THE EFFECTS OF AGE AT SLAUGHTER AND CARCASS TRAITS ON BOXED BEEF YIELDS OF FEEDLOT STEERS

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1991

Submitted to the faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1994

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ACKNOWLEDGEMENTS

I would like to express sincere thanks to Dr. H. Glen Dolezal for his knowledge, assistance and encouragement throughout the duration of my Masters Program. Additionally, a special thanks goes to Drs. D. R. Gill and J. W. Lamkey for serving on my committee.

A special thanks is due to Betty Rothermel and Kris Novotony for their help and assistance. Additionally, a special thanks goes out to fellow graduate and undergraduate students for keeping life in perspective during the ups and downs of graduate school. Particular thanks is owed to Brandon Burton, Mike Rose, Shane Deering, and Tracy Taylor.

To my parents and family, thank you for the support throughout all of my endeavors.

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CHAPTER I

INTRODUCTION

U. S. cattlemen are extremely resourceful and are continually striving for ways to improve efficiency and ultimately increase profitability. Many technologies such as implants, feed additives, feed processing, and improved genetic selection are in current use. Unfortunately, these practices sometimes affect the end product negatively.

Diversification of the United States cattle population during the past two decades has resulted in many different cattle types. Although the influx of new cattle breeds has contributed increased growth rate, size, and to an extent muscularity, these breeds as well as the intensified use of crossbreeding have also increased variability and inconsistency during the growing and finishing phases of production. This has resulted in many different management and marketing strategies to achieve maximum profitability for different cattle types. For example, with increased growth to weaning some producers are placing calves directly in the feedlot in an effort to moderate slaughter and carcass weights to meet a more desirable weight range. However, health, nutrition, and management become increasingly important with this practice. Additionally, there is a current belief in the industry that marbling and maturity are positively related. This causes concerns for many with the production of calf-feds given the current U. S. qualitative marketing methodology. Not only do these differing cattle types cause inconsistencies in the feedlot, but these problems overlap to the rail as well. Due to differences in growth rate, and size at slaughter it would seem logical that cattle differing in type but of similar weight would also be contrasting in composition. May et al. (1989) noted cutability differences between different cattle types. If a value based marketing system where cattle were sold on cutability as well as quality were implemented in the United States, how would the current production schemes fit into such a system? Therefore, this study was conducted to determine the effects of age (maturity) at slaughter and carcass traits (quality grade, adjusted s.c. fat thickness, and muscle thickness classification) on boxed beef yields of feedlot steers.

CHAPTER II

REVIEW OF LITERATURE

Management Systems

Diversification of the U. S. beef cattle population during the past two decades as well as the intensified use of crossbreeding has led to increased variability in cattle type. Not only do these cattle differ in carcass characteristics, but they differ as well in growth and performance traits. Therefore, the advent of different management strategies such as backgrounding and early weaning has become necessary.

Forage finishing of beef may become a reality in the future as grain supplies become more and more in demand for human consumption. Grass-fed cattle have advantages as well as disadvantages when compared to grain-finished cattle. Previous research has shown that grass-fed steer carcasses had the lowest numerical values for fat thickness and longissimus muscle area; grass-fed heifer carcasses had lower values for fat thickness, longissimus muscle area, carcass weight and yield grade than did carcasses from heifers fed grain for either 90 or 200 days (Dolezal et al., 1982). In a study conducted by Shinn et al. (1976), grass-fed steers had lighter slaughter weights, lower dressing percentages, and less fat thickness as compared to steers grazed on fescue and then fed a high energy diet for either 56 or 112 days. The grass-fed steers had the highest retail product yield of 72.7 % versus 72.4 % for the 56-day steers and 69.5 % for the 112 day steers. However, the grass-fed cattle had the lowest quality grade (Utility$^+$) as compared to Good$^-$ for the 56-day and Good$^+$ for the 112-day steers. Schroeder et al. (1980) observed that carcasses from forage-finished cattle had an advantage in cutability; however, this advantage was negated by their lower dressing percentages and increased cooler shrinkage. Additionally, grain finishing of beef cattle improved dressing percentage and all carcass qualitative characteristics for lean color, marbling, quality grade, and retail acceptability of longissimus muscle steaks. Bowling et al. (1977) noticed that grain-finished beef had twice as much subcutaneous fat as forage-finished beef as well as longer sarcomeres and lower shear force values. Bowling et al. (1978) observed that steers fed grain reached slaughter weight and grade 100 to 230 days sooner, were higher in USDA quality grade, dressed higher and yielded lower percentages of primal cuts than steers finished on forage management systems.

Many producers implement backgrounding systems. This process utilizes forage to allow cattle to grow and mature prior to entering the feedlot. Dinius et al. (1978) observed that cattle gained carcass weight rapidly when shifted from a forage to a concentrate diet, and such economically important traits as dressing percentage and quality grade were improved by feeding concentrate. In a study examining different cattle management systems, Bowling et al. (1978) noticed that steers reared on grass or with grain supplementation on grass were approximately six months older and were lower and more variable in palatability if slaughtered at comparable weight and grade of steers fed in a drylot after grazing. Also, steers grown on grass and then fed concentrates for 98 days before slaughter produced much more protein than did steers fed grain 125 or 255 days after weaning, or steers which were grazed or fed grain on grass as either long yearlings or 2 year olds. Ridenour et al. (1982) observed that carcass quality grade tended to be higher for steers fed high concentrate, 50% concentrate to 273 kg and then high concentrate, or wheat pasture to 273 kg and then high concentrate as compared to steers grown on 50 % concentrate or wheat pasture to 364 kg and then high concentrate. Steers grown on high concentrate had higher dressing percentages, larger ribeye areas and more kidney, pelvic and heart fat than those in other treatments.

Many advancements have been made in beef cattle genetics with respect to growth and performance traits. With increased growth rate many producers are early weaning and sending their calves directly to the feedlot. Lunt et al. (1987) studied the differences between weanling- and yearling-fed heifers that were slaughtered when live weight approached 443 kg. Yearlings tended to gain weight more rapidly in the feedlot than did weanlings. Weanlings were fatter, had more kidney, pelvic and heart fat, merited higher (less desirable) USDA yield grades, had more desirable USDA quality grades and higher dressing percentages than did yearlings. Ribeye area was not different between treatments. However, yearlings yielded a higher percentage of closely-trimmed (0.6 cm) retail cuts than did weanlings. These data suggested that carcass composition is influenced by the way cattle are managed. However, Dikeman et al. (1985) examined the differences between accelerated (85% concentrate for 140 days with Angus x Hereford cattle) and conventional (backgrounded on prairie hay and sorghum grain for 140 days and then finished on 82% concentrate for 116 days for Angus x Hereford cattle) feeding systems and found somewhat contrasting results. Cattle on the accelerated system had less fat thickness, smaller longissimus muscle areas, lower numerical USDA yield grades, lower marbling scores and lower USDA quality grades than cattle on the conventional system. However, these cattle were not slaughtered at the same weights. It is very likely that cattle on the accelerated system would have been fatter than those on the conventional if the accelerated cattle had been slaughtered at 92.3 kg heavier weights, particularly with Angus x Hereford cattle.

Maturity/Age

The age and maturity of feedlot cattle can impact both performance and carcass merit. Totusek (1971) observed that as the initial age of feedlot cattle increases, usually accompanied by heavier starting weights, feed intake and rate of gain increases, and feed per pound of gain increases. Less time-on-feed is required to reach a grade endpoint and heavier carcasses are most often attained. However, cutability is less predictable. If cattle are capable of reaching grade with a short feeding period because of advanced age, a thin fat cover may result in higher cutabilities in contrast to younger cattle which must be fed to a fatter endpoint to grade. Ferrell et al. (1978) concluded that carcasses from large-type, later maturing steers were heavier and contained greater amounts of protein and edible product than carcasses from small-type steers. Protein and edible product produced per unit of feed intake was greater in the larger, faster growing steers than in smaller, earlier maturing steers. Rate of gain favored the large-type steers, but feed efficiency was similar between the two types. Moody et al. (1970) observed that longissimus muscle area increased though not proportionally to increases in carcass weight as cattle became older and larger. Also, percentage bone was highest for younger cattle.

Lusby (1986) outlined some generalities concerning calf-feds. Younger animals are more efficient in feed conversion, but calves will require more days to reach optimal finishing weights. Calves will gain somewhat slower than yearlings but will have lower daily feed intakes throughout the feeding period and will be more efficient than yearlings if slaughtered at the same degree of fatness. If calves are too light at the beginning of the finishing period, they may become too fat before attaining finishing weight. For this reason, smaller framed calves are frequently fed lower energy "growing rations" for the first 2 or 3 months in the feedlot to permit a period of further skeletal development before being fed high energy rations. Carcass quality grade may be slightly lower with calves than yearlings if the calves are slaughtered too young, typically less than 14-15 months.

Miller (1991) reported in the National Beef Quality Audit that beef from calf-feds may have a greater reduction in dollars as a result of lost marbling ability and reduced USDA quality grades. The industry average for calf-feds at slaughter is 3.0 % and the cost to the beef industry is $ 1.25 per head due to reduced marbling and quality grades. Beef cattle deposit adipose tissue at varying rates in different fat depots according to their maturity level. Calf-feds may never reach a maturity level for accelerated marbling deposition. It is interesting that calf-fed dairy breed cattle are not affected (Miller, 1991). The decrease in marbling and quality grade seems to be breed dependent, with English breeds and their crosses being affected the least and Exotic breeds and crosses and heat-tolerant breeds affected the most.

Time - On - Feed

Extensive research has been conducted to examine the effect of days-on-feed on production and carcass characteristics of feedlot cattle. Zinn et al. (1970a) noted that average daily gain increased with increasing time on feed up to 180 days. Burson et al. (1980) showed that among steers entering the feedlot at similar weights, extended time-on-feed resulted in heavier weights at the end of the test period. Therefore, it would seem logical for slaughter and hot carcass weights to increase with increasing time-on-feed, as noted by Williams et al. (1989). The age at which cattle are placed in the feedlot can influence live animal performance. Lunt et al. (1987) observed that yearlings tended to gain weight more rapidly in the feedlot than did weanlings.

Given the current U. S. marketing methodology, most feeders target for the production of U. S. Choice beef. Although animal age, genetics and other factors may influence U. S. Choice beef production, the most commonly used method to manipulate grade is the time the animal is fed a high concentrate diet. As time-on-feed is extended, there are increases in marbling score and quality grade (Zinn et al., 1970a; Campion et al., 1975; Harrison et al., 1978; Schroeder et al, 1980; Tatum et al., 1980; Dolezal et al., 1982). Zinn et al. (1970a) showed with calf-feds that marbling score and carcass grade increased significantly up to 240 days on feed, and Schroeder et al. (1980) found that added time-on-feed improved quality determinants of muscle. Carcasses from cattle fed 160 days had significantly higher values for marbling than did carcasses from cattle fed 100 or 130 days, and the percentage of U. S. Choice carcasses increased and the percentage of U. S. Good carcasses decreased as a result of increased time-on-feed (Tatum et al., 1980). However, Williams et al. (1989) observed that marbling score increased from 84 to 112 days-on-feed and then remained constant. In a study examining diet energy density and time-on-feed, Burson et al. (1980) noticed that, in general, group means for USDA Quality Grade factors increased as diet energy density and time-on-feed increased.

Feeding cattle for an extended time period in an effort to increase percentage U. S. Choice can result in the negative side effect of increased carcass fatness. Increased time-on-feed is associated with increased subcutaneous, internal and intramuscular fat deposition (Tatum et al., 1980). Fat deposition increased with the length of the period that the cattle were fed concentrate as evidenced by increases in fat thickness and percentage of kidney, pelvic and heart fat (Dinius et al., 1978). Williams et al. (1989) observed that as time-on-feed increased from 84 to 112 days mean values for fat thickness and estimated kidney, pelvic and heart fat increased, and the percentage of fat removed from the carcasses during hot fat trimming increased. Moody et al. (1970) found that fat thickness at the 12^{th} rib increased significantly between 28 and 56 and between 56 and 84 days-on-feed. As well, percentage kidney fat increased significantly between 56 and 84 days-on-feed. In a study examining diet energy density as well as time-on-feed, Burson et al. (1980) observed that means for adjusted fat thickness and kidney, pelvic and heart fat were lowest for carcasses from the sub maintenance group and highest for the high energy density diet steers fed 175 days. In a similar study conducted by Ferrell et al. (1978), most of the increase in carcass weight due to increased energy density of the diet apparently resulted from increased carcass fat.

Increasing carcass fatness from increased days-on-feed affects USDA Yield Grade as well as dressing percent. Feeding cattle for extended periods of time results in increased yield grade (Dinius et al., 1978; Burson et al., 1980; Tatum et al., 1980; Dolezal et al., 1982; Williams et al., 1989). Dinius et al. (1978) also observed that dressing percentage increased as the period of feeding concentrate increased. Dressing percent increased with an increase in feeding time from 28 to 112 days (Moody et al., 1970).

Some research indicates that longissimus muscle area is increased with increasing days-on-feed (Schroeder et al., 1980; Williams et al., 1989). Schroeder et al. (1980) compared differences between forage and grain finished beef and observed that added time-on-feed markedly increased ribeye area. Carcasses from the forage finished cattle had an advantage in percent cutability; however, this advantage was negated by their lower dressing percentages and increased cooler shrinkage. Williams et al. (1989) noticed similar results with increased mean values for ribeye area as days-on-feed increased from 84 to 112 days. Additionally, conventional and trimmed dressed yields (%) increased from 112 to 140 days-on-feed, whereas trimmed dressing percentages were similar for steers fed 84 or 140 days. This increase in ribeye size should probably be attributed to increases in live and carcass weights or size and not actual increases in muscularity. Williams et al. (1989) also observed that percentage of bone trim decreased with increased feeding time.

Fat Trim Level

Fat trim can have a great impact on retail product yield. Belk et al. (1991) noticed as steers became fatter, relative proportions of total dissectible fat and subcutaneous fat in the abdominal and dorsal regions of the carcass increased and relative proportions of fat in the distal regions decreased. There was a tendency for the growth impetus of total dissectible fat and subcutaneous fat to shift from the ventral portions of the carcass toward the dorsal region of the carcass as fattening progressed. In a study conducted by May et al. (1992), they observed that 12^{th} rib fat and sex class had the greatest effect on boneless subprimal yield and production of trimmable fat. Also, within the same phenotypic group, percentage of trimmable fat increased by 2.32 % as 12^{th} rib fat thickness increased by .75 cm. Mies et al. (1992) concluded that depending on the price difference between Choice and Select carcasses and subprimals, leaner cattle types can be more valuable than their fatter counterparts when their subprimals are trimmed more closely. At a constant quality level, fatter cattle types were more valuable at the 2.54 cm of fat trim level. As more fat was trimmed, the leaner cattle types became more valuable and the fatter types became less valuable. However, cattle types with higher percentages of U. S. Choice carcasses were more valuable at the 2.54 cm fat trim level, but when subprimals were trimmed to .64 cm the lower-grading carcasses became closer in value due to cutability advantages. Parrett et al. (1985) conducted a study examining the effects of different fat thickness endpoints (1.5, 1.0, and .50 cm) on carcass characteristics. As fat thickness endpoint increased, hot carcass weight, total separable fat, marbling, quality grade and yield grade increased, but percentage boneless retail cuts and feed efficiency (feed/gain) decreased. Feed to gain ratios, days on feed, and weight increased with increased fat thickness, and there was a difference for final weight, with the fatter cattle being heavier.

Griffin et al. (1992) observed that percentage of fat trimmed from a carcass ranged from 7.9 to 10.9 from Choice carcasses trimmed to 2.54 cm or less fat, whereas ranges from 8.9 to 12.9 and 9.0 to 15.6 % were found from Choice carcasses with maximum trim levels of 1.27 and .64 cm, respectively. Ranges of fat trimmed from Select carcasses were similar, but generally .50 % less fat was trimmed from Select than from Choice carcasses at each trim level. Although the observation that percentage of fat trimmed on all carcasses increased as both the maximum trim level was reduced and as numerical yield grade decreased should be obvious based solely on the definition of USDA yield grades, it is interesting to note similarities in percentage yields as the maximum trim level decreases. For example, a Choice beef steer carcass with a yield grade of 3.5 with cuts trimmed to a maximum of 2.54 cm will yield a slightly higher percentage of fat than will a Choice, yield grade 2.5 steer with cuts trimmed to a maximum of 1.27 cm (Griffin et al., 1992).

Muscularity

Muscle thickness can impact carcass characteristics and retail yields. Williams et al. (1989) studied the effects of muscle thickness on hot fat trim yields, carcass characteristics and boneless subprimal yields. In this study medium-framed crossbred steers with muscle thickness scores of No. 1 and No. 2 were utilized. No. 1 steers had heavier hot carcass weights (trimmed and untrimmed) than No. 2 steers, resulting in higher conventional and trimmed dressed yields. No. 1 steer carcasses possessed lower numerical yield grades than No. 2 carcasses, even though the two muscle thickness classes did not differ in fat thickness. Carcasses from No. 1 steers yielded higher percentages of ribeye roll, strip loin and all subprimals from the round than No. 2 carcasses, and No. 1 steers produced carcasses with larger ribeye areas. Steers with No. 1 muscle thickness yielded 2.76 % more of their live weight in boxed product and had lower percentages of bone trim compared to No. 2 steers. No differences were noted for slaughter weight, adjusted fat thickness, marbling score, or percentage kidney, pelvic and heart fat between the two muscle thickness classes. Tatum et al. (1982) examined the effects of frame size and muscle thickness on steers fed 112 days and then slaughtered. Feeder steers assigned muscle thickness scores of No. 1 were heavier and fatter, gained weight more rapidly and produced fatter and heavier carcasses than did feeder cattle assigned muscle thickness scores of No. 3. Differences were observed for all muscle thickness classes in longissimus muscle area and carcass weight, but no differences were observed in yield grade between the No. 1 and No. 3 muscle thickness groups. This may be explained by the fact that carcasses from steers in the No. 1 muscle thickness group were heavier and had greater fat thickness over the longissimus muscle. However, when holding fat thickness or fat thickness and frame size constant, yield grade was different between the No. 1 and No. 3 muscle thickness classes. Also, carcasses from steers assigned muscle thickness scores of No. 1, as feeders, had the highest muscle to bone ratios of the round 4.1:1.0 while carcasses from steers assigned thickness scores of No. 3, as feeders, had the lowest muscle to bone ratios of the round 3.4:1.0. Additionally, feeder steers with muscle thickness scores of No. 1 had the highest yield of boneless, closely trimmed major retail cuts, conversely, carcasses from steers with muscle thickness scores of No. 3 had the lowest yield of boneless, closely trimmed major retail cuts. May et al. (1992) observed that when holding frame size, sex class, and fat thickness constant, there was a higher percentage yield of chuck roll, ribeye roll, and strip loin for carcasses from thick-muscled cattle than for those from average or thin-muscled cattle. Additionally, regardless of frame size, fat thickness, or sex class, percentage yield of round and rib decreased as muscle score changed from thick to thin. Knapp et al. (1989) indicated that Holstein steers with a muscle thickness score of thin had a lower percentage yield of rib and a higher percentage yield of chuck than that of English steers which had a muscle score of average. Furthermore, Holstein steers had less fat trim at the three trim levels (2.54, 1.27, and .64 cm), but they also had lower yields of major cuts, which was due to heavier bone and lower muscling scores. Kauffman et al. (1976) determined that increased muscularity is associated with higher dressing percentages when weight and finish are held constant. Kauffman et al. (1977) examined muscularity and it's relationship to feed efficiency. When live empty body weight and percentage fat of live empty body weight were held constant, visually appraised muscling (shape) of the live animal starting on test did not significantly affect the conversion of feed to fat-free muscle. As anticipated, fatter animals required more feed to produce fat-free muscle. Muscle shape did not affect feed efficiency. However, muscular animals are leaner at a given chronological age and are, for this reason only, more efficient converters of feed to fat-free muscle. Muscle thickness did not influence absolute growth rate, but was associated with differences in carcass muscle-to-bone ratio at a common bone weight and in muscle percentage when carcass fatness was statistically standardized (Tatum et al., 1986).

Tatum et al. (1986) examined the effects of muscle thickness on the partitioning of separable carcass fat. Among muscle-thickness groups, No. 1 and No. 2 steers partitioned similar proportions of total separable fat into intermuscular, subcutaneous and internal fat; however, No. 3 steers had lower levels of subcutaneous and higher levels of internal fat. Moreover, No. 3 steers had lower percentages of total separable fat than did No. 1 and No. 2 steers, when the groups were compared at a common marbling score. When carcass fatness was expressed as a ratio of total separable fat to bone (a measure of fat that is independent of muscle development), No. 1 and No. 2 steers were similar (TSF/bone = 1.53 and 1.56 for No. 1 and No. 2 cattle, respectively) and No. 3 steers were markedly leaner (TSF/bone = 1.35). Therefore, these results suggest that if cattle were fed to a common USDA grade (U. S. Choice for example), steers with No. 3 muscle thickness would produce leaner carcasses than their more muscular contemporaries.

Tatum (1991) reported in the National Beef Quality Audit that among cattle that are similar in skeletal size and degree of finish, differences in muscling can result in substantial differences in live animal and carcass weights. Increased muscling is also associated with higher dressing percentages. Moreover, the relationship between muscling and dressing percentage is independent of the effects of fatness. Therefore, it is possible to produce cattle with high dressed yields (i.e., cattle with superior muscling), without making them excessively fat. Holding fat thickness constant, increased muscle thickness is associated with higher muscle-to-bone ratios, higher percentage yields of trimmed, boneless cuts and higher carcass cut-out values. Additionally, differences in carcass muscle-to-bone ratio were directionally consistent with visually discernible differences in feeder cattle muscling (No. 1> No. 2> No. 3). Also, the effects of muscle thickness on muscle-to-bone ratio were most pronounced within the large-frame class (Tatum et al., 1988). Tatum et al. (1988) also observed that muscle thickness influenced carcass composition primarily via its effect on weight of separable muscle, resulting in group differences in muscle-to-bone ratio. In general, means for muscle-to-bone ratio were highest for No. 1 steers, intermediate for No. 2 steers and lowest for cattle in the No. 3 group. However, it is important to note that differences in muscle-to-bone ratio among muscle thickness groups were most pronounced within the large-frame class and became smaller in magnitude and disappeared as frame size decreased. Additionally, weights of separable muscle were similar for steers finished on grain or silage based diets; however, separable bone weights were lowest for grain fed steers. Consequently, steers finished on the grain diet produced carcasses with the highest muscle-to-bone ratios. When cattle of the same frame size are compared at a common weight, animals with superior muscularity have a higher proportion of separable muscle and a lower proportion of separable fat in their carcasses, compared with cattle with inferior muscle development.

Retail Product Yield

As the U. S. moves closer to a value or formula based marketing system, retail product yield will become increasingly important. Many different factors such as breed type, animal age, muscle thickness and time-on-feed may affect retail product yield. When holding frame size, sex class and fat thickness constant, a higher percentage yield of chuck roll, ribeye roll and strip loin was noted for carcasses from thick-muscled cattle than from average and thin-muscled cattle (May et al., 1992). In a study examining the age at which cattle are placed in the feedlot, Lunt et al. (1987) noted that yearlings yielded a higher percentage of closely-trimmed retail product lean cuts than did weanlings. Stifler et al. (1985) observed that differences of considerable magnitude exist in percentage yield of wholesale cuts, boneless, closely-trimmed retail cuts, lean trim, fat trim and bone from slaughter cattle selected to be lean and those selected to produce "Choice" carcasses.

In a study examining diet energy density and time-on-feed, Ferrell et al. (1978) observed that energy density of the diet affected carcass composition in that carcasses from steers receiving the higher energy diets were heavier and contained greater amounts of fat but similar or lower amounts of protein than carcasses from steers which received the lower energy diets. The decrease in percentage cutability largely negated advantages of heavier carcass weights associated with the higher energy diets, and resulted in similar weights of primal lean cuts; e.g. carcasses from steers receiving the low energy diet contained 137 kg of primal lean cuts, whereas those from steers receiving the high energy diet contained 144 kg. These data indicated that although the high energy diet resulted in improved rates of gain, a very high proportion of the extra gain consisted of fat; thus, the high energy diets resulted in no increase in protein available for human consumption. Moody et al. (1970) observed that as time-on-feed increased, fat also increased, and subsequently retail product yield decreased. Several researchers (Cole et al., 1964; Kropf and Graf, 1959; Hedrick et al., 1963; Brungardt and Bray, 1963) have shown that retail yield and value decreases as fat increases.

One factor that definitely impacts retail product yield is fat trim level. This will also become increasingly important as we move towards closer trimmed boxed beef. In a study examining different fat thickness endpoints (1.5, 1.0, and .50 cm), Parrett et al. (1985) observed that actual percentage boneless retail cuts (PBRC) were less than predicted by Murphy et al. (1960). This could be due to the trimming procedure used in the project, in which all boneless roasts were trimmed to .50 cm fat, which is less than many industry procedures. The .50 cm fat thickness endpoint carcasses had 3.5 and 7.2 % more PBRC than the 1.0 and 1.5 cm fat thickness endpoint carcasses, respectively. Differing cattle types vary in cutability and these differences are more important when carcasses are fabricated into boneless, closely-trimmed boxed beef subprimals. If 2.54 cm of fat is to be left on subprimal cuts, there is little advantage in selecting leaner, more muscular cattle; in fact, selecting cattle with up to 2.54 cm of fat maximized fabrication yields (Knapp et al., 1989). As the maximum fat trim level of the major subprimals increases from .64 to 2.54 cm, the yield of fatter carcasses is greater than that of leaner carcasses (Griffin et al., 1992). However, as fat trim went from 2.54 to .64 cm, the yields of major cuts decreased more for the fatter cattle types. The advantage of selecting leaner cattle was only realized when wholesale cuts were trimmed to the 1.27 or .64 cm fat trim levels. At these levels the fatter carcasses lost their yield advantage present at the 2.54 cm fat-trim level.

Slaughter/Carcass Weight

With improved performance, growth rate, and size in the U. S. beef population, slaughter and carcass weights have also increased. This can cause problems for the packer. Excessively large and heavy cuts will not properly fit the box and can result in injuries to workers. Lochner (1991) reported that, as a guideline, presuming a mean dressing percentage of 63.5 %, the desired range of liveweights of slaughter steers and heifers should be 446.3 to 589.2 kilograms. Also, there are presently discounts for fed beef carcasses that weigh less than 283.5 and more than 374.2 kilograms. The most popular weight range, and one from which primals (subprimals) are of sizes and weights considered optimal by purveyors, restaurateurs and supermarket meat-managers is 333.4 to 340.2 kilograms.

Parrett et al. (1985) studied differences between beef steers slaughtered at three different fat thickness endpoints (1.5, 1.0, and .50 cm). There was a difference for final weight, with the fatter cattle being heavier. Also, carcass weights were heavier with increasing fat thickness endpoint.

CHAPTER III

EFFECT OF AGE AT SLAUGHTER ON CARCASS TRAITS AND BOXED BEEF YIELDS OF FEEDLOT STEERS

ABSTRACT

Steers (n=140) from two different ranches (70 Angus; 70 Angus x Hereford) were randomly allocated to one of five chronological age treatments: EW = early weaned directly to the feedlot at 3.5 mo of age, NW = normal weaned and placed in the feedlot at 7.9 mo, WP = backgrounded on wheat pasture for 112 d then placed in the feedlot at 11.6 mo, SG = dry wintered and then grazed on early, intensively managed native range for 68 d prior to feedlot entrance at 15.4 mo, and LG = dry wintered, season long grazed on native range for 122 d, and then placed in the feedlot at 17.4 mo of age. Steers were slaughtered when each 7 head pen reached an estimated mean of 1.3 cm s.c. fat thickness. Age at slaughter was 13.1, 14.5, 16.1, 19.6, and 20.7 mo for EW, NW, WP, SG, and LG, respectively. Yield grade data were collected and the left side of each carcass was fabricated and trimmed of s.c. fat to three levels (2.5, 1.3, and .6 cm) for boxed beef yield determinations. All carcass traits were adjusted to the mean s.c. fat thickness of 1.4 cm within each ranch x age treatment subclass. EW and NW steers had lighter ($P < .05$) carcass weights than backgrounded steers. No ($P > .05$) differences were noted among age treatments for longissimus muscle area, percentage kidney, pelvic, and heart fat, or yield grade. Carcasses from EW and NW steers had higher ($P < .05$) percentages of .6 cm fat trim and lower ($P < .05$) percentages of closely trimmed boxed beef product than carcasses from steers that were backgrounded. Percentage bone decreased ($P < .05$) with advancements in animal age with the exception of the LG steers which had higher ($P < .05$) percentage bone than did SG steers (EW > NW; EW and NW > WP, SG, and LG; WP > SG and LG; SG < LG). However, boxed beef product (.6 cm fat trim) to bone ratios differed ($P < .05$) only for directly placed vs. backgrounded steers. Differences ($P < .05$) between ranches were noted for percentage fat and percentage boxed beef product at .6 cm trim level. These results indicate that despite similarities in carcass grade traits, accelerated weaning and feeding regimens may depress boxed beef yields.

(Key Words: Steers, Age, Meat Yields)

Introduction

Diversification of the U. S. cattle population during the past two decades has resulted in many different cattle types. Although the influx of new cattle breeds has contributed increased growth rate, size, and to an extent muscularity, these breeds as well as intensified use of crossbreeding have also increased variability and inconsistency during the growing and finishing phases of production. This has resulted in many different management and marketing strategies to achieve maximum profitability for different cattle types. For example, with increased growth rate to weaning some producers are placing calves directly into the feedlot in an effort to moderate slaughter and carcass weights to meet a more desirable weight range. Therefore, this study was conducted to determine the effect of age (maturity) at slaughter on carcass traits and boxed beef yields of feedlot steers.

Materials and Methods

Animals. One hundred and forty steers (70 Angus; 70 Angus x Hereford) obtained from two reputable Oklahoma herds were randomly assigned to one of five chronological age treatments: EW = early weaned directly to the feedlot at 3.5 mo of age, NW = normal weaned and placed in the feedlot at 7.9 mo, WP = backgrounded on wheat pasture for 112 d then placed in the feedlot at 11.6 mo, SG = dry wintered and then grazed on early, intensively managed native range for 68 d prior to feedlot entrance at 15.4 mo, and LG = dry wintered, season long grazed on native range for 122 d, and then placed in the feedlot at 17.4 mo of age. Each treatment contained 28 steers (14 head per ranch) that were fed as 7 head per pen in the feedlot.

At weaning all steers were vaccinated with IBR-PI3 (modified live virus; intramuscularly) 7-way clostridial bacterin, and injected with Ivermectin. EW steers received a shot of Nasalgen one week after feedlot arrival. All steers were implanted with Synovex-S (20 mg estradiol benzoate + 120 mg progesterone). EW calves received their first implant at approximately 101 d on feed and were reimplanted every 84 d. NW calves received their first implant at approximately 8 months of age and were reimplanted every 84 d thereafter. WP, SG, and LG steers received their first implants before going to wheat or grass and were reimplanted every 84 d, except the LG steers which received implants before grass but were never reimplanted.

Feedlot diets are presented in Table 1. Each treatment was fed a standardized feedlot diet containing 12.4% protein with the exception of the EW calves which were started on an 18% all natural protein diet (3 to 5 mo of age), switched to a 16% all natural protein diet (5 to 6 mo of age), adjusted to a 13.4% protein diet (6 to 7 mo of age), and finally placed on the standardized 12.4% protein diet at 8 mo of age. Steers were adapted over 14 days through a series of four diets to a 91% concentrate diet. In the workup diets, alfalfa hay and cottonseed hulls (2 to 1 ratio) replaced corn to achieve 50, 60, 70, and 80% concentrate levels, except the EW calves were initiated on 50% concentrate and then elevated to 80% concentrate. Steers were weighed every 28 d to monitor average daily gain and feed efficiency.

Carcass evaluation. All treatments were slaughtered upon reaching a subjectively evaluated pen mean of 1.3 cm of s.c. fat thickness. Days on feed for the five age treatment groups were: 287, 198, 134, 124, and 100 days for EW, NW, WP, SG, and LG, respectively.

Steers were commercially slaughtered and complete quality and yield grade data were collected on each carcass approximately 48 hours postmortem (USDA, 1989). The left side of each carcass (28 per treatment) was shipped to the Oklahoma State University Meat Laboratory for fabrication into boneless subprimals to determine compositional differences at three different fat trim levels (2.5, 1.3, and .6 cm). A modern boxed beef partitioned to determine the following effects: DB = directly weaned to the feedlot (EW and NW) vs. backgrounded (WP, SG, LG); EN = early (EW) vs. normal weaned (NW); WG = wheat (WP) vs. native range backgrounded (SG and LG); SL = short (SG) vs. long (LG) background grazing on native range. Data were analyzed using least squares means and significance was reported at the .05 level.

Results and Discussion

The results of this study must be considered relative to the s.c. fat thickness endpoint (1.4 cm) and breed type (predominately Angus) used. Mean squares for carcass yield grade traits are presented in Table 2 and corresponding least squares means for age at slaughter, days on feed, and carcass yield grade traits across age groups are presented in Table 3. Slaughter weights increased as age at slaughter increased up to the wheat pasture age group. Steers placed directly in the feedlot (EW and NW) had lighter ($P < .05$) slaughter weights (41 kg less) than backgrounded steers (WP, SG, and LG). This is in agreement with Dolezal et al. (1993) who reported that slaughter and hot carcass were the highest for steers fed as long yearlings, intermediate for steers fed as yearlings, and the lightest for steers fed high concentrate diets as calves. Conversely, Burson et al. (1980) reported that extended time on feed resulted in heavier weights at the end of the test period. EW and NW steers were fed for longer periods than backgrounded steers (WP, SG, and LG). Carcass weights followed the same general trend as slaughter weight in that EW and NW steers had lighter (P <

.05) carcass weights than backgrounded steers. Again, this is contradictory with Williams et al. (1989) who observed that slaughter and hot carcass weights increased with increasing time on feed. No (P > .05) differences were noted in slaughter and carcass weights among backgrounding (WP, SG, and LG) treatments.

Longissimus muscle area increased numerically as age at slaughter and weights increased (Table 3). However, differences were too small and inconsistent for statistical significance (P > .05). This agrees with the results of Schroeder et al. (1980) and Williams et al. (1989) who observed that longissimus muscle area increased as days on feed or age at slaughter increased. Among carcasses with similar s.c. fat thickness (1.4 cm), no (P > .05) differences were noted in percentage kidney, pelvic, and heart fat or yield grade regardless of age treatment (Table 3). This is somewhat contradictory to earlier studies that associated increased time on feed with increased internal fat and increased yield grade (Dinius et al., 1978; Burson et al., 1980; Tatum et al., 1980; Dolezal et al., 1982; Williams et al., 1989). However, in this particular study there was a constant adjusted s.c. fat thickness of 1.4 cm, and this would eliminate differences in fatness that may have otherwise been observed.

Mean squares for carcass cutability traits are presented in Table 4 and corresponding least square means are given in Table 5. As expected, as severity of fat trim increased from 2.5 to .6 cm maximum, percentage fat trim increased (Table 5). Among steers slaughtered at a constant s.c. fat thickness, percentage carcass fat trim tended to decrease as age at slaughter increased for all three fat trim levels (2.5, 1.3, and .6 cm). Dinius et al. (1978) observed similar results in that fat deposition increased with the length of the period that the cattle were fed concentrate as evidenced by increases in fat thickness and percentage of kidney, pelvic and heart fat. Additionally, Tatum et al. (1980) reported that increased time-on-feed is associated with increased subcutaneous, internal, and intramuscular fat deposition. Carcasses from steers placed directly in the feedlot (EW and NW) had higher ($P < .05$) percent fat (1.6% higher) at the .6 cm trim level than did carcasses from WP, SG, and LG steers. At the 1.3 and 2.5 cm trim level directly placed steers had higher ($P < .05$) percentages of fat trim than did backgrounded steers, and carcasses from SG steers had higher ($P < .05$) percentages of fat trim than did LG steers. This is in agreement with Lunt et al. (1987) who examined the differences between weanling and yearling fed heifers, and observed that weanlings were fatter than yearlings.

Percentage boxed beef product yields across age treatment groups are presented in Table 5. With increasing fat trim percentage, boxed beef product yields decreased. Similar results were pubished by Parrett et al. (1985) who observed that carcasses with .50 cm fat thickness endpoint had 3.5 and 7.2% more boneless retail cuts than 1.0 and 1.5 cm fat thickness endpoints, respectively. This is in agreement with Knapp et al. (1989) who noted that if 2.54 cm of fat is to be left on a subprimal cut, there is no advantage in selecting leaner, more muscular cattle; in fact, selecting cattle with up to 2.54 cm of fat maximized fabrication yields. Percentage boxed beef product tended to increase with increasing age at slaughter at all three fat trim levels (2.5, 1.3, and .6 cm). Lunt et al. (1987) observed similar results in that yearling fed heifers yielded a higher percentage of closely trimmed (.60 cm) retail cuts than did heifers fed as weanlings. Similar results were noted by Griffin et al. (1992). They observed as the maximum fat trim level of the major subprimals increased from .64 to 2.54 cm, the yield of fatter carcasses was greater than that of leaner carcasses. However, as fat trim decreased from 2.54 to .64 cm, the yields of major cuts decreased more for the fatter cattle types. At the .6 cm trim level, carcasses from EW and NW steers yielded lower ($P < .05$) percentages of boxed beef product (2.25%) than carcasses from backgrounded steers (WP, SG, and LG). At the 1.3 and 2.5 cm trim levels, carcasses from steers sent directly to the feedlot (EW and NW) had decreased ($P < .05$) percentage boxed beef product yields (1.8%) compared to carcasses from backgrounded steers (WP, SG, and LG). Likewise, carcasses from steers backgrounded on wheat pasture had lower ($P < .05$) percentage boxed beef product yields (1.0%) than did carcasses from native range backgrounded steers (SG and LG), and carcasses from SG steers had less ($P < .05$) boxed beef product (1.2%) than carcasses from LG steers.

Bone percentage decreased ($P < .05$) as age at slaughter increased with the exception of the long grazed steers which had higher percentages of bone than did carcasses from short grazed steers (Table 5). This is similar to results by Williams et al. (1989) and Moody et al. (1970) who observed that percentage of bone trim decreased with increased feeding time (i.e. age at slaughter). Dolezal et al. (1993) reported that long yearlings had lower percentages of bone as compared to steers fed high concentrate diets as calves or yearlings. Significant differences ($P < .05$) were noted for all four of the orthogonal contrasts tested (EW > NW; EW and NW > WP, SG, and LG; WP > SG and LG; SG < LG. Carcasses from steers sent directly to the feedlot (EW and NW) had .7% more bone than did backgrounded steers (WP, SG, and LG). Among steers placed directly in the feedlot, early weaned steers had more bone (.5%) than did normal weaned steers. Wheat pasture backgrounded steers had more bone (.5%) than grass backgrounded steers and between the grass backgrounded steers, carcasses from the long grazed steers had .6% more bone than did short grazed steers.

Boxed beef product lean:bone ratios (Table 5), computed at the .6 cm fat trim level, differed between carcasses from steers placed directly in the feedlot vs. backgrounded steers. Carcasses from EW and NW steers had lower boxed beef product lean:bone ratios than did carcasses from WP, SG, and LG steers. Apparently, carcasses from backgrounded steers had more muscle mass surrounded by a constant carcass s.c. fat thickness (1.4 cm) than carcasses from steers sent directly to the feedlot. This would agree with Tatum (1992) who observed that when holding fat thickness constant, increased muscle thickness is associated with higher muscle:bone ratios.

Least squares means for carcass traits for the two ranches are presented in Table 6. Differences ($P < .05$) between the two ranches were noted only for percentage fat trim and percentage boxed beef product at the .6 cm fat trim level.

Implications

During the feedlot phase of production, early and normal weaned calf-fed steers reached a carcass s.c. fat thickness endpoint (1.4 cm) at lighter weights than steers backgrounded on wheat pasture, early intensive grazing, or season long grazing prior to finishing. These results indicate that early and normal weaned steers placed directly in the feedlot can be managed without suffering discounts for carcass traits (weight and grade). However, among steers slaughtered at a constant s.c. fat thickness, accelerated weaning and feeding regimens may depress boxed beef yields as a result of decreased boxed beef lean:bone ratios in carcasses from steers placed directly in the feedlot.

Table 1. Feedlot diet composition

	Diet % of DM			
Item	18% Starter diet	16% Starter diet	13.4% Starter diet	12.4% Final diet
Corn, dry rolled	52.97	59.25	73.79	79.61
Alfalfa hay, ground	7.80	6.58	4.65	5.02
Cottonseed hulls	10.0	10.0	7.0	3.90
Molasses, cane	3.75	3.75	3.75	4.38
Soybean meal 44	23.02	18.22	8.32	--
Cottonseed meal	--	--	--	3.55
Meat and bone meal	--	--	--	1.42
Distillers grains, corn	--	--	--	.87
Salt	.30	.30	.30	.35
Calcium carbonate	1.25	1.50	1.34	.35
Dicalcium phos.	.83	.33	.29	--
Urea, 46% N	--	--	.50	.30
Ammonium sulfate	--	--	--	.21
Vitamin A-30	.02[a]	.02[a]	.02[a]	--
Rumensin, 60 g/lb	.02[a]	.02[a]	.02[a]	.018
Tylan 40	.01[a]	.01[a]	.01[a]	--
Vitamin A and D_3	--	--	--	.00375[b]
Vitamin E 226800	.02[c]	.002[d]	--	--
Trace mineral premix	.01	.01	.01	.014
Calculated analysis				
NEm	87.14	88.67	92.35	94.63
NEg	55.00	56.00	59.00	60.39
Crude protein	18.00	16.00	13.40	12.40

[a]Additive package formulated to provide 30,000 IU vitamin A per day, 24.6 grams per ton of Rumensin, and 10
grams per ton of Tylan.
[b]Contained 88,000 IU vitamin A and 88 IU vitamin D_3 per gram.
[c]Formulated to provide 600 IU vitamin E per day.
[d]Formulated to provide 50 IU vitamin E per day.

Table 2. Mean squares for carcass traits

Source	df	Slaughter wt, kg	Carcass wt, kg	Longissimus area, cm	Kidney, pelvic, and heart fat, %	Yield grade
Ranch	1	3,593.74	17.31	1.14	.0007	.132
Treat	4	88,823.57**	27,154.02**	4.10**	1.10**	.185
Ranch x treat	4	21,473.02*	12,144.16**	3.12**	.71**	.231*
Residual error	130	6,854.54	2,776.68	.87	.17	.081

*Denotes $P < .05$.
**Denotes $P < .01$.

Table 3. Least squares means for carcass traits stratified by age treatment

	Age treatment						
Trait	Early weaned	Normal weaned	Wheat pasture	Short grazed	Long grazed	Effect[a]	SE
Age at slaughter, mo	13.1	14.5	16.1	19.6	20.7	--	--
Days on feed	287	198	134	124	100	--	--
Slaughter wt, kg	505.6	538.6	563.5	569.0	555.6	DB	7.10
Carcass wt, kg	332.6	342.1	364.0	364.2	357.3	DB	4.52
Longissimus area, cm^2	76.7	79.7	81.1	82.5	82.7	--	1.14
KPH fat, %	2.5	2.4	2.3	2.4	2.0	--	.08
Yield grade	3.4	3.3	3.4	3.3	3.2	--	.05

[a]DB = Significant difference ($P < .05$) between steers placed directly in the feedlot (EW, NW) vs steers that were backgrounded (WP, SG, LG).

Table 4. Mean squares for carcass cutability traits

Source	df	Fat trim 2.5 cm, %	Fat trim 1.3 cm, %	Fat trim .6 cm, %	Boxed beef product 2.5 cm, %	Boxed beef product 1.3 cm, %	Boxed beef product .6 cm, %	Bone, %	Muscle to bone ratio
Ranch	1	8.45	9.36	27.32*	2.92	3.47	16.23*	1.43	.022
Treat	4	19.55**	23.96**	30.90**	32.74**	38.20**	49.16**	6.75**	1.81**
Ranch x treat	4	2.12	2.53	4.99	1.27	1.57	5.62	.38	.114
Residual error	130	2.65	3.04	4.22	2.06	2.30	3.20	.501	.068

*Denotes $P < .05$.
**Denotes $P < .01$.

Table 5. Least squares means for percentage fat trim and boxed beef product yields stratified by age treatment

	Age treatment						
Trait	Early weaned	Normal weaned	Wheat pasture	Short grazed	Long grazed	Effect[a]	SE
Fat trim 2.5 cm, %	19.0	19.0	18.1	18.7	17.0	DB,SL	.31
Fat trim 1.3 cm, %	20.7	20.8	19.9	20.4	18.6	DB,SL	.33
Fat trim .6 cm, %	24.0	23.2	21.6	22.9	21.5	DB	.39
Boxed beef product 2.54 cm, %	67.2	67.6	68.5	68.8	69.9	DB, SL, WG	.27
Boxed beef product 1.3 cm, %	65.4	65.8	66.8	67.1	68.4	DB, SL, WG	.29
Boxed beef product .6 cm, %	62.2	63.4	65.1	64.6	65.4	DB	.34
Bone, %	13.9	13.4	13.3	12.5	13.1	EN, DB, SL, WG	.13
Muscle:bone ratio	4.5	4.7	4.9	5.2	5.0	DB	.05

[a]EN = Significant difference ($P < .05$) for steers that were early weaned vs steers normal weaned;
DB = Significant difference ($P < .05$) for steers sent directly to the feedlot (EW, NW) vs steers backgrounded (WP, SG, LG);
SL = Significant difference ($P < .05$) for short term grazed vs long term grazed steers;
WG = Significant difference ($P < .05$) for steers grazed on wheat pasture vs steers grazed on native range (SG, LG).

Table 6. Least squares means for carcass and cutability traits stratified by ranch

Trait	Ranch[a]		Effect[b]	SE
	Ranch 1	Ranch 2		
Slaughter weight, kg	548.8	544.2	--	9.90
Carcass weight, kg	352.2	351.9	--	6.30
Longissimus area, cm^2	80.0	81.1	--	.11
KPH fat, %	2.3	2.3	--	.05
Yield grade	3.3	3.3	--	.03
Fat trim 2.5 cm, %	18.1	18.6	--	.19
Fat trim 1.3 cm, %	19.8	20.3	--	.21
Fat trim .6 cm, %	22.2	23.1	*	.25
Boxed beef product 2.5 cm, %	68.5	68.2	--	.17
Boxed beef product 1.3 cm, %	66.9	66.5	--	.18
Boxed beef product .6 cm, %	64.5	63.8	*	.21
Bone, %	13.3	13.1	--	.08
Muscle:bone ratio	4.9	4.9	--	.03

[a]Ranch 1 = predominately Angus; Ranch 2 = predominately Angus x Hereford.
[b]* = $P < .05$.

CHAPTER IV

IMPACT OF CARCASS FATNESS, MUSCLING, AND QUALITY ON BOXED BEEF CUTOUT

ABSTRACT

Steer carcasses (n=120) of unknown prior management history ranging from 318 to 362 kg were selected from a commercial slaughtering facility to represent four preliminary yield grades: 2.7, 3.0, 3.3, and 3.6 corresponding to adjusted subcutaneous fat thicknesses of .7, 1.0, 1.3, and 1.6 cm, respectively; and three levels of muscling: thin, average, and thick based on longissimus muscle areas of 69.7, 82.6, and 95.5 sq cm. Each side was fabricated into boxed beef primals. All primals were weighed and further fabricated into boneless subprimals (IMPS). Individual subprimals were then weighed and further fabricated to obtain retail cuts (steaks and roasts) for sequential fat and bone trimming. Carcasses with less adjusted fat thickness and more muscularity yielded less carcass fat and more carcass lean. Among carcasses of similar fatness, muscularity greatly influences boxed beef yields. Carcass quality grade (Choice vs. Select) did not influence the amount of

carcass fat or lean yields. However, Choice carcasses had lower carcass bone, higher muscle:bone ratios and higher fat:bone ratios than did Select carcasses.

Key Words: Steers, Quality Grade, Muscle, Fat, Carcass

Introduction

The present system for estimating the yield of closely-trimmed (1.3 cm or less), boneless retail cuts from the major wholesale cuts was published by USDA in 1965. Surprisingly, the prediction equation used in this system is based on research conducted on only 150 carcasses (Murphey et al., 1960). Yield grades (YG) are intended to provide a means of segmenting carcasses for assigning value based on cutability. Unfortunately, current practices in the U. S. industry use YG 3 or better as a cutability base and assign pricing discounts only to YG 4 or higher carcasses; premiums for YG 1 and 2 carcasses are virtually nonexistent at this time because most packers abide by Institutional Meat Purchasing Specification guidelines allowing up to 2.5 cm s.c. fat thickness on boxed beef subprimals (USDA, 1988).

Adjusted fat thickness over the ribeye, percentage kidney, pelvic and heart fat, and ribeye area are the most important factors for predicting carcass yields of boneless, closely trimmed retail cuts (Abraham et al., 1980). Subcutaneous fat thickness has been shown to be highly and positively correlated with carcass fatness and inversely related to the yield of retail cuts

(Murphey et al., 1960). Aside from adjusted fat thickness, additional research has documented marbling score as an important predictor of carcass fatness (Kauffman et al, 1975; Parrett et al., 1985).

With the advent of closer fat trim practices, carcass muscularity will become more important. Tatum et al. (1986) reported that muscle thickness was associated with percentage carcass muscling when fat thickness was statistically standardized. Among carcasses of similar s.c. fat thickness (trimmed to .6 cm), carcasses with large ribeye areas have more desirable yield grades, more boneless product, less bone trim and more fat trim than carcasses with small ribeyes (Williams et al., 1989).

Therefore, the purpose of this study was to examine the impact of carcass fatness, muscularity and quality grade on boxed beef yields at multiple fat thickness levels.

Materials and Methods

Carcass selection. Steer carcasses (n=120) of unknown prior management history ranging from 318 to 362 kg were selected at a commercial facility for a 2 x 4 x 3 factorial arrangement as: two marbling levels (small vs. slight), four preliminary yield grades (2.7, 3.0, 3.3, and 3.6) corresponding to adjusted s.c. fat thicknesses of .7, 1.0, 1.3, and 1.6 cm (USDA, 1989), and three levels of muscling (thin, average, and thick) based on longissimus muscle areas of 69.7, 82.6, and 95.5 sq cm (USDA, 1989), respectively (outlined in Table. 1).

Table 1. General design

Preliminary yield grade[b]	Longissimus area, sq. cm[a] 69.7 (-12.9)	82.6 Base	95.5 (+12.9)
2.7	10[c]	10	10
3.0	10	10	10
3.3	10	10	10
3.6	10	10	10

[a]Longissimus areas are based on a carcass weight schedule where a 340 kg carcass needs an 82.6 sq. cm ribeye (USDA, 1989).
[b]Preliminary yield grades correspond to adjusted s.c. fat thickness: 2.7=.7 cm; 3.0=1.0 cm; 3.3=1.3 cm; 3.6=1.6 cm (USDA, 1989).
[c]Ten carcasses were selected as 5 U.S. Choice and 5 U.S. Select (USDA, 1989) for each cell.

Fabrication. One side from each carcass was fabricated into boxed beef primals (round, loin, rib, chuck, rough flank, rough navel, brisket, and foreshank). All primals were then weighed and further fabricated into semi-boneless subprimals according to Institutional Meat Purchase Specifications (USDA, 1988) for three s.c. and intermuscular fat thickness endpoints (2.5, 1.3, and .6 cm). All subprimals were boneless except for two small sections of beef short-ribs. Lean trim was accumulated as either 80:20 or 50:50 (lean:fat). Lean reported in tabular form represents lean trim plus appropriately trimmed subprimals.

Statistical analysis. Data were analyzed by a 2 x 4 x 3 factorial arrangement of treatments with aggregate side weight as a covariate using

SAS least squares means procedures. Significance was reported at the .05 level.

Results and Discussion

Population means, standard deviations and respective coefficients of variation for carcass traits are shown in Table 2. Marbling scores for the two quality grades selected approximated the mid-point of "small" and "slight" with $\pm$ 30% deviation. Kidney, pelvic, and heart fat percentage and yield grade were not part of the selection criteria and were the most variable. Selection was limited to "A" maturity carcasses for skeletal and lean maturities.

Mean squares and least squares means for the carcass grade traits evaluated are reported in Tables 3 and 4, respectively. Due to the selection criteria, marbling differed ($P < .05$) effected by quality grade. As well, actual and adjusted fat thickness varied ($P < .05$) for the four adjusted fat thicknesses (.7, 1.0, 1.3, and 1.6). Longissimus area was significantly influenced ($P < .05$) by muscle thickness classification. Muscle thickness classification as well as fat thickness combined to have an effect on yield grade.

Mean squares for carcass cutability traits are presented in Table 5. No ($P > .05$) interactions were noted between quality grade, adjusted fat thickness, and muscle thickness for any of the cutability traits. Least squares means for carcass cutability traits are presented in Table 6.

Quality grade. Carcass quality grade (Choice vs. Select) did not influence (P > .05) the amount of carcass fat at either the 2.54 or .64 cm fat trim levels. U. S. Choice steer carcasses yielded more fat (1.0 and 1.7 kg) as compared to U. S. Select carcasses at the 2.54 and .64 cm trim levels, respectively. However, these differences were not large enough to be of statistical importance (P > .05). Griffin et al. (1992) observed that percentage of fat trimmed from a carcass ranged from 7.9 to 10.9% from Choice carcasses trimmed to 2.54 cm or less fat, whereas ranges from 8.9 to 12.9% and 9.0 to 15.6% were found from Choice carcasses with maximum trim levels of 1.27 and .64 cm, respectively. Ranges of fat trimmed from Select carcasses were similar, but generally .50% less fat was trimmed from Select than from Choice carcasses at each trim level. Carcass lean paralleled the results observed for carcass fat. U. S. Choice steer carcasses yielded more carcass lean at both trim levels (1.7 kg at 2.54 cm and 1.1 kg at .64 cm) as compared to U. S. Select steer carcasses. Again, these differences were not large enough in magnitude to be of statistical importance (P > .05). These findings are somewhat contradictory to those of Stifler et al. (1985) who observed that differences of considerable magnitude exist in percentage yield of wholesale cuts, boneless, closely trimmed retail cuts, lean trim, fat trim and bone from slaughter cattle selected to be lean and those selected to produce "Choice" carcasses. Differences (P < .05) were observed for carcass bone. U. S. Select carcasses yielded 1.7 kg more bone than did U. S. Choice carcasses. Consequently, U. S. Choice carcasses possessed higher (P < .05) muscle:bone ratios (5.0) than did U. S. Select carcasses with (4.8). Additionally, U. S. Choice carcasses had higher (P < .05) fat:bone ratios (1.3) as compared to U. S. Select (1.2).

Fat thickness. Adjusted fat thickness appeared to have the greatest impact on carcass cutability traits. These results are similar to those reported by Parrett et al. (1985) who observed that as fat thickness end point increased, hot carcass weight, total separable fat, marbling, quality grade and yield grade increased, but percentage boneless retail cuts decreased. As adjusted fat thickness increased from .7 to 1.6 cm, carcass fat increased at both the 2.54 and .64 cm trim levels, and yield of carcass fat was highest at the .64 cm trim level. Differences ($P < .05$) were noted for all adjusted fat thicknesses at both trim levels. Carcasses with 1.6 cm adjusted fat thickness yielded 3.5, 7.0, and 10.2 kg more carcass fat at the 2.54 cm trim level than did carcasses with 1.3, 1.0, and .7 cm adjusted fat thickness, respectively. Additionally, carcasses with 1.6 cm adjusted fat thickness yielded 4.5, 9.6, and 14.5 kg more carcass fat at the .64 cm trim level than did carcasses with 1.3, 1.0, and .7 cm adjusted fat thickness, respectively. Several workers (Cole et al., 1964; Kropf and Graf, 1959; Hedrick et al., 1963; Brungardt and Bray, 1963) have shown that retail yield and value decreases as fat increases. As adjusted fat thickness increased from .7 to 1.6 cm, carcass lean yield decreased. At the 2.54 cm trim level, carcasses with the adjusted fat thickness of .7 cm had the highest lean yield and yielded 4.1 kg more lean product than did the 1.6 cm carcasses which had the lowest lean yield. Carcasses with 1.0 and 1.3 cm adjusted fat thickness were intermediate for carcass lean. Carcass lean yield values were lower at the .64 cm trim level than at the 2.54 cm level. Again, as adjusted fat thickness increased from .7 to 1.6 cm , carcass lean yield decreased. Carcasses with .7 cm adjusted fat thickness yielded the most carcass lean, and yielded 2.6, 5.5, and 8.4 kg more carcass lean than the 1.0, 1.3, and 1.6 cm adjusted fat thickness carcasses, respectively.

Carcass bone decreased with increasing adjusted fat thickness. Carcasses with .7 cm adjusted fat thickness yielded the most ($P < .05$) bone. However, as adjusted fat thickness increased, muscle:bone ratio increased. Carcasses with .7 cm adjusted fat thickness had the lowest ($P < .05$) muscle:bone ratios and carcasses at the 1.6 cm level had the highest ($P < .05$) muscle:bone ratios. As expected, with increasing adjusted fat thickness, fat:bone ratio also increased and differences ($P < .05$) were noted for each adjusted fat thickness level.

Muscle thickness. Muscle thickness classification also had a great impact on carcass cutability traits. These results are in general agreement with those of Tatum et al. (1988) who noticed that when cattle of the same size are compared at a common weight, animals with superior muscularity have a higher proportion of separable muscle and a lower proportion of separable fat in their carcasses, compared to cattle with inferior muscle development. As degree of muscling increased from thin to thick, yield of carcass fat decreased at both trim levels (2.5 and .6 cm). Carcasses from thin muscled steers yielded 3.2 and 5.7 kg more ($P < .05$) carcass fat at the 2.5 cm trim level than did carcasses from average or thick muscled steers, respectively. Similar results were observed at the .6 cm trim level where thin muscled steers yielded 4.2 and 6.5 kg more ($P < .05$) carcass fat than did average and thick muscled steers, respectively. This is somewhat contrasting to results published by Tatum et al. (1982) who observed that carcasses from feeder steers assigned muscle thickness scores of No. 1 were heavier and fatter. Additionally, Tatum et al. (1986) observed that carcasses from steers with muscle thickness scores of No. 3 had lower levels of s.c. fat and increased levels of internal fat. Moreover, carcasses from steers in the No. 3 muscle thickness class had lower percentages of total separable fat than did carcasses from No. 1 and No. 2 steers when the groups were compared at a common marbling score. Although average muscled carcasses yielded more carcass fat (49.5 and 58.6 kg for 2.54 and .64 cm trim), the actual magnitude was not large enough for statistical difference between thick muscled carcasses with 47.0 kg carcass fat at 2.54 cm and 56.3 kg at .64 cm trim (Tatum et al., 1986). As expected, carcass lean yield increased as muscle thickness class increased from thin to thick. Several workers (Williams et al., 1989; Tatum et al., 1982; May et al., 1992; Knapp et al., 1989) have shown that retail product yield increases as muscularity is increased. Differences ($P < .05$) in carcass lean yield were noted between all three muscle thickness classes. Carcasses from thick muscled steers yielded the most carcass lean at both the 2.5 and .6 cm trim levels. Thick muscled steer carcasses yielded 5.1 and 4.9 kg more carcass lean than did average muscled steer carcasses at the 2.5 and .6 cm trim levels, respectively. Additionally, carcasses from thick muscled steers yielded 11.2 and 12.1 kg more carcass lean at the 2.5 and .6 cm trim levels than did thin muscled steer carcasses. Carcass lean yield was lower for all three muscle thickness classes at the .6 cm trim level.

Carcass bone yield decreased ($P < .05$) as muscularity increased from thin to thick. Carcasses from thin muscled steers yielded 3 and 6 kg more bone than did carcasses from average and thick muscled steers, respectively. Similar results were observed by Williams et al. (1989) where carcasses from steers with No. 1 muscle thickness had lower percentages of bone as compared to carcasses from No. 2 steers. Tatum et al. (1988) observed that muscle thickness influenced carcass composition primarily via its effect on weight of separable muscle, resulting in group differences in muscle:bone ratio. In general, means for muscle:bone ratio were highest for No. 1 steers, intermediate for No. 2 steers and lowest for cattle in the No. 3 muscle thickness group (Tatum et al., 1988). Additionally, Tatum et al. (1986) reported that muscle thickness did not influence absolute growth rate, but was associated with differences in carcass muscle:bone ratio at a common bone weight and in muscle percentage when carcass fatness was statistically standardized. Consequently, carcasses from thick muscled steers had the highest ($P < .05$) muscle:bone ratios at 5.3. Average muscled steer carcasses were intermediate with muscle:bone ratios of 4.9, and thin muscled steer carcasses possessed the lowest ($P < .05$) muscle:bone ratios at 4.5. This is in agreement with Tatum et al. (1982) who observed that steers assigned muscle thickness scores of No. 1, as feeders, had the highest muscle:bone ratios of the round (4.1:1.0) while carcasses from steers assigned thickness scores of No. 3, as feeders, had the lowest muscle:bone ratios of the round (3.4:1.0). Interestingly, no differences ($P > .05$) were noted between the three muscle thickness classes with respect to fat to bone ratio. Fat to bone ratios for the thin, average and thick muscled steer carcasses were 1.3, 1.2 and 1.3, respectively.

Implications

Adjusted fat thickness seemed to have the greatest impact on carcass cutability traits, especially on carcass fat yields. Carcasses with less adjusted fat thickness yielded less carcass fat and more carcass lean. More muscular carcasses yielded less carcass fat, more carcass lean and had higher muscle:bone ratios. Among carcasses of similar fatness, muscularity greatly influences boxed beef yields. Carcass quality grade (Choice and Select) did not influence carcass fat or carcass lean yields. However, U. S. Choice carcasses had lower carcass bone, higher muscle to bone ratios and higher fat to bone ratios than did U. S. Select carcasses.

Table 2. Means, standard deviations and coefficient of variance

Variable	Mean	SD	CV
Carcass weight, kg	338.6	13.60	4.1
Overall maturity[a]	144.8	11.00	7.6
Marbling[b]	408.5	70.00	17.1
Fat thickness, cm	1.14	.40	3.5
Adj. fat thickness, cm	1.18	.36	3.1
Longissimus area, cm^2	82.46	12.10	14.7
KPH, %	1.94	.49	25.3
Yield grade	2.8	.70	25.0
Carcass fat 2.54 cm, kg	49.73	6.26	12.6
Carcass fat .64 cm, kg	59.24	6.47	10.9
Carcass lean 2.54 cm, kg	241.28	6.91	2.9
Carcass lean .64 cm, kg	231.85	7.29	3.1
Carcass bone, kg	47.61	3.20	6.7
Muscle to bone ratio	4.91	.36	7.3
Fat to bone ratio	1.26	.19	14.8

[a]100 to 199 = "A" maturity.
[b]400 to 499 = small degree of marbling.

Table 3. Means squares for carcass grade traits

Source	df	Carcass weight, kg	Overall maturity	Marbling	Fat thickness, cm	Adj. fat thickness, cm	Longissimus area, cm^2	KPH, %	Yield grade
Quality grade, Q	1	26.7	0.8	390,907.1**	.02	.01	14.8	.002	.002
Fat thickness, F	3	8.5	231.5	125.7	5.4**	4.78**	12.0	.136	4.9**
Muscle group, M	2	2.6	78.7	563.2	.01	.001	6,690.3**	.694	18.3**
Q x F	3	11.3	162.0	441.7	.03	.007	.95	.114	.01
Q x M	2	8.6	329.9	2,172.7	.01	.004	6.1	.047	.03
F x M	6	6.1	65.3	1,140.7	.05*	.02*	10.1	.554*	.04
Q x F x M	6	6.5	144.2	792.5	.005	.004	4.4	.178	.04
b(side weight)	1	15,868.1**	121.8	196.0	.001	.0003	377.2**	.198*	.09
Residual error	95	19.2	128.2	1,292.7	.02	.01	9.54	.23	.04

*Denotes $P < .05$.
**Denotes $P < .01$.

Table 4. Least squares means for carcass grade traits

Effect	Carcass wt, kg	Overall Maturity[a]	Marbling[b]	Fat thickness, cm	Adj. fat thickness, cm	Longissimus area, cm^2	KPH, %	Yield grade
Quality grade								
Choice	339.1	144.7	465.8[c]	1.16	1.20	82.8	1.93	2.80
Select	338.1	144.9	351.2[d]	1.13	1.17	82.1	1.94	2.80
Adj. fat thickness, cm								
.7	339.3	142.4	407.2	.64[f]	.72[f]	83.4	2.04	2.32[f]
1.0	338.0	148.2	406.6	.96[e]	1.02[e]	82.2	1.92	2.64[e]
1.3	338.4	146.0	411.2	1.32[d]	1.34[d]	82.2	1.92	2.96[d]
1.6	338.7	142.8	409.0	1.65[c]	1.67[c]	82.0	1.88	3.28[c]
Muscle group								
Thin	333.8	144.9	404.1	1.15	1.20	68.8[e]	2.1[c]	3.52[c]
Average	338.7	143.4	409.5	1.12	1.17	82.7[d]	1.9[cd]	2.77[d]
Thick	338.3	146.2	411.8	1.16	1.18	95.8[c]	1.8[d]	2.11[e]
RSD	4.38	11.32	35.95	.135	.073	3.09	.483	.188

[a]100 to 199 = "A" maturity.
[b]400 to 499 = small degree of marbling; 300 to 399 = slight degree of marbling.
[c,d,e,f]Means in the same column and within the same item bearing a different superscript letter differ ($P < .05$).

Table 5. Mean squares for carcass cutability traits

Source	df	2.54 cm trim Fat, kg	2.54 cm trim Lean, kg	.64 cm trim Fat, kg	.64 cm trim Lean, kg	Bone	Muscle to bone	Fat to bone
Quality grade, Q	1	29.0	87.8	80.4	37.9	92.1**	1.2**	.2*
Fat thickness, F	3	553.1**	90.3	1119.8**	374.2**	241.1**	1.4**	1.2**
Muscle group, M	2	303.8**	1162.9**	400.2**	1341.3**	333.5**	6.8**	.02
Q x F	3	46.9	93.9	77.5	137.5	.6	.1	.02
Q x M	2	10.8	40.1	5.0	20.2	7.0	.1	.001
F x M	6	29.0	48.2	48.8	70.3	18.6	.2	.1
Q x F x M	6	54.7	44.1	77.3	54.4	3.8	.1	.05
b(side weight)		121.9	8,795.6**	127.5	9,013.2**	434.5**	.004	.07
Residual error	96	39.2	47.8	41.9	53.2	10.3	.1	.03

*$P < .05$.
**$P < .01$.

Table 6. Least squares means for carcass cutability traits

Effect	2.54 cm trim		.64 cm trim		Bone	Muscle to bone	Fat to bone
	Fat, kg	Lean, kg	Fat, kg	Lean, kg			
Quality Grade							
Choice	50.2	242.1	60.1	232.4	46.7^{a}	5.0^{b}	1.3^{b}
Select	49.2	240.4	58.4	231.3	48.5^{b}	4.8^{a}	1.2^{a}
Adj. fat thickness, (cm)							
.70	44.7^{d}	243.1	51.9^{d}	236.0^{a}	51.5^{a}	4.6^{c}	1.0^{d}
1.0	47.9^{c}	242.1	56.8^{c}	233.4^{ab}	48.0^{b}	4.9^{b}	1.2^{c}
1.3	51.4^{b}	240.9	61.9^{b}	230.5^{bc}	46.1^{c}	5.0^{ab}	1.4^{b}
1.6	54.9^{a}	239.0	66.4^{a}	227.6^{c}	44.9^{c}	5.1^{a}	1.5^{a}
Muscle group							
Thin	52.7^{a}	235.5^{c}	62.8^{a}	225.4^{c}	50.6^{a}	4.5^{c}	1.3
Average	49.5^{b}	241.6^{b}	58.6^{b}	232.6^{b}	47.6^{b}	4.9^{b}	1.2
Thick	47.0^{b}	246.7^{a}	56.3^{b}	237.5^{a}	44.6^{c}	5.3^{a}	1.3
RSD	6.26	6.91	6.47	7.29	3.20	.36	.19

^{a,b,c,d}Means in the same column and within the same effect bearing a different superscript letter differ ($P < .05$).

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APPENDIX

Table A1. Adjusted subcutaneous fat thickness arithmetic means and standard deviations for ranch by age treatment subclasses

	Ranch[a]			
	1		2	
Age treatment	Mean, cm	SD	Mean, cm	SD
Early weaned	1.28	.143	1.80	.111
Normal weaned	1.44	.161	1.40	.131
Wheat pasture	1.40	.080	1.55	.111
Short grazed	1.46	.155	1.45	.111
Long grazed	1.27	.083	1.31	.144

[a]Ranch 1 = predominately Angus; Ranch 2 = predominately Angus x Hereford.

VITA 2

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