cattle fed to 15 mm of backfat when compared to cattle fed to 13 or 15 mm of backfat.

Comparing the data by fat thickness endpoint with diet showed that cattle fed the high concentrate had heavier carcasses, were fatter and had larger ribeyes than carcasses from cattle fed the low concentrate diet. Those cattle fed to 15 mm of backfat possessed carcasses which were higher ($P<.05$) in quality and yield grades when compared to carcasses of cattle fed to 10 mm of backfat using the MH and HI concentrate diets.

Diet by breed interaction showed that within all concentrate diets AXH, BOG, and STG cattle tended to be fatter and higher in quality than the other breeds.

Breed by fat thickness interaction demonstrated that carcasses of L X H cattle were lighter, lower in marbling scores and yield grades, than all other breeds within each fat thickness endpoint. Within all breed types, those cattle which were fed to 15 mm of finish were heavier, fatter, higher in quality and yield grades, and lower in cutability than those fed to 10 mm of finish.

LITERATURE CITED

Adams, N. J., W. N. Garrett and J. T. Elings. 1973. Performance and carcass characteristics of crosses from imported breeds. J. An. Sci. 37:623.

Adams, N. J., G. C. Smith and Z. L. Carpenter. 1977. Carcass and palatability characteristics of Hereford and crossbred steers. J. An. Sci. 45:438.

Andrews, F. N. 1958. Fifty years of progress in animal physiology. J. An. Sci. 17:1064.

Arthaud, V. H., R. W. Mandigo, R. M. Koch and A. W. Kotula. 1977. Carcass composition, quality and palatability attributes of bulls and steers fed different energy levels and killed at four ages. J. An. Sci. 44:53.

Behrens, W. C., H. H. Stonaker, M. H. Hazaleus and N. L. Landblom. 1955. The genetic and phenotypic relationship between estimates of fat deposition in Hereford steers. Proc. West. Sec. Amer. Soc. Anim. Prod. 6:49.

Bowling, R. A, G. C. Smith, Z. L. Carpenter, T. R. Dutson and W. M. Oliver. 1977. Comparison of forage-finished and grain-finished beef carcasses. J. An. Sci. 45:209.

Bowling, R. A., J. K. Riggs, . C. Smith, Z. L. Carpenter, R. L. Reddish and O. D. Butler. 1978. Production, carcass and palatability characteristics of steers produced by different management systems. J. An. Sci. 46:333.

Boyer, D. E., W. M. F. Leat, A. N. Howard and G. P. Gresham. 1963. The determination of the fatty acid composition of serum lipids separated by thin-layer chromatography; and a comparison with column chromatography. Biochem. Biophys. Acta. 70:423.

Bryant, H. T., R. C. Hammes, Jr., R. E. Blaser and J. P. Fontenot. 1965. Effects of feeding grain to grazing steers to be fattened in drylot. J. An. Sci. 24:676.

Brungardt, V. H. 1972. Efficiency and profit differences of Angus, Charolais and Hereford cattle varying in size and growth. Univ. of Wisconsin Res. Rep. 2397-2401.

Butler, O. D., T. C. Cartwright, L. E. Kunkle, R. A. Orts, G. T. King and D. W. Lewter. 1962. Comparative feedlot performance and carcass characteristics of Hereford and Angus steers. J. An. Sci. 21:298.

Butterfield, R. M. 1965. The relationship of carcass measurements and dissection data to beef carcass composition. Res. Vet. Sci. 6:24.

Cabezas, M. T., J. F. Hentges, Jr., J. E. Modre and J. A. Olson. 1965. Effect of diet on fatty acid composition of body fat in steers. J. An. Sci. 24:57.

Callow, E. H. 1950. Comparative studies of meat. IV. Rates of fattening to the deposition of fat and protein in the fatty and muscular tissue of meat carcasses. J. Agric. Sci. 40:1.

Callow, E. H. 1962. Comparative studies of meat. VIII. The percentage of fat in the fatty and muscular tissue of steers and the iodine number of the extracted fat, as affected by breed and level of nutrition. J. Agric. Sci. Camb. 58:295.

Carroll, F. D., M. T. Clegg and Dietrich Kroger. 1964. Carcass characteristics of Holstein and Hereford steers. J. Agric. Sci. 62:1.

Cartwright, T. C., G. F. Ellis, Jr., W. E. Kruse and E. K. Crouch. 1964. Hybrid vigor in Brahman Hereford crosses. Texas Agr. Exp. Sta. Tech. Monogr. 1.

Church, D. C., A. T. Ralston and W. H. Kennick. 1967. Effeck of diet or diethystilbesterol on fatty acid composition of bovine tissues. J. An. Sci. 26:1296.

Clemens, Edgar, V. Arthaud, R. Mandigo and W. Woods. 1973. Fatty acid composition of bulls and steers as influenced by ase and dietary energy level. J. An. Sci. 37:1326.

Cole, J. W., C. B. Ramsey, C. S. Hobbs and R. S. Temple. 1963. Effects of type and breed of British, Zebu and Dairy cattle on production, palatability and composition. I. Rate of gain, feed efficiency and factors affecting market value. J. An. Sci. 22:702.

Cramer, D. A., A. L. Hecker and D. P. Cornforth. 1973a. Intramuscular fat deposition in cattle. Proc. West. Sec. Amer. Soc. Ani. Sci. 24:95.

Cramer, D. A., A. L. Hecker and D. P. Cornforth. 1973b. Breed and sex differences in the distribution of fat in cattle. Reg. Highlights of the Anim. Sci. Dept., Colorado State Univ. Exp. Sta. Gen. Ser. 931:45.

Cross, H. R. and D. A. Dinus. 1978. Carcass and palatability characteristics of beef steers finished on forage diets. J. An. Sci. 47: 1265.

Cundiff, L. V., K. E. Gregory, R. M. Koch and G. E. Dickerson. 1969. Genetic variation in total and differential growth of carcass components in beef cattle. J. An. Sci. 29:233.

Cundiff, L. V., K. E. Gregory, R. M. Koch, G. E. Dickerson and R. D. Humphrey. 1970. Hybrid vigor in beef cattle. 1969 Nebraska beef Cattle Rep. E. C. 69-218 p. 19-20.

Damon, R. A., J., R. M. Crown, C. B. Singletary and S. E. McCraine. 1960. Carcass characteristics of purebred and crossbred beef steers in the Gulf Coast region. J. An. Sci. 19:820.

Dickerson, G. E., H. A. Glimp, H. J. Tuma and K. E. Gregory. 1972. Genetic resources for efficient meat production in sheep. Growth and carcass characteristics of ram lambs of seven breeds. J. An. Sci. 34:940.

Dinkel, C. A. and D. A. Busch. 1973. Genetic parameters among production, carcass composition and carcass quality traits of beef cattle. J. An. Sci. 36:832.

Dinus, D. A. and H. R. Cross. 1978. Feedlot performance, carcass characteristics and meat palatability of steers fed concentrate for short periods. J. An. Sci. 47:1109.

Dryden, F. D., J. A. Marchello, W. C. Figroid and W. H. Hale. 1973. Composition changes in bovine subcutaneous lipid as influenced by dietary fat. J. An. Sci. 36:19.

Dryden, F. D. and J. A. Marchello. 1973. Influence of dietary fat upon carcass lipid composition in the bovine. J. An. Sci. 37:33.

Edwards, R. L., S. B. Tove, R. N. Blumer and E. R. Barrick. 1961. Effects of added dietary fat on fatty acid compositoin and carcass characteristics of fattening steers. J. An. Sci. 20:712.

Edwards, R. L., G. C. Skelly, J. W. Hubbard, J. J. Starnes and W. A. Balk. 1973. A comparison of ten drylot steer-finishing systems involving corn silage, urea and pelleted coastal bermudagrass. South Carolina Agr. Exp. Bull. 563.

Elson, C. E., W. A. Fuller, E. A. Kline and L. N. Hazel. 1963. Effect of age on the growth of porcine muscle. J. An. Sci. 22:946.

Epley, R. J., H. B. Hedrick, W. L. Mies, R. L. Preston, G. F. Krause and G. B. Thompson. 1971. Effects of digestable protein to digestable energy ratio diets on quantitative and qualitative carcass composition of beef. J. An. Sci. 33:355.

Erwin, E. W., W. Sterner and G. J. Marco. 1963. Effect of type of oil and site of administration on the fate of fatty acids in sheep. J. Amer. Oil. Chem. Soc. 40:344.

Forrest, J. C., E. D. Aberle, H. B. Hedrick, M. D. Judge and R. A. Merkel. 1975. Principles of Meat Science. B. S. Schweigert (Ed.). W. H. Freeman and Company, San Francisco.

Gaines, J. A., G. V. Richardson, W. H. McClure, D. W. Vogt and R. C. Carter. 1976. Heterosis from crosses among British breeds of beef cattle. Carcass characteristics. J. An. Sci. 26:1317.

Garrett, W. N. 1974. Influence of roughage quality on the performance of feedlot cattle. 13th Ann. Calif. Feeders' Day Rep., p. 51.

Garton, G. A., A. K. Lough and E. Vioque. 1961. Glyceride hydrolysis and glycerol fermentation by sheep rumen contents. J. Gen. Microbiol. 25:215.

Gregory, K. E., L. A. Swiger, L. J. Sumption, R. M. Koch, J. E. Ingalls, W. W. Rowden and J. A. Rothlisberger. 1966. Heterosis effects on carcass traits of beef steers. J. An. Sci. 25:311.

Guenther, J. J., D. H. Bushman, L. S. Pope and R. D. Morrison. 1965. Growth and development of the major carcass tissue in beef calves from weaning to slaughter weight, with reference to the effect of plane of nutrition. J. An. Sci. 24:1184.

Haecker, T. L. 1920. Investigation in beef production. Minnesota Agr. Exp. Sta. Bull. 193.

Hammes, R. C., Jr., J. P. Fontenot, H. T. Bryant, R. E. Blaser and R. W. Engel. 1964. Value of high-silage rations for fattening beef cattle. J. An. Sci. 23:795.

Hankes, R. N. 1974. Effect of breed or crossbreed combination and energy level on feedlot and carcass merit of steers. Ph.D. Dissertation. University of Illinois, Urbana, Illinois.

Hecker, A. L. 1972. Effect of growth on carcass and fat composition in the bovine. Dissertation Abstr. Int. B. 33:558.

Hilditch, T. P. 1956. The chemical constitution of natural fats. Chapman and Hall Pub., London.

Hiner, R. L. and J. Bond. 1971. Growth of muscle and fat in beef from 6 to 36 months of age. J. An. Sci. 32:225.

Hornstein, I., P. F. Crowe and R. Hiner. 1967. Composition of lipids in some beef muscles. J. Food Sci. 32:650.

Jeremiah, L. E., G. C. Smith and J. K. Hillers. 1970. Utilization of breed and traits determined from live beef steer for prediction of marbling score. J. An. Sci. 31:1089.

Johnson, E. R., R. M. Butterfield and W. J. Pryor. 1972. Studies of fat distribution in the bovine carcass. I. The portion of fatty tissues between depots. Aust. J. Agr. Res. 23:381.

Jones, S. D. M., M. A. Price and R. T. Berg. 1978. Effects of breed type and slaughter weight on feedlot performance and carcass composition in bulls. Can. J. Anim. Sci. 58:277.

Kauffman, R. G., Z. L. Carpenter, R. W. Bray and W. G. Hoekstra. 1964. Biochemical properties of pork and their relationship to quality. III. Degree of saturation and moisture content of subcutaneous fat. J. Food Sci. 29:75.

Kauffman, R. G., G. G. Suess, R. W. Bray and R. D. Scarth. 1968. Incidence of marbling of the bovine and porcine Longissimus. J. An. Sci. 27:969.

Kempster, A. J., A. Cuthbertson and G. Harrington. 1976. Fat distribution in steer carcasses of different breeds and crosses. I. Distribution between depots. Ani. Prod. 23:25.

Kidwell, J. F. and J. A. McCormick. 1956. The influence of size and type on growth and development of cattle. J. An. Sci. 15:109.

Kincaid, C. M. 1962. Breed crosses with beef cattle in the South. A report of cooperative research under Southern Regional Project S-10 Southern Cooperative Series Bull. 81.

Koch, R. M., M. E. Dikeman, D. M. Allen, M. May, I. D. Crouse and D. R. Campion. 1976. Characterization of different biological types of cattle. III. Carcass composition, quality and palatability. J. An. Sci. 43:48.

Lasley, J. F., G. F. Krause, J. P. Jain, H. B. Hedrick, B. Sibbit, L. Langford, J. E. Comfort and A. J. Dayer. 1971. Carcass quality characteristics in heifers of reciprocal corsses of the Angus, Charolais and Hereford breeds. J. An. Sci. 32:406.

Lasley, J. F. Genetics of livestock improvement. 1972. 2nd Ed. Prentice-Hall, Inc. Englewood Cliffs, N. J.

Leat, W. M. F. and G. A. Embleton. 1970. Adipose tissue fatty acids of young and mature Jersey cattle. Pro. Nutr. Soc. 29:48A.

Link, B. A., R. W. Bray, R. G. Cassens and R. G. Kauffman. 1970. Fatty acid composition of bovine subcutaneous adipose tissue lipids during growth. J. An. Sci. 30:722.

Lofgreen, G. P. 1968. The effect of nutrition on carcass characteristics, 4th Ann. Ariz. Feed-Elanco Seminar, p. 7.

Lohman, T. G. 1971. Biological variation in body composition. J. An. Sci. 32:647.

Marchello, J. A., F. D. Dryden and W. H. Hale. 1971. Bovine serum lipids. I. The influence of added animal fat to the ration. J. An. Sci. 32:1008.

Marchello, J. A. 1979. (In publication).

Martin, E. L. and C. C. O'Mary. 1973. Carcass characteristics of Charolais x Angus and Angus steers. J. An. Sci. 36:1194. (Abstr).

McMeekan, C. P. 1940. Growth and development in the pig, with special reference to carcass quality characteristics. II. The influence of plane of nutrition on growth and development. J. Agr. Sci. 30:387.

McMeekan, C. P. 1941. Growth and development in the pig, with special reference to carcass quality characteristics. IV. The use of sample joints and of carcass measurements as indices of the composition of the bacon pig. V. The bearing of the main principles emerging upon the many problems of animal production and human development. J. Agr. Sci. 31:1.

Miller, G. J., T. R. Varnell and R. W. Rice. 1967. Fatty acid composition of certain ovine tissues as affected by maintenance level roughage and concentrate. J. An. Sci. 26:41.

Moulton, C. R., P. F. Trowbridge and L. D. Haigh. 1923. Studies in animal nutrition. V. Changes in the composition of the mature dairy cow during fattening. Mo. Agr. Sta. Res. Bull. 61.

Nie, N. H., G. H. Hull, J. G. Jenkins, K. Steinbrenner and D. H. Bent. 1975. SPSS, 2nd ed. McGraw-Hill Book Co., New York.

National Resource Council. 1970. Nutrient requirements of beef cattle. Nutritional Acad. of Sci., Washington, D.C.

Oltjen, R. R. and P. D. Williams. 1974. Microbial populations and metabolic parameters of ruminants fed a purified diet with and without dietary lipids. J. An. Sci. 38:915.

Olentine, C. G., Jr., N. W. Bradley, J. A. Boling and W. G. Moody. 1976. Comparison of Charolais crossbred and Angus yearling steers finished on pasture. J. An. Sci. 42:1375.

O'Mary, C. C., E. L. Martin and D. C. Anderson. 1979. Production and carcass characteristics of Angus and Charolais x Angus steers. J. An. Sci. 48:239.

Ostrander, J. and L. R. Dugan, Jr. 1961. A rapid, quantitative lipid extraction method. Amer. Meat Inst. Found. Bull. 50.

Palsson, H. and J. B. Verges. 1952. Effects of the plane of nutrition on growth and development of carcass quality in lambs. Part I. The effects of high and low planes of nutrition at different ages. J. Agr. Sci. 42:1.

Pomeroy, R. W. and D. R. Williams. 1974. The partition of fat in the bovine carcass. Proc. Br. Soc. Anim. Prod. (New Series) 3:85 (Abstr).

Prior, R. L., R. H. Kohlmeier, L. V. Cundiff, M. E. Dikeman and J. D. Crouse. 1977. Influence of dietary energy and protein on growth and carcass composition in different biological types of cattle. J. An. Sci. 45:132.

Ramsey, C. B., J. W. Cole and R. L. Sliger. 1967. Effect of age of females on carcass composition, meat characteristics and palatability. Texas AES Bul. 420.

Reiser, R. 1951. Hydrogenation of polyunsaturated fatty acids by the ruminant. Fed. Proc. 10:236.

Reiser, R. and H. G. Reddy. 1956. The hydrogenation of dietary unsaturated fatty acids by the ruminant. J. Amer. Oil Chemists Soc. 33:155.

Reiser, R. and R. B. R. Chaudbury. 1959. On the origin of stearic acid in ruminant depot fat. J. Amer. Oil Chemists Soc. 36:129.

Roberts, W. K. and J. A. McKirby. 1964. Weight gains, carcass fat characteristics and ration digestability in steers as affected by dietary rapeseed oil, sunflower seed oil and animal tallow. J. An. Sci. 23:682.

Rumsey, T. S., R. R. Oltjen, J. P. Bovard and B. M. Priode. 1972. Influence of widely diverse finishing regimens and breeding on depot fat composition in beef cattle. J. An. Sci. 35:1069.

Scarth, R. D., R. G. Kauffman and R. W. Bray. 1973. Effects of breed and age classification on live weight and carcass traits of steers shown at international quality beef show. J. An. Sci. 36:653.

Skelly, G. C., W. C. Stanford and R. L. Edwards. 1973. Bovine fat composition and its relation to animal diet and carcass characteristics. J. An. Sci. 36:576.

Skelly, G. C., R. L. Edwards, F. B. Wardlaw and A. K. Torrence. 1978. Selected high forage rations and their relationship to beef quality, fatty acids and amino acids. J. An. Sci. 47:1102.

Skipski, V. P., M. Barclay, R. K. Barclay, V. A. Fetzer, J. Good and F. M. Archibald. 1976. Lipid composition of human serum lipoproteins. Biochem. J. 104:340.

Sink, J. D., J. L. Watkins, J. H. Ziegler and R. C. Miller. 1964. Analysis of fat deposition in swine by gas-liquid chromatography. J. An. Sci. 23:121.

Stuedemann, J. A., J. J. Guenther, S. A. Ewing, R. D. Morrison and G. V. Odell. 1968. Effect of nutritional level imposed from birth to eight months of age on subsequent growth and development patterns of full-fed beef calves. J. An. Sci. 27:234.

Sumida, D. M., D. W. Vogt, E. H. Cobb, I. I. Iwanaga and D. Reimer. 1972. Effect of breed type and feeding regimen on fatty acid composition of certain bovine tissues. J. An. Sci. 35:1058.

Terrell, R. N., G. G. Suess and R. W. Bray. 1969. Influence of sex, live weight and anatomical location of bovine lipids. I. Fatty acid composition of subcutaneous and intermuscular fat depots. J. An. Sci. 28:449.

Tove, S. B. and G. Matrone. 1962. Effect of purified diets on the fatty acid composition of sheep tallow. J. Nutr. 76:271.

Trenkle, A., D. L. DeWitt and D. G. Topel. 1978. Influence of age, nutrition and genotype on carcass traits and cellular development of the M. Longissimus of cattle. J. An. Sci. 46:1597.

Ulyatt, M. J., J. W. Czerkawski and K. L. Blaxter. 1966. A technique for quantitative measurement of hydrogenation of longchain fatty acids in the fore-stomach of the sheep. Proc. Nutr. Soc. 25: XVIII.

United States Department of Agriculture. 1976. Official U. S. standards for grades of carcass beef. Agr. Mktg. Ser. Title 7, Chil. Part 53, Sec. 53.100-53.105. United States Dept. of Agr., Washington, D.C.

Waldman, R. C., G. G. Suess, R. W. Lewis, R. W. Bray and V. H. Brungardt. 1965. Certain fatty acids of bovine tissue and their association with carcass characteristics. J. An. Sci. 24:869.

Waldman, R. C., G. G. Suess and V. H. Brungardt. 1968. Fatty acids of certain bovine tissue snd their association with growth, carcass and palatability traits. J. An. Sci. 27:632.

Waldman, R. C., W. J. Tyler and V. H. Brungardt. 1971. Changes in the carcass composition of Holstein steers associated with ration energy levels and growth. J. An. Sci. 32:611.

Willham, R. L. 1974. Genetics of fat content in animal products. Proceedings of a symposium. The national research council. The fat content and composition of animal products. p. 85.

Wooten, R. A., C. B. Roubicek, J. A. Marchello, F. D. Dryden and R. S. Swingle. 1979. Realimientation of cull range cows. 2. Changes in carcass traits. J. An. Sci. 48:823.

Zinn, D. W. 1964. Interrelations of live performance traits and quantitative and qualitative characteristics of beef carcasses. Proc. Recip. Meat Conf. 17:43.