PRESLAUGHTER FASTING OF BOVINE AND ITS EFFECT ON CARCASS CHARACTERISTICS

by

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INTRODUCTION

Live and carcass weight loss of meat animals caused by preslaughter handling and slaughter conditions is of economic importance to the livestock and meat industry. Traditionally, cattle have been fed while being held prior to slaughter with the assumption that the feed will prevent a loss of tissue. Some question has arisen concerning the value of preslaughter feeding as related to tissue yield.

Several economic advantages are offered through preslaughter withdrawal of feed. The obvious advantage is the potential savings in feed cost. This becomes increasingly important if cattle are taken to a terminal market as the mark-up on feed at these yards is considerable. If feed were not required the last few days preslaughter, a saving in labor costs would result. This could be of considerable economic importance considering the present labor expense. Finally, it is a recognized fact that shrunk cattle kill easier with less intestinal waste resulting in increased efficiency of slaughter crews.

This project was undertaken to study the effects of fasting on various carcass characteristics. The primary objectives of this experiment were to determine the differences, if any, in tissue yield, carcass grade, incidence of dark cutters, live weight shrink, muscle pH, and muscle water holding capacity.

LITERATURE REVIEW

Rate of Passage of Foodstuffs Through the Alimentary Canal

Rate of passage of foodstuffs in animals has been researched extensively. Foodstuff passage through the alimentary canal varies considerably between species, especially between monogastrics and ruminants. Time of passage of a normal daily intake of feed in a meat animal is of particular importance to this study. Several workers have shown that the rate of passage of feedstuffs in cattle is approximately four days. Thus, it is logical to question the value slaughter animals derive from feed fed the last few days prior to slaughter.

Rate of Passage in Monogastrics.

Early research dealing with rate of passage in monogastric animals was done by Hoelzel (1930). Rate of passage of various inert materials through the digestive tracts of rabbits, guinea pigs, dogs, cats, albino rats, white mice, one monkey, and one man was observed. The test materials included rubber, cotton knots, seeds, glass beads, aluminum, steel, silver, and gold. Hoelzel found that rate of passage was directly proportional to the specific gravity of the test materials. Considerable variation was noted between species and between individuals within a species. For instance, cotton knots passed through rats and man in 24 hours but 43 hours were required in dogs. Gold balls required 69 hours in rats and 77 hours in man and dogs. King and Moore (1957) concluded that density and size of particles affected passage rate of ingesta in humans and bovine; most rapid passage of particles was observed when their specific gravity was 1.2.

Evidently factors which effect separation in the monogastric tract of the human were similar to those which operate more dramatically in the ruminant due to larger organs, greater volumes of ingesta, and more divergent physical pathways of feed.

Ishikawa (1966) determined the rates of flow and excretion in the swine digestive tract using polyethyleneglycol and chromic oxide as indicators. After 36 hours, 75 percent of both indicators were collected. After 72 hours, 80 percent of polyethyleneglycol had been collected compared to 90 percent for chromic oxide.

Cunningham (1967), using chromic oxide as an indicator, experimented with control and gastrectomized pigs. He concluded gastrectomy had no effect on basal diet rate of passage, since 24 hours were required for the appearance of tracer doses of chromic oxide in the feces of both groups.

Rate of Passage in Ruminants.

Castle (1956) determined the rate of passage of feedstuffs through the alimentary tract of the goat. Eight adult goats ranging in weight from 26.6 to 57.3 kg. were used. The technique consisted of feeding a small meal of stained meadow hay and counting the colored particles found in the feces. Stained particles first appeared in the feces after 11 to 15 hours, reached a maximum at about 30 hours, and disappeared after 6 to 7 days.

Johnson, Dinusson and Bolin (1964) fed pelleted alfalfa hay containing chromic oxide in both a powder and paper form to sheep. After 24 hours, 52 percent of the paper and 60 percent of the powder had been excreted. After 48 hours, approximately 95 percent of both had been excreted; no chromic oxide appeared after the experiment was 72 hours old.

Stielau (1967) reported differing results. He fed sheep three different rations of lucerne hay (fine, medium, and coarse) at two intake levels. Mean time for the first fecal appearance of stained particles was 16.3 hours; while the mean excretion times for 5 and 95 percent were 28.3 and 129.6 hours, respectively.

Eng et al. (1964) used twenty mature wethers to study corn and hay rate of passage when fed at different ratios. Five rations were studied using dyed corn and basic fuchsin dyed hay. The rations included an all corn, an all Coastal Bermuda hay, and three rations with corn: hay ratios of 3:1, 1:1 and 1:3. At the 120 hour interval, an average of 78 percent of the hay and 92 percent of the corn had been excreted. The experimenter concluded that the movement of both corn and hay was hastened by an increase in the hay portion of the ration.

Blaxter, McC.Graham and Wainmain (1956) also used stained food particles to determine the rate of passage in sheep. He found that increasing the feeding level of cubed and dried long grass resulted in an increase in passage rate. Ninety percent excretion occurred in 130 hours for those sheep fed 600 g. of medium ground and cubed dried grass. Only 74 hours were required for ninety percent excretion when the lambs were fed 1500 g. of the same ration.

Some of the earliest work dealing with rate of passage in cattle was done by Ewing and Smith (1917) using stained particles. Ewing concluded that the two most important factors determining rate of passage were the nature of and the amount of the ration fed. He also determined the rate of passage of feed residues in a normal steer varied between 72 and 85 hours. Moore and Winter (1934) fed silage containing iron oxide to three purebred

Holstein cows. The results showed that the first iron excreted appeared around 12 hours after feeding; the high point of excretion was 33 hours and the end point of excretion varied from 143 to 156 hours. Balch (1950), using stained particles, fed a group of cows ground and unground hay. Ground hay was generally excreted more rapidly than unground, but the difference was very slight. Excretion curves for the hay rations were characterized by an initial appearance of markers in the feces from 12 to 24 hours after feeding. A slow rate of excretion of the first 10% of the residues usually occurred followed by a higher rate of excretion usually resulting in the passage of 80 percent of the residues within 70 to 90 hours. Excretion then proceeded more slowly and was completed 7 to 10 days after feeding. Rodrique and Allen (1960) measured the rate of ground hay by using the dye method of Balch (1950). Their results compared favorably with those of Ewing et al. (1917). Putnam, Bond and Lehmann (1967) studied the rate of passage of chromic oxide in pregnant Angus heifers. The greatest amount of chromic oxide was excreted during the 18 to 24 hour interval after the marker was fed. The recovery of chromic oxide at 96 hours averaged 80.4 percent.

Shellenberger and Kesler (1961) determined the rate of passage in twelve Holstein cows by feeding a normal herd ration containing stained hay. The first particles of dyed hay appeared in the fecal samples collected at 14 to 20 hours after feeding. Most of the particles were excreted during the period between 26 and 120 hours after feeding and very few appeared after 160 hours. He concluded that the passage rate was faster in high producing cows than in those at low production.

Stress Variations

Meat animals as they are shipped to market terminals and slaughtering plants are exposed to many forms of stress. Stress pertaining to a market animal is defined as exposure to an abnormal environment or circumstance. These ante-mortem stresses have been extensively researched. Hormonal secretion is generally altered under conditions of stress with the adrenal gland increasing its output.

Hormonal Induced Stress.

Hedrick, Parrish and Bailey (1964) injected sixteen Hampshire hogs with "adrenaline," significantly reducing liver and muscle glycogen with ultimate higher muscle pH. Flavor and tenderness of loin chops from "adrenaline"-treated animals were as desirable as those chops from the control animals. Palmin et al. (1963) concluded that preslaughter treatment with "adrenaline" improved juiciness, taste and lowered cooking losses in post-mortem pig muscle.

Hedrick et al. (1961) injected lambs with "adrenaline" preslaughter and found that flank muscles from the treated animals were significantly darker in color and presented higher pH values than controls. These results were substantiated by Forrest, Merkel and Mackintosh (1964) studying high levels of epinephrine injection in ovine. Lamb muscle tissue was darker in color and longissimus dorsi pH was significantly higher in the epinephrine-treated lambs. Judge and Stob (1963) reported that epinephrine-treated lambs had an increase in liver glycogen but a decrease in muscle glycogen. Bramblett, Judge and Vail (1963) concluded the epinephrine-treated lambs were less tender than non-treated, but their water holding properties were

similar.

Hedrick et al. (1959) found that preslaughter injections of "adrenaline" reduced muscle glycogen levels in beef, producing dark-cutting carcasses. Tenderness, aroma, flavor and juiciness were not affected by this treatment. Hedrick, Brady and Turner (1957) found that administering hydrocortisone prior to the injection of "adrenaline" will help to alleviate the pronounced effect of "adrenaline" upon muscle glycogen depletion. Lawrie (1962a) studied the effects of "adrenaline" on a crossbred Angus-Jersey steer using an identical twin as a control. Samples from the treated steer were rated more tender than the control samples. Lawrie (1962b) concluded that the most desirable tenderness scores in beef occur when muscle pH is near 7.0 and the lowest at a pH of 5.8 to 6.0.

Other compounds have been administered to bovines in an effort to improve meat quality. Bouton, Howard and Lawrie (1957) presented evidence that preslaughter administration of tuberculin, potassium chloride, magnesium sulfate or pyrophosphate resulted in ultimate pH values above the normal range of 5.4 to 5.6 and lowered the flavor and overall acceptability of the meat. Howard and Lawrie (1957) reported that preslaughter injection of steers with magnesium sulfate resulted in stronger flavor, but did not affect tenderness. Huffman et al. (1960) have shown that preslaughter injections of physiological saline, papain, ashed crude papain, denatured crude papain or crystalline papain improved meat tenderness.

Stress due to Exercise and Fatigue.

Exercise and fatigue are two forms of stress which may definitely alter meat quality. Rose and Peterson (1951) concluded that exercise seriously

depletes carbohydrate reserves in both muscle and liver of rats.

Callow (1936) first studied the effect of ante-mortem fatigue in hogs on the quality of cured pork. He reported that electrical resistance in muscle 24 hours post-mortem was much lower in rested hogs than in those stressed due to transportation. Gibbons and Rose (1950) observed that meat from fatigued pigs had a lower glycogen reserve and a higher pH (6.0 to 6.6) than meat from fed and rested hogs. They also found meat of low pH contained less sodium nitrite immediately after cure with the cut lean surfaces retaining the desirable red color longer than meat of high pH. Briskey et al. (1959) administered various levels of forced exercise to hogs using an animal exerciser. Hogs readily adapted to repeated exercise had ham appearance and muscle characteristics similar to the controls. Fasted and full-fed hogs that were subjected to a single, severe exercise possessed muscles that were dark in color, high in pH value and dry in appearance.

Mitchell and Hamilton (1933) exercised Hereford steer calves on a treadmill for 122 days and 131 days in consecutive years. Their results suggested that exercise tended to lower the content of ether soluble material in all tissues; however, muscle glycogen and tenderness were increased. Similar findings were reported by Bull and Rush (1942) as panel and shear values showed that rib eye steaks of heavily exercised steers were more tender than from unexercised steers.

Stress due to Excitement.

The influence of excitement on physiological processes and subsequent meat properties is dependent in part on the excitability of individual

animals and the duration and severity of the stress condition. Lewis, Brown and Heck (1959, 1962a) periodically stimulated hogs with an electrical shock for 5 1/2 hours preslaughter. Longissimus dorsi, psoas major, and quadriceps femoris pH increased from the stress as did the tenderness scores of fresh hams and chops. Another report by Lewis, Brown and Heck (1961) showed that preslaughter stress, induced by 5 hours of periodic electrical stimulation, decreased the dry matter and moisture cooking loss of the three muscles mentioned in their earlier work. Lewis, Brown and Heck (1962b) reported that cooked muscles from pigs stressed by an "electric hotshot" contained more nutrients per pound than the cooked muscles of rested pigs.

Hedrick et al. (1959) stressed cattle by prodding them periodically with an electric "hot shot." Preslaughter electrical stimulation had a pronounced effect upon muscle pH and color. Lean from stressed animals was sticky and gummy and the carcasses were considered extreme examples of dark cutting beef. Similar findings were reported by Lewis, Brown and Heck (1961, 1962c, 1963) who showed that dark color and high pH in muscle occurred from steers subjected to periodic electrical stimulation for 24 hours preslaughter. Superior juiciness, lowered cooking loss, decreased tenderness, and less desirable flavor and aroma of cooked muscle was noted in treated steers.

Preslaughter Feeding.

Preslaughter feeding has been used by some workers as a method for improving meat quality. Wismer-Pedersen (1959) studied the effect of rest and feeding sugar at the slaughter house on the quality of cured bacon. No

improvement of flavor, texture, or color of fried bacon was noted. In most instances, bacon from control pigs was more desirable than that from sugar-fed pigs. Hall et al. (1961) reported that feed and a 16 hour rest at the slaughter plant reduced the average pH of the psoas major muscle slightly, but had little effect on chemical, physical and palatability factors and keeping qualities of loin and sausage. Heck (1958) placed 3 pounds per 5 gallons of high concentrate carbohydrate (brown sugar) in the drinking water of hogs. Live weight shrinkage was greatest by 4.24 percent when comparing the controls with the treated hogs. No significant organoleptic differences were found among ham samples. Lewis, Heck and Brown (1961) added 10 percent sugar to the drinking water of hogs for 48 hours prior to slaughter. Water consumption, amount of fill, and glycogen content of the psoas major muscle were all significantly increased. There was no significant effect on live shrink, dressing percent, or yield of ham and shoulder.

Wilcox et al. (1953) fed sucrose at different levels to 96 beef cattle and 12 swine from 6 hours to 14 days preslaughter. Lower muscle pH, improved color, and a slight increase in dressing percent and carbohydrate content in both the liver and muscle were noted in the sucrose-fed animals. Quality appraisal scores and shear force values were similar for all lots of beef but sucrose-fed pork muscle was slightly more tender than the control.

Tissue Loss

Tissue Loss in Monogastrics.

Most early work dealing with fasting effects on carcass shrink has been done with swine. Henning and Stout (1932) attempted to determine the effect

of fasting hogs on the morning of shipment. Those fasted the morning of shipment lost less live weight in transit and took on a larger fill at the yards than those fed. This difference was more than offset by weight differences observed when hogs were weighed for shipping. Some evidence indicated that a portion of the shrinkage observed in fasted hogs was actual loss in carcass weight, since the fasted hogs dressed 76.6 percent compared to 77.2 percent for the controls. The half percent lower yield represented a tissue difference of 1.1 lb. per head. When two feedings were omitted, dressing percent was reduced 1.3 percent. Bjorka (1938) concluded that tissue loss begins early in transit and continues until hogs reach their destination. He also decided that tissue loss is probably caused by nervous disturbances of hogs and that it occurs more rapidly in lighter than heavier hogs. Callow (1938a) fasted hogs for two days and reported that the loss in tissue weight was due to an abnormal water loss from the muscular tissue.

Pomeroy (1941) fed Large White hogs weighing 330 lb. a submaintenance diet of straw and water and slaughtered them at various intervals between 330 and 200 lb. Tissue loss occurred in reverse order to their development; losing first fat, than muscle and finally bone. Fat loss occurred first in the kidney fat, then subcutaneous fat and lastly the early-developing intermuscular, caul and mesenteric fat. Saffle and Cole (1960) used eighty-four hogs to study fasting effects on tissue shrinkage. During the four day test, nearly 50 percent of the total shrinkage had occurred after 24 hours and 88 percent after 48 hours. A significant negative relationship was noted between dressing percent and fasting time which denotes a small loss in carcass weight possibly attributed to tissue shrinkage.

Stout and Armstrong (1960) shipped 6,600 hogs various distances

concluding that there was no advantage in feeding hogs intended for immediate slaughter. In fact, they found the immediate effect of feeding was to lower dressing percent.

Bowland and Standish (1966) withheld feed from swine for 24 hours. The fasted hogs had 5.7 percent live weight shrink and 2.1 percent carcass weight shrink. Withholding feed for 48 hours resulted in 7.9 percent live weight shrink and 3.1 percent carcass weight shrink. Ingram et al. (1967) used three hundred and forty-eight commercial hogs of Yorkshire breeding to evaluate the effect of three days fasting on carcass weight. Hot carcass weights decreased progressively ($P < .01$) with each day of fasting. The results showed that the largest weight loss was during the first day of fasting. Cole and Miller (1968) made observations on carcasses of hogs held over from slaughter for 0, 24, 48 and 72 hours. All hogs had access to water. There was a significant difference in dressing percentage between the treatments; however, it was felt small differences in live weight and fat thickness between lots probably contributed as much to the variation in dressing percentage as did treatment effects. It was concluded that feeding "holdover" hogs 48 hours antemortem is probably a waste of feed and labor. Davidson et al. (1968) fasted some hogs 68 to 70 hours and produced significant losses in carcass, gastrointestinal tract and liver weights.

Tissue Loss in Ruminants.

Little information is available concerning tissue loss in ruminants. Shier (1939) fasted four groups of 20 lambs for 3, 32, 56 and 77 hours. The average group live weight loss ranged from 2.75 lb. to 9.1 lb. No difference was found in grade, color, or bloom of the carcasses due to fasting.

Using wethers that had been fasted 4 1/2 days, Blaxter (1962) found that sheep still produced methane showing that fermentation of food still occurred. He concluded that 76 percent of the energy lost from the body came from fat oxidation and 24 percent from protein degradation. Callaghan and Thompson (1940) divided 170 lambs averaging 63 pounds into six treatment groups. These were fasted from zero to 96 hours. The greatest live weight loss occurred during the first 24 hours, being 4.31 pounds. Lambs fasted 96 hours lost an average of 7.08 pounds. Hot carcass yields decreased as the length of the fast increased. Kirton, Clarke and Carter (1967) used 100 ram lambs, 50 being fasted for 16 hours and 50 for 75 hours prior to slaughter. The 75 hour fast reduced live weight by 5.3 lb. and carcass weight by 2.4 lb. compared to the lambs fasted overnight.

Wilcox et al. (1953) reported feeding only sucrose to cattle for periods of 6, 30, and 72 hours prior to slaughter. A six hour feeding of 2 to 12 pounds of sucrose did not affect dressing percentage. Feeding 6 pounds of sucrose for 30 hours before slaughter increased dressing percentage while feeding 12 pounds for 30 hours decreased dressing percent. Feeding sucrose for 72 hours increased dressing percentage significantly.

Yeates (1964) found that starvation affected various portions of the carcass to differing degrees. This ranged from a 20 percent loss in weight in the leg to an 84 percent loss in weight of kidney fat. Starvation also caused a reduction of muscle fiber diameter, but there appeared to be no evidence of change in amount of connective tissue due to starvation.

The Effects of Fasting on Quality

Antemortem stress and its effect on meat quality has been widely

researched in swine especially regarding its role in causing pale, soft and exudative pork. Minimal work has been conducted concerning the effects of fasting on muscle quality.

Zessin et al. (1961) showed that hogs on maintenance and sub-maintenance diets for 4 weeks preslaughter, compared to hogs on a growing and fattening diet, had less intramuscular fat in the longissimus dorsi muscle and less backfat. Cooked roasts and chops from the pigs subjected to dietary restriction were less tender and juicy, had less odor and flavor and were less desirable according to a taste panel compared to samples from hogs on the higher level of nutrition. This agrees with Cole and Backus (1967) who fasted hogs for three days and concluded that fasting increased shearing strength significantly; however, cooking losses were decreased.

One of the most detailed reports dealing with fasting of beef cattle and its effect on quality was done by Lewis et al. (1962c). They fed 8 steers a limited ration of 2 lb. of hay per day for a week prior to slaughter. Fourteen days after slaughter, the longissimus dorsi, psoas major, and quadriceps femoris muscles were sampled for taste panel evaluations, pH determination, cooking losses, color and expressible water. They concluded that limited feeding prior to slaughter decreased tenderness scores of the longissimus dorsi muscle and made it darker in color. Limited feeding also decreased evaporation loss in cooking the psoas major muscle; however, the pH and shear force values of the psoas major and quadriceps femoris muscles were increased. Lewis, Brown and Heck (1965b) studied the effects of fasting and castration on 24 animals. The same three muscles used in their previous research project were studied. Preslaughter stress significantly darkened the color and increased the pH of uncooked samples of all three muscles.

Tenderness scores of the psoas major and quadriceps femoris muscles were increased as was the juiciness score of the psoas major muscle. Preslaughter stress significantly decreased the cooking losses in all three muscles. These results agreed with a similar project concerning bovine preslaughter stress reported by Lewis, Brown and Heck (1965a). Hall, Latscher and Mackintosh (1944) fasted a steer for ten days and concluded that fasting does not affect color of lean. The longissimus dorsi muscle presented a normal bright color as did the lean surface of the round.

Chemical Effects Due to Fasting

Fasting is not a usual condition for animals, especially those that have been accustomed to full feed; consequently, animals handled this way are under considerable stress. The animal's ability to adapt to such a condition involves many chemical changes in its physiological system. These changes may vary both between and within species.

Protein Metabolism Under Fasting Conditions.

Addis, Poo and Lew (1936) quantitated the amount of protein lost by various organs and tissues in the rat during fasting. After a 7-day fast, the liver lost 40 percent of its original protein content, the prostate and seminal vesicles, 29 percent; while the testicles and adrenals remained constant. Protein losses from the heart, kidneys, drawn blood, and alimentary tract were between 18 to 28 percent; the muscle, skin and skeleton, each 8 percent; and the brain, 5 percent.

Cole et al. (1968) after fasting hogs for 0, 24, 48, and 72 hours concluded protein content was not affected by fasting. These results disagree

with the findings of Kirton et al. (1967) who studied the effect of fasting on ram lambs. Chemical analyses of the carcasses showed that weight of protein had been reduced and dehydration had occurred. In considering these two research reports, it should be remembered that one was conducted using monogastrics and the other ruminants.

Fat Metabolism Under Fasting Conditions.

Researchers have investigated fatty acid metabolism during fasting. Mitchell and Longwell (1964) using albino rats, fasted and exposed them to cold (3° to 5° C.) for periods ranging from 4 to 30 hours. Tissue from the cold-exposed rats released significantly more fatty acids than from the controls. The control and cold-exposed rats were all fasted for the same length of time.

Goodman and Knobil (1959) studied plasma fatty acid concentration in normal and hypophysectomized rhesus monkeys. They concluded fasting caused a marked increase in plasma (nonesterfied fatty acids) NEFA concentrations within a few hours. The hypophysectomized monkeys showed the same response suggesting that the NEFA mobilization during fasting was not mediated by an increased secretion of growth hormone.

Evans, Riemenschneider and Herb (1954) fasted rabbits and determined the composition of the marrow fat. They concluded that absolute quantities of all components of marrow fat diminished during starvation. The percent of linoleic and linolenic acids decreased during fasting, whereas that of arachidonic, pentaenoic, and oleic acids increased.

Analysis of fatty acid synthesis after a 5-day fasting of dairy cows was conducted by Luick and Smith (1963). Low molecular weight fatty acids

in the milk fell an average of 64 molecular percent compared to normal milk. A compensatory increase was noted in the long-chain fatty acids, palmitoleic, stearic and especially oleic. These findings were substantiated by those of Evans et al. (1954).

Stevensen, Box and Szlavko (1964) discovered a fat mobilizing substance in the urine of fasting rats. Subcutaneous injections of the fat mobilizing substance caused an increase in plasma and liver free fatty acids.

Glycogen Mobilization Under Fasting Conditions.

Fasting definitely influences the metabolic processes of the liver. Zimny and Tyrone (1957) found that liver glycogen increased in the fasted ground squirrel. They concluded the increase in glycogen was due to glycolysis in both skeletal and cardiac muscle. The lactate-pyruvate ratio in both types of muscle greatly favored lactate. Therefore, it is possible that the formation of a "lactate pool" by muscle supplies the glycogenetic needs of the liver during fasting. Genes and Markarevich-Gal'Perin (1964) reported conflicting results studying fasted rats. They reported glycogen content of the liver decreased with increased fasting time. To a lesser extent similar results were observed in skeletal muscles.

Gutman and Shafrir (1964) found 66 percent decreased activity of liver phosphorylase in rats fasted for 4 days. Fasting did not markedly affect the glucose-6-phosphate-independent activity of transglucosylase.

Hall et al. (1961) reported that transporting hogs to slaughter and not feeding them resulted in fatigue and loss of muscle glycogen. Feed and a 16-hour rest were effective in restoring liver glycogen.

Callow (1938a) reported fasting hogs for 48 hours caused sufficient

loss of glycogen from the psoas muscles to raise the ultimate pH from 5.7 to 6.1. It also tended to lower the water content by about 0.4%.

Liver glucose and glycogen analysis shows similar results in fasted ruminants and monogastrics. Robinson and Wilber (1955) reported a decrease in glucose tolerance in the liver of goats fasted for 16 days. Kronfeld and Raggi (1964) reported that fasting cows for 4 days caused exchangeable glucose of the glucose pools of body cells to fall to two-thirds and glucose entry rate to half normal. Plasma glucose concentration also dropped about 1/5. They concluded that hypoglycemia develops during fasting since glucose utilization exceeds glucose formation.

Howard and Lawrie (1956a) fasted steers for 28 days. They observed a slight fall in muscle glycogen after seven days, but found no effect on ultimate pH. They concluded that fasting normally had no effect on the glycogen reserves in steers. Howard and Lawrie (1956b) after conducting further studies on steer fasting concluded diet restriction alone does not deplete muscle glycogen since cortical hormone secretion increases and initiates gluconeogenesis. Kauflin, Hedrick and Stringer (1969) fasted a total of 140 cattle and found the mean liver glycogen of the fed cattle was significantly greater than that of fasted cattle. Liver glycogen in fasted cattle declined until the fourth day at which time it increased. Hall et al. (1944) fasted a steer for 10 days. A decisive drop in both blood and muscle tissue glucose occurred in the first three days of fast. Blood glucose was at a minimum on the third day, but muscle glucose reached a minimum on the sixth day.

Effect of Fasting Upon Urine Components.

Urine work was conducted by Richterick, Goldstein and Dearborn (1958). A marked drop of ammonia excretion was observed in guinea pigs during fasting. Windmueller, Anderson and Mickelsen (1964) analyzed the urine of humans fasted from 24 to 37 hours. The total 24 hour riboflavin excretion during the fast was approximately twice the total excreted the day immediately preceding the fast. At the end of the fasting period, some excretion was 10 to 15 times that of the control day. The amount of nitrogen and creatine excreted remained constant.

Blaxter and Wood (1951) fasted two young Ayrshire calves for 4 days. The calves lost an average of 250 mg. of urinary nitrogen per day. Urinary Cl, K, Na, and Ca fell during starvation and there was also a constant fall in metabolic rate.

Gupta (1966) fasted five adult buffaloes for eight days. Excretion of nitrogen and phosphorus in the urine decreased gradually as did water consumption.

Effect of Fasting on Blood Components.

Some early blood analysis work on fasted animals was done by Robertson (1913). He studied fasting in the horse, rat, rabbit, and ox and compared their sera with respect to content of various proteins. In the rabbit, ox, and horse, starvation led to an increase in the proportion of albumins to globulins in the serum, while in the rat and dog, starvation resulted in the reverse of this. This agrees with Torbert (1935) who fasted rats up to 15 days and concluded that the fall in serum protein concentration was caused by a fall in the albumin fraction.

Cooper and Archdeacon (1960) fasted dogs from 66 to 84 hours. Venous blood and cerebrospinal fluid samples were withdrawn simultaneously during this time. There was a tendency for the glucose level to drop slightly in both components as fasting progressed.

Ulmanis (1956) studying 60 men after fasting found no essential differences in the erythrocyte count, hemoglobin, and thrombocyte count. Shope (1927) fasted a woman 5 days, a 120 lb. barrow 4 days and guinea pigs 42 hours. He concluded that during a period of fasting, there is a decrease in the sugar content of human, swine, and guinea pig blood serum, with an increase in both total cholesterol and cholesterol bound as an ester.

Kornegay et al. (1964) fasted nine pigs for 167 hours and found that hematocrit, hemoglobin, and serum cholesterol values were significantly greater after 27 hours of fasting. Blood glucose and serum Ca were significantly lower in the fasted pigs while the blood volume as a percent of body weight was 53 percent greater.

Reid (1950) fasted sheep for 4 days. The decrease in blood sugar observed during the fast was similar to that observed in non-ruminants, but the response was delayed. Fasting for 24 hours and in many cases 46 hours had little effect on the blood sugar level. Meyer, Weir and Smith (1955) fasted some lambs for 36 hours and concluded that blood plasma, sodium and chloride did not change. However, a rise in blood hematocrit and plasma albumin was noted during the 36-hour fast.

Gupta (1966) fasted five buffalo for 8 days, and blood calcium, phosphorus, and nitrogen were unaffected. Consumption of water decreased as the days of fasting increased. This agrees with Meyer et al. (1955) who noticed a decrease in water consumption during a 36-hour fast. Contrary to

this, Huang (1955) reported that rabbits increase their water intake when they are fasted.

EXPERIMENTAL PROCEDURE

Source of Material.

Two trials comparing fasting versus feeding were conducted at the Circle E Feedyards, Potwin, Kansas. Trial one, involving 175 head of steers (Table 1), occurred in June, 1968; trial two, involving 125 steers took place in March, 1969. These steers had been on full-feed for 130 to 140 days. All animals were individually identified by number and apparent breeding. Fed cattle were continued on the normal ration and feeding regime; the fasted cattle were simply removed from feed. Both treatments had water available ad libitum. The cattle were hauled 20 miles and slaughtered at the Excel Packing Company in Wichita, Kansas. Carcasses were chilled for 24 hours and complete carcass data was collected. This information included hot carcass weight, chilled carcass weight, marbling score, conformation score, maturity, lean color score, and final carcass grade.

Experimental Design.

Table 1

	Days			
Treatment	0	1	2	3[a]
Fed	25	25	25	25
Fasted	--	25	25	25

[a] The experimental design for trial 2 was identical to trial 1 except day 3 was deleted.

Water Holding Capacity.

Water holding capacity was determined on fresh muscle by a modification of two methods: 1) the press method of Grau and Hamm (1956) and 2) the centrifuge method of Wierbicki, Kunkle and Deatherage (1957). A sample of the longissimus dorsi was used for the press method, while the Wierbicki determination used a sample of the pars lumbalis (crura or pillars) of the diaphragm.

The procedure for the determination of water holding capacity by the press method was as follows: A muscle sample weighing 300 mg. $\pm$ 20 mg. was removed from the center of the original sample, weighed to the nearest 0.1 mg., and quickly placed on humid filter paper on a plexiglass plate. Whatman number 1 filter paper was kept in a desiccator over a saturated potassium chloride solution for 24 hours to maintain a constant humidity. Another plexiglass plate was immediately placed on top of the sample. Each sample was done in duplicate. Ten thousand pounds pressure was then applied to the plexiglass plates for five minutes using a Carver Laboratory Press. After pressing, the muscle and juice areas were outlined with pencil and the muscle sample removed. The two areas were then measured with a compensating polar planimeter. Results were expressed as percent of total water content. This value was determined by the following formula:

$$\% \text{ of Total } H_2O \text{ Content} = \frac{\left(\frac{\text{ring area in sq. in. X } 6.452}{0.0948} + 8.0\right)}{\text{Sample wt. (mg)}}$$

A modification of the Wierbicki et al. (1957) method was used in determining water hold capacity. The modification of the procedure was as follows: a 9 to 14 gram sample of muscle was placed into a polyethylene

centrifuge tube and a rubber stopper, fitted with a capillary tube, was placed tightly on the tube. The centrifuge tube was then placed in a 70° C water bath for 30 minutes. The sample and juice were immediately transferred to a fritted glass crucible which was then taped to the top of the centrifuge tube and centrifuged for 5 minutes at 3,000 rpm.

The juice obtained by centrifugation was measured to the nearest 0.1 ml. with a calibrated pipette. Percent moisture was computed using the following formula:

$$\% \text{ moisture expressed} = \frac{\frac{\text{ml. of juice}}{100 \text{ g.} \times F}}{\% \text{ total moisture in sample}} \times 100$$

F = 0.95 (F represents the approximate fraction of the juice that is water.)

Glycogen Determination.

Glycogen contained in the liver was determined by modification of the procedure of Hansen, Rutler and Craine (1951).

The procedure was as follows: A sample of ground liver weighing approximately 0.1 g. was placed into a test tube containing 1 ml. of 30% KOH. The test tube was immediately placed in a boiling water bath for twenty minutes and then put in a cold water bath (25° C) for eight minutes. Two ml. of 95% ethanol was added, the contents mixed, and again placed in a boiling water bath until the mixture started boiling. The tube was put in a cold water bath (25° C) for eight minutes and then centrifuged at 3,000 rpm. for ten minutes. After centrifugation, the supernatant was decanted and drained, and one ml. of distilled water plus 2 ml. of 95% ethanol were added. The

contents were mixed and centrifuged for ten minutes at 3,000 rpm. The contents were decanted and drained, and 5 ml. of distilled water was added to the original tube and mixed. Using a Labindustries Automatic Dilutor, 0.1 ml. of the above solution was taken and placed in another test tube. Then 6.9 ml. of anthrone reagent (0.2 g. of anthrone/100 ml. of 75% H_2SO_4) was added and mixed. After mixing, the test tube was capped with a marble and placed in a boiling water bath for eight minutes. The solution was cooled for eight minutes and read on a Beckman DU-2 Spectrophotometer at 660 mu wavelength. The solution should be light blue in color if it contains any glycogen.

Moisture Determination.

Moisture determinations on ground muscle samples were carried out as outlined by A.O.A.C. (1960). The ground muscle samples were obtained from the pars lumbalis muscle in trial 1 and the longissimus dorsi muscle in trial 2.

pH Determination.

The pH value of ground muscle was determined by a Beckman Expandomatic pH meter using a special surface electrode. A 10 to 15 g. sample was slightly moistened with distilled water and the electrode placed on the surface of the sample. Two readings were taken on each sample.

Ether Extract Determination.

Ether extract content in ground liver samples was determined by a procedure outlined by A.O.A.C. (1960).

Statistical Analyses.

The statistical procedures followed were described in Least-Squares Analysis of Data with Unequal Subclass Numbers by Harvey (1960). Some of the means were compared using orthogonal contrasts as presented by Snedecor (1956).

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CHAPTER I

THE EFFECT OF PRESLAUGHTER FASTING ON BOVINE TISSUE YIELD AND QUALITY

Live and carcass weight loss of meat animals caused by preslaughter handling and slaughter conditions are of economic importance to the livestock and meat industry. Traditionally, cattle have been fed while being held prior to slaughter under the assumption that this will prevent a tissue loss; recently some question has arisen concerning the validity of this assumption. Henning and Stout (1932) reported that fasted hogs dressed 76.6 percent compared to 77.2 percent for the controls. The half percent lower yield represented a tissue difference of 1.1 lb. per head. Bowland and Standish (1966) withheld feed from swine for 24 and 48 hours and reported carcass weight shrink of 2.1 and 3.1 percent, respectively. Cole and Miller (1968) fasted hogs up to 72 hours and concluded that feeding "holdover" hogs 48 hours antemortem was probably a waste of feed and labor.

Kirton, Clarke and Carter (1967) fasted ram lambs up to 75 hours. This reduced live weight by 5.3 lb. and carcass weight by 2.4 lb. compared to the lambs fasted overnight.

Minimal work has been conducted concerning the effects of fasting on muscle quality. Zessin et al. (1961) showed that hogs on a sub-maintenance diet had less intramuscular fat in the longissimus dorsi muscle compared to hogs on a fattening diet. They also reported that cooked roasts and chops from the fasted hogs were less tender and juicy and had less flavor.

Lewis, Brown and Heck (1962) fed 8 steers a limited ration for a week prior to slaughter. They concluded that limited feeding increased the pH and shear force values of the psoas major and quadriceps femoris muscles.

In addition, tenderness scores of the longissimus dorsi muscle were decreased and the muscle was darker in color. On the contrary, Hall, Latscher and Mackintosh (1944) reported that the longissimus dorsi muscle remained normal in color after fasting a steer ten days.

The experiment reported here was specifically designed to determine the differences, if any, in tissue yield, carcass grade, and incidence of dark cutters due to fasting.

Experimental Procedure

Two trials comparing fasting versus feeding were conducted at the Circle E Feedyards, Potwin, Kansas. Trial one involving 175 head of steers (table 1) occurred in June, 1968; trial two, involving 125 steers was conducted in March, 1969. These steers had been on full feed for 130 to 140 days. All animals were individually identified by number and apparent breeding. Fed cattle were continued on the normal ration and feeding regime; fasted cattle were simply removed from feed. Both treatments had water available ad libitum. The cattle were transported 20 miles and slaughtered at the Excel Packing Company in Wichita, Kansas. Carcasses were chilled for 24 hours and complete carcass data collected.

Experimental Design:

Table 1

Treatment	Days 0	1	2	3[a]
Fed	25	25	25	25
Fasted	--	25	25	25

[a] The experimental design for trial 2 was identical to trial 1 except day 3 was deleted.

The statistical procedures followed were described in Least-Squares Analysis of Data with Unequal Subclass Numbers by Harvey (1960).

Results and Discussion

Effect of Fasting on Slaughter Weight. Treatment and trial had a highly significant ($P < .01$) effect on slaughter weight (table 2). The cattle fasted for 24, 48 and 72 hours had 3.07, 4.15 and 5.77 percent live weight shrink, respectively. This weight loss in fasted cattle occurred as expected and the results agree with the work of Bowland and Standish (1966) who after fasting swine for 24 and 48 hours, reported a loss of 5.7 and 7.9 percent live weight, respectively. Also, Callaghan and Thompson (1940) fasted lambs up to 96 hours. Those fasted 24 hours lost 6.84 percent live weight, while those fasted 96 hours lost 11.24 percent live weight. The greatest weight loss among the fasted cattle in this study occurred during the first 24 hours, losing an average of 36 pounds. Similar results were reported by Saffle and Cole (1960) and Callaghan and Thompson (1940) who concluded that 50 percent or more of total shrinkage occurred after a 24 hour fast. The day 3 fed cattle had significantly ($P < .05$) heavier slaughter weights than did the day 1 fed cattle as shown in table 3. Significant mean differences were computed using Duncan's New Multiple Range Test at the .05 level according to Harvey (1960). The heavier slaughter weights can be attributed to weight gain since the day 3 fed cattle were on feed two more days and would be expected to be somewhat heavier.

Trial also had a highly significant ($P < .01$) effect on slaughter weight (table 2). It is noted in table 7 that the weights (slaughter, hot and chilled carcass) for trial 1 were significantly heavier than for trial 2. It would appear from studying the mean weights that handling and weighing the cattle on day 0, when all cattle were individually weighed and identified,

Table 2. Analysis of Variance for Slaughter Weight, Hot Carcass Weight and Chilled Carcass Weight.

Source of Variation	d.f.	Mean Squares		
		Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight
Treatment	6	29207.96**	1511.02*	1642.57*
Trial	1	11217.58**	13147.70**	11648.00**
Breed	3	436.00	3907.98**	3716.31**
Initial Weight	1	3028572.00**	1205506.00**	1167901.00**
Error	288	291.08	699.52	714.12

* $P < .05$.

** $P < .01$.

Table 3. Adjusted Treatment Means and Standard Error for Slaughter Weight, Hot Carcass Weight and Chilled Carcass Weight.

Treatments	Slaughter Weight[f]	Hot Carcass Weight[f]	Chilled Carcass Weight[f]
Control	1169.80 ± 2.43[ab]	712.96 ± 3.77[a]	697.80 ± 3.80[a]
Fed - Day 1	1165.02 ± 2.47[a]	706.07 ± 3.83[ab]	692.82 ± 3.87[a]
Fed - Day 2	1166.99 ± 2.47[ab]	707.93 ± 3.82[ab]	693.60 ± 3.86[a]
Fed - Day 3	1174.55 ± 3.61[b]	721.30 ± 5.60[a]	706.47 ± 5.66[a]
Fast - Day 1	1129.22 ± 2.45[c]	707.98 ± 3.80[ab]	694.14 ± 3.84[a]
Fast - Day 2	1118.58 ± 2.43[d]	709.86 ± 3.77[ab]	695.94 ± 3.80[a]
Fast - Day 3	1106.78 ± 3.61[e]	696.36 ± 5.59[b]	679.75 ± 5.65[b]

[a, b, c, d, e] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[f] Slaughter weight, hot carcass weight and chilled carcass weight are expressed in pounds.

did cause a slight loss in weight which was not recovered in the fed cattle until after the 3rd day of feeding. Part of this loss might also be due to a mill explosion and irregular feeding regime experienced during the second trial. It is quite obvious, after comparing tables 4 and 5, that something occurred in trial 2 which caused all the cattle to shrink considerably more than those in trial 1.

Table 4. Percent Actual Weight Gain or Loss During Trial 1.

	Day			
Treatment	0	1	2	3
Fed	--	+ 0,59	+ 0.33	+ 0.58
Fasted	--	- 2.48	- 3.68	- 4.75

Table 5. Percent Actual Weight Gain or Loss During Trial 2.

	Day		
Treatment	0	1	2
Fed	--	- 1.31	- 0.61
Fasted	--	- 4.39	- 4.83

The fed steers lost weight during trial 2 which is quite abnormal; consequently, the mill explosion may have influenced all of the weights to some extent. Trial also had a highly significant ($P < .01$) effect on hot and chilled carcass weight (table 2).

Effect of Fasting on Hot and Chilled Carcass Weight. Fasting had a significant ($P < .05$) effect on hot and chilled carcass weight (table 2). After looking at table 3 and comparing the means for hot and chilled carcass weights of the various treatment groups, it is noted that the controls and day 3 fed cattle had the heaviest carcass weights. They were significantly ($P < .05$) different from only the day 3 fasted cattle. The decrease in hot and chilled carcass weights in the day 3 fasted cattle may be caused by an actual loss of body tissue. Callaghan and Thompson (1940) found that in lambs, hot carcass yields decreased as the length of the fast increased. Similar findings were reported by Kirton, Clarke and Carter (1967).

Breed also had a highly significant ($P < .01$) effect on hot and chilled carcass weight (table 2). It can be noted in table 6 that there is a significant difference between the hot and chilled carcass weights of the English-beef breed cross cattle and Herefords as well as the dairy-beef breed cross cattle. No difference is observed between Hereford and Angus cattle, but Angus have significantly heavier hot and chilled carcass weights than do dairy cross cattle. This difference may be attributed to several factors which were not studied. There possibly is a difference in offal weight in favor of Angus and beef crossbred cattle. It is widely accepted that Angus cattle have lighter hides than do other breeds. The predominant proportion of the beef crossbred cattle were Hereford-Angus cross cattle which could tend to make them lighter hided. There could also have been a difference in the degree of fatness in favor of the beef crossbreds and Angus causing them to dress higher. In studying table 3, it was noted that the mean for chilled carcass weight of the day 3 fasted cattle is significantly ($P < .05$) different from all other treatments. On a hot carcass weight basis, it was not

Table 6. Adjusted Breed Means and Standard Error for Slaughter Weight, Hot Carcass Weight and Chilled Carcass Weight.

Breed	No. of Observations	Slaughter Weight[d]	Hot Carcass Weight[d]	Chilled Carcass Weight[d]
Hereford	125	1147.11 ± 1.61[a]	706.90 ± 2.50[ab]	692.69 ± 2.53[ab]
Angus	62	1143.43 ± 2.20[a]	711.47 ± 3.41[bc]	696.83 ± 3.45[bc]
English-Beef Cross	61	1149.28 ± 2.28[a]	718.58 ± 3.54[c]	703.75 ± 3.57[c]
Dairy-Beef Cross	52	1149.29 ± 2.42[a]	698.76 ± 3.76[a]	684.29 ± 3.79[a]

[a, b, c] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[d] Slaughter weight, hot carcass weight and chilled carcass weight are expressed in pounds.

Table 7. Adjusted Trial Means and Standard Error for Slaughter Weight, Hot Carcass Weight and Chilled Carcass Weight.

Trial	No. of Observations	Slaughter Weight[c]	Hot Carcass Weight[c]	Chilled Carcass Weight[c]
I	175	1154.06 ± 1.36[a]	716.26 ± 2.11[a]	701.30 ± 2.13[a]
II	125	1140.50 ± 1.75[b]	701.58 ± 2.72[b]	687.48 ± 2.75[b]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[c] Slaughter weight, hot carcass weight and chilled carcass weight are expressed in pounds.

different from any of the other treatment groups except the controls and day 3 fed cattle. This would suggest that there was a greater cooler shrink in day 3 fasted cattle than any of the other treatment groups indicating a greater proportion of water being present in day 3 fasted cattle or a lesser proportion of fat.

Effect on Conformation. Breed had a highly significant ($P < .01$) effect on conformation (table 8). It is noted in table 10 that the dairy-beef crossbred cattle were significantly ($P < .05$) different from the Hereford, Angus and English-beef crossbred cattle. This difference may be attributed to the superior conformation, especially in the round, that the beef breeds possess. It is widely recognized that dairy-beef crossbred cattle tend to have carcasses that are more angular in shape and have less bulge and thickness in the round, thereby lowering their conformation scores.

Effect of Fasting on Color. Treatment had a significant ($P < .05$) effect on color of lean (table 8). The means in table 9 show a definite difference in color between the fed and fasted cattle with the carcasses from fasted steers having a brighter, more youthful appearing color of lean. It is theorized that this improved color of lean of the fasted compared to the fed cattle could possibly be due to an increase in the glycogen stores within the muscle tissue. These results conflict with those of Shier (1939) who reported that fasting lambs had no effect on color of lean and those of Hall, Latscher and Mackintosh (1944) who fasted a steer ten days finding no difference in lean color. Lewis, Brown and Heck (1962, 1965) reported some conflicting results. They concluded limited feeding for 7 days prior to slaughter significantly increased darkness of lean color of the longissimus dorsi, psoas major and quadriceps femoris.

Table 8. Analysis of Variance for Conformation, Maturity, Color of Lean, Marbling and Final Grade

Source of Variation	d.f.	Mean Squares				
		Conformation	Maturity	Color of Lean	Marbling	Final Grade
Treatment	6	1.88	0.4563	5.30*	31.26*	2.55
Trial	1	.00034	0.1562	1.94	26.47	3.67
Breed	3	7.48**	0.5725**	3.76	66.68**	5.91*
Initial Weight	1	20.33**	3.9984	0.71	95.43**	14.58**
Error	288	1.56	0.3924	1.97	14.12	1.69

* $P < .05$.

** $P < .01$.

Effect of Fasting on Marbling Score. Treatment had a significant ($P < .05$) effect on marbling (table 8). It is noted in table 9 that a significant difference in marbling occurred between day 3 fed, the controls and day 1 fed cattle. The day 3 fed cattle were not significantly different from 4 of the other treatment groups. The day 3 fed cattle had the lowest marbling scores among the treatment groups which would not be expected and was probably due to chance only. Fasting did not appear to have any detrimental effect on marbling since the day 1 fasted cattle had higher marbling scores, though not significantly so, than did the day 2 and day 3 fed cattle. Zessin et al. (1961) reported that hogs fed a sub-maintenance diet for 4 weeks pre-slaughter had less intramuscular fat in the longissimus dorsi muscle. Thus, it would appear that longer periods of fasting bovine, than occurred in this experiment, would have to be initiated before any effect on intramuscular fat score would be noticed.

As has been reported by Butler et al. (1962), breed had a highly significant ($P < .01$) effect on marbling (table 8). It is noted from table 9 that Angus cattle have significantly ($P < .05$) more marbling than any of the other breed types included in this study. This caused the Angus breed to also have significantly ($P < .05$) higher grading carcasses than any of the other breed types. This result would be expected due to the influence of marbling on final carcass grade.

Effect of Fasting on Final Grade. Treatment had no effect on final carcass grade (table 8). Similar results were reported by Kauflin, Hedrick and Stringer (1969). Shier (1939) also found that fasting lambs had no effect on final grade. Thus, from the results of this study, it would appear that cattle can be fasted for up to three days with no effect on final carcass grade.

Table 9. Adjusted Treatment Means and Standard Error for Conformation, Maturity, Color of Lean, Marbling and Final Grade

Treatments	Conformation[c]	Maturity[c]	Color of Lean[c]	Marbling[c]	Final Grade[c]
Control	20.48 ± 0.178[a]	2.30 ± 0.089[a]	3.65 ± 0.199[ab]	16.90 ± 0.535[a]	19.40 ± 0.185[a]
Fed-Day 1	20.36 ± 0.181[a]	2.32 ± 0.091[a]	4.04 ± 0.204[a]	16.69 ± 0.545[a]	19.33 ± 0.188[a]
Fed-Day 2	20.42 ± 0.180[a]	2.35 ± 0.090[a]	3.96 ± 0.203[a]	15.40 ± 0.543[ab]	18.98 ± 0.188[a]
Fed-Day 3	20.06 ± 0.264[a]	2.08 ± 0.133[a]	4.06 ± 0.297[a]	14.09 ± 0.796[b]	18.62 ± 0.275[a]
Fast-Day 1	20.49 ± 0.179[a]	2.18 ± 0.090[a]	3.43 ± 0.202[b]	15.81 ± 0.541[ab]	19.05 ± 0.187[a]
Fast-Day 2	20.54 ± 0.178[a]	2.17 ± 0.089[a]	3.14 ± 0.199[b]	15.54 ± 0.535[ab]	19.22 ± 0.185[a]
Fast-Day 3	19.81 ± 0.264[a]	2.05 ± 0.132[a]	3.56 ± 0.297[ab]	14.86 ± 0.794[ab]	18.76 ± 0.275[a]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[c] Numerical standards for conformation, maturity, color of lean, marbling and final grade are listed in Appendix A.

Table 10. Adjusted Breed Means and Standard Error for Conformation, Maturity, Color of Lean, Marbling and Final Grade

Breed	No. of Observations	Conformation[c]	Maturity[c]	Color of Lean[c]	Marbling[c]	Final Grade[c]
Hereford	125	20.48 ± 0.118[a]	2.17 ± 0.059[a]	3.98 ± 0.133[a]	14.72 ± 0.356[a]	18.95 ± 0.123[a]
Angus	62	20.54 ± 0.161[a]	2.31 ± 0.081[a]	3.67 ± 0.181[a]	16.95 ± 0.485[b]	19.52 ± 0.168[b]
English-Beef Cross	61	20.45 ± 0.167[a]	2.25 ± 0.084[a]	3.53 ± 0.188[a]	15.51 ± 0.502[a]	18.93 ± 0.174[a]
Dairy-Beef Cross	52	19.76 ± 0.177[b]	2.09 ± 0.089[a]	3.58 ± 0.199[a]	15.27 ± 0.534[a]	18.81 ± 0.185[a]

[a,b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[c] Numerical standards for conformation, maturity, color of lean, marbling and final grade are listed in Appendix A.

Summary

From the results of this study, it would appear that fasting definitely affects slaughter weight of steers with the greatest percent shrink occurring in the first 24 hours of fasting. It would seem that complete feed-withdrawal, contrasted with continued feeding, has no effect on ultimate carcass yield for up to two days when cattle are held and slaughtered under conditions prevalent in this trial. A significantly lower hot and chilled carcass weight was noted after fasting cattle for three days. Thus, when cattle are to be moved directly from the feedlot to the packing plant, the advantage of complete or partial feed withdrawal two days prior to slaughter is obvious. No detrimental effects of fasting were noted on any of the carcass quality traits studied. A significant improvement was noted in the color of lean in the day 1 and day 2 fasted cattle as compared to those fed. Breed had a highly significant ($P < .01$) effect on conformation of the carcass, maturity score and marbling score, and a significant ($P < .05$) effect on final grade.

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CHAPTER II

THE EFFECT OF PRESLAUGHTER FASTING ON CHEMICAL PROPERTIES OF BOVINE MUSCLE AND LIVER TISSUE

Fasting is not a usual condition for animals, especially those that have been accustomed to full feed; consequently, animals handled this way are under considerable stress. The animal's ability to adapt to the fasting state involves many chemical changes in its physiological system.

Hall et al. (1961) reported that liver glycogen of fed hogs was significantly higher than that of fasted hogs. Robinson and Wilber (1955) found a decrease in glucose in the liver of goats fasted for 16 days. Kauflin, Hedrick and Stringer (1969) fasted 140 cattle and found the mean liver glycogen was significantly greater in the fed compared to those fasted. This would indicate that fasting definitely influences the metabolic processes of the liver.

The literature reports conflicting results concerning the effect of fasting on ultimate muscle pH. Callow (1938) and Henning and Stout (1932) observed that muscle from fasted hogs had higher ultimate pH values than muscle from fed hogs. In contrast, Cole and Backus (1967) reported that fasting hogs from zero to 96 hours produced significantly lower ultimate muscle pH. According to Lawrie (1966), steers can be fasted for up to 28 days without affecting ultimate muscle pH. Similar results were obtained by Hall, Latscher and Mackintosh (1944) when they fasted a steer for ten days.

Zessin et al. (1961) found that muscle from hogs on a sub-maintenance diet had poorer moisture holding properties than muscle from the controls. These findings agree with Lewis, Brown and Heck (1962) who reported that

expressible water values of the psoas major and quadriceps femoris muscles decreased when steers were fasted.

This investigation was conducted to determine the effect of fasting on muscle pH and water holding capacity; and glycogen and ether extract content of the liver.

Experimental Procedure

Two fasting trials involving 300 head of steers were conducted at the Circle E Feedyards, Potwin, Kansas. Fed cattle were continued on the normal ration and feeding regime; the fasted cattle were simply removed from feed. Both treatments had water ad libitum. Liver and muscle tissue samples were obtained from each carcass and used for various chemical analyses. The liver samples, weighing approximately 300 g. each, were acquired during the slaughtering process and immediately quick-frozen at -70° C. The muscle tissue samples, weighing approximately 75 g., were obtained after the carcasses had undergone a 24-hour chill.

Water holding capacity was determined on fresh muscle by a modification of two methods: 1) the press method of Grau and Hamm (1956) and 2) the centrifuge method of Wierbicki et al. (1957). Modification of the two methods are discussed thoroughly in the general section on experimental procedure. A sample of the longissimus dorsi was used for the press method, while the Wierbicki determination was conducted using a sample of the pars lumbalis (crura or pillars) of the diaphragm. Glycogen contained in the liver was determined by the procedure of Hansen et al. (1951) as modified in the manner presented in the general section on experimental procedure. The pH value of

ground muscle was determined by a Beckman Expandomatic pH meter using a special surface electrode. Ether extract content in ground liver samples was determined by a procedure outlined by A.O.A.C. (1960).

Results and Discussion

Effect of Fasting on Percent Moisture. Treatment had a highly significant ($P < .01$) effect on percent moisture from muscle tissue (table 11). Table 12 shows the means and standard deviations for muscle pH and percent moisture. Differences in means were tested using Duncan's new multiple range test as described by Harvey (1960). The day 3 fed cattle had significantly ($P < .05$) more moisture than all other treatments except the control group. These results are in agreement with Kirton, Clarke and Carter (1967) who fasted rams for 3 days. Chemical analyses of the carcasses showed that percent water had been reduced and carcass dehydration had taken place. Contrary to this, Cole and Miller (1968) found that fasting hogs did not affect the percent moisture of muscle tissue. However, Lewis, Brown and Heck (1963) reported that limited feeding of steers increased the moisture content of the longissimus dorsi, psoas major and quadriceps femoris.

The low moisture percentage found in the day 3 fasted cattle may be due to a decrease in water intake. Blaxter (1962), Meyer, Weir and Smith (1955) and Gupta (1966) all reported a decrease in water consumption in their fasted animals compared to the controls. This decrease in water consumption is probably attributed to the lack of feed intake. Water is the necessary medium for the transfer of dissolved nutrients to the cells and for the removal of waste products from the cells. Since the fasted cattle received no

Table 11. Analysis of Variance for Percent Moisture and Muscle pH

Source of Variation	d.f.	Mean Squares	
		Percent Moisture	Muscle pH
Treatment	6	15.22**	0.0090
Trial	1	0.0035	8.0453**
Breed	3	2.29	0.0271*
Treatment×Breed	18	1.47	0.0067
Trial×Breed	3	4.86	0.0091
Error	268	4.46	0.0088

* $P < .05$.

** $P < .01$.

Table 12. Adjusted Treatment Means and Standard Error for Percent Moisture and Muscle pH

Treatments	Percent Moisture	Muscle pH
Control	67.65 ± 0.334^{ab}	5.81 ± 0.0149^{a}
Fed - Day 1	68.54 ± 0.607^{d}	5.82 ± 0.0270^{a}
Fed - Day 2	68.44 ± 0.355^{cd}	5.77 ± 0.0158^{a}
Fed - Day 3	69.94 ± 0.538^{e}	5.77 ± 0.0240^{a}
Fast - Day 1	67.88 ± 0.408^{bc}	5.82 ± 0.0181^{a}
Fast - Day 2	68.10 ± 0.447^{cd}	5.77 ± 0.0199^{a}
Fast - Day 3	67.21 ± 0.508^{a}	5.78 ± 0.0226^{a}

a, b, c, d, e Means in the same column bearing a different superscript are significantly ($P < .05$) different.

feed, less water may be needed to carry on metabolism.

A decrease in metabolic water may also contribute to the decrease in percent moisture of the fasted cattle compared to the fed. Metabolic water is derived from the intracellular oxidation of organic substances or foodstuffs in the body. Fasted animals will probably have less metabolic water than fed animals since there will be less organic substances in the digestive tract to metabolize. Fat oxidation is also a source of metabolic water so fasting may or may not decrease water of oxidation.

Effect of Fasting on Muscle pH. Treatment had no effect on muscle pH in this experiment (table 11). Similar results were reported by Lawrie (1966), Hall et al. (1944), and Kauflin, Hedrick and Stringer (1969).

Trial had a highly significant ($P < .01$) effect on muscle pH (table 11) with breed having a significant ($P < .05$) effect. Trial 1 had significantly ($P < .05$) higher muscle pH values than did trial 2 (table 13). Much of the reason for this difference may be attributed to the use of two different muscles to determine muscle pH. A sample of the pars lumbalis (crura or pillars) of the diaphragm was used in trial 1 while a sample of the longissimus dorsi was used in trial 2.

It is shown in table 14 that the beef-crossbred cattle had significantly lower pH values than did the Angus or Hereford cattle. This difference may be due to temperament variations between straight-bred and crossbred cattle. The Angus steers had the highest pH values, followed closely by the Herefords. This may indicate that straight-bred cattle have a tendency to be more spirited and excitable than do crossbred cattle; consequently, they may be more susceptible to stressful conditions. Lewis, Brown and Heck (1961, 1962, 1963) showed that muscle from steers subjected to periodic electrical

Table 13. Adjusted Trial Means and Standard Error for Percent Moisture and Muscle pH

Trial	No. of Observations	Percent Moisture	Muscle pH
I	175	68.25 ± 0.237[a]	6.06 ± 0.0106[a]
II	125	68.26 ± 0.286[a]	5.52 ± 0.0127[b]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

Table 14. Adjusted Breed Means and Standard Error for Percent Moisture and Muscle pH

Breed	No. of Observations	Percent Moisture	Muscle pH
Hereford	124	68.53 ± 0.216[a]	5.80 ± 0.0096[a]
Angus	61	68.32 ± 0.284[a]	5.81 ± 0.0126[a]
English-Beef Cross	91	68.20 ± 0.265[a]	5.76 ± 0.0118[b]
Dairy-Beef Cross	24	67.97 ± 0.518[a]	5.79 ± 0.0230[ab]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

Table 15. Analysis of Variance for Percent Liver Ether Extract, Liver Glycogen Content and Percent Liver Moisture

Source of Variation	d.f.	Mean Squares: Percent Liver Ether Extract	Liver Glycogen Content[e]	Percent Liver Moisture
Treatment	6	88.62**	1327.89**	32.77**
Trial	1	17.70**	2.48	20.73**
Breed	3	2.83	60.57	4.64*
TreatmentxBreed	18	2.46**	100.55	2.45*
TrialxBreed	3	0.97	7.40	4.27*
Error	268	1.09	91.80	1.48

* $P < .05$.

** $P < .01$.

[e] Liver glycogen expressed in mg./g.

Table 16. Adjusted Treatment Means and Standard Error for Percent Liver Ether Extract, Liver Glycogen Content and Percent Liver Moisture

Treatments	Percent Ether Extract	Liver Glycogen Content[e]	Percent Liver Moisture
Control	1.34 ± 0.166[a]	18.05 ± 1.52[a]	72.75 ± 0.192[a]
Fed - Day 1	1.08 ± 0.301[a]	16.37 ± 2.76[a]	72.68 ± 0.350[a]
Fed - Day 2	1.23 ± 0.176[a]	17.75 ± 1.61[a]	72.30 ± 0.204[a]
Fed - Day 3	1.40 ± 0.266[a]	16.80 ± 2.44[a]	72.40 ± 0.310[a]
Fast - Day 1	2.90 ± 0.202[b]	5.66 ± 1.85[b]	72.59 ± 0.235[a]
Fast - Day 2	3.66 ± 0.221[c]	2.81 ± 2.03[b]	71.72 ± 0.257[b]
Fast - Day 3	6.61 ± 0.252[d]	3.12 ± 2.31[b]	69.09 ± 0.292[c]

[a, b, c, d] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[e] Liver glycogen expressed in mg./g.

stimulation for 24 hours preslaughter was elevated in pH. A combination of the stresses of fasting and slaughtering may have caused the straight-bred cattle to have higher muscle pH than the crossbreds.

Effect of Fasting on Water Holding Capacity. Fasting had no significant effect on muscle water holding capacity. Bramblett, Judge and Vail (1963) reported similar results when stressing sheep with electric shock and epinephrine and saline injections. Water holding properties were similar among the treatments whether measured as cooking loss, juice loss after centrifugation, or press fluid. Zessin et al. (1961) found that water holding properties were decreased when swine were put on a sub-maintenance diet. Lewis et al. (1962) reported a decrease in the expressible water values of the raw psoas major and quadriceps femoris muscles due to preslaughter stress of steers.

Effect of Fasting on Percent Liver Ether Extract. Treatment had a highly significant ($P < .01$) effect on percent ether extract from the liver (table 15). It can be seen in table 16 that liver ether extract values from all of the fasted groups were significantly ($P < .05$) different from each other and from all other treatments. The liver is considered a storage place for fats and also some protein. As an animal is fasted, the fat depots of the body are mobilized to provide the animal with the necessary energy to maintain normal body functions. As the days of fasting increased, the amount of fat mobilized to the liver from lipid depots also increased. These findings agree with those of Mitchell and Longwell (1964) who, after fasting rats from 4 to 30 hours, found that significantly more fatty acids were released compared to the controls. Also, Goodman and Knobil (1959) reported a marked increase in nonesterfied fatty acid concentration in fasted hypophysectomized

Table 17. Adjusted Trial Means and Standard Error for Percent Liver Ether Extract, Liver Glycogen Content and Percent Liver Moisture

Trial	No. of Observations	Percent Liver Ether Extract	Liver Glycogen Content[e]	Percent Liver Moisture
I	175	2.20 ± 0.118[a]	11.66 ± 1.08[a]	72.36 ± 0.137[a]
II	125	3.00 ± 0.142[b]	11.36 ± 1.30[a]	71.50 ± 0.165[b]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[e] Liver glycogen expressed in mg./g.

Table 18. Adjusted Breed Means and Standard Error for Percent Liver Ether Extract, Liver Glycogen Content and Percent Liver Moisture

Breed	No. of Observations	Percent Liver Ether Extract	Liver Glycogen Content[e]	Percent Liver Moisture
Hereford	124	2.78 ± 0.107[a]	12.46 ± 0.981[a]	71.62 ± 0.124[a]
Angus	61	2.30 ± 0.140[b]	11.24 ± 1.288[a]	72.07 ± 0.163[b]
English-Beef Cross	91	2.69 ± 0.131[a]	10.33 ± 1.204[a]	72.18 ± 0.153[b]
Dairy-Beef Cross	24	2.64 ± 0.256[ab]	11.99 ± 2.350[a]	71.85 ± 0.298[ab]

[a, b] Means in the same column bearing a different superscript are significantly ($P < .05$) different.

[e] Liver glycogen expressed in mg./g.

rhesus monkeys.

There was a significantly ($P < .05$) greater percent of liver ether extract in the trial 2 cattle compared to the cattle in trial 1. This difference is possibly due to the season of the year. Cattle may mobilize more fat in the liver during the winter months than they do in the summer.

Breed also had a significant ($P < .05$) effect on percent liver ether extract (table 18) with the Angus cattle having a significantly lesser amount of ether extract than did Hereford and beef cross bred cattle. This result is very difficult to explain. Possibly due to the excitable temperament of the Angus breed, their energy reserves were utilized more quickly, resulting in a more rapid turnover in metabolic fat in the liver. Table 15 shows a highly significant ($P < .01$) treatment-breed interaction indicating a difference between the breeds studied and their physiological response to fasting conditions.

Effect of Fasting on Glycogen Content. Treatment had a highly significant ($P < .01$) effect on the glycogen content of the liver (table 15) as all the fasted cattle had much lower glycogen levels than did the fed and control cattle (table 16). The liver is a major source of energy reserve for the body with glycogen being the primary energy source stored in this organ. In the normal animal with access to food, the quantity of glycogen in the liver remains relatively constant, being continuously formed and degraded; however, in a stressed animal, the stored glycogen is quickly mobilized and used for energy. There was no significant difference between cattle from the different days of fasting concerning liver glycogen content, but the values decreased from day 1 to day 2 fasting. A slight increase in glycogen content was noted between day 2 and day 3 fasted cattle. Kauflin, Hedrick

and Stringer (1969) reported similar results. The amount of glycogen in their fasted cattle declined until the fourth day of fasting when the glycogen increased. They concluded that apparently the cattle had become accustomed to the fast by that time. Howard and Lawrie (1956a, 1956b) reported conflicting results as they concluded that fasting normally had no effect on the glycogen reserves in steers.

Effect of Fasting on Percent Liver Moisture. Treatment had a highly significant ($P < .01$) effect on percent liver moisture (table 15) with the day 2 and day 3 fasted cattle having significantly less liver moisture than the other treatments (table 16). This agrees with the findings of Lewis et al. (1962) who reported that limited feeding of beef steers significantly decreased liver moisture. One possible explanation for the differences in percent liver moisture may be the increased amount of ether extract in the liver. There is an inverse relationship between percent liver moisture and percent ether extract in the liver. Those cattle fasted for three days had the highest percent ether extract and the lowest percent liver moisture. Another possible explanation which has been previously mentioned pertains to the water intake of the fasted cattle. Since feed and water intake are directly correlated, the fasted cattle probably consumed less water than the fed; and if less water is consumed, then there may be less moisture in the various tissues of the body.

Table 15 shows a highly significant ($P < .01$) difference in percent liver moisture between trial 1 and trial 2 with trial 1 having the highest percent liver moisture (table 17). Again, the same inverse relationship between percent ether extract and percent liver moisture prevails. Table 17 shows that trial 2 has the highest percent ether extract and the lowest

percent liver moisture. Season of the year may be partially responsible for this difference, especially if cattle tend to mobilize and use more fat in the winter. If fat mobilization in the liver is increased during the colder months, then the percent moisture would be expected to be lower.

Breed had a significant ($P < .05$) effect on percent liver moisture (table 15) with the Hereford cattle being significantly different from the Angus and English beef crossbred cattle (table 18). The inverse relationship between percent liver moisture and percent ether extract holds true in this case as the Hereford cattle had the highest percent liver ether extract but was one of the lowest in percent moisture.

Summary

It can be concluded from these findings that fasting cattle for 1, 2 and 3 days has a highly significant ($P < .01$) effect on all compositional factors of liver tissue studied and also on the percent moisture from muscle tissue. No treatment differences were noted for muscle pH. A trial difference was noted but can be explained as being due to the use of two vastly different muscles in determining the pH values. In trial 1, a sample of the pars lumbalis was used while in trial 2, a sample of the longissimus dorsi was used. Breed had a significant ($P < .05$) effect on muscle pH with the English beef crossbred cattle having significantly lower pH than Hereford or Angus cattle. This would seem to indicate greater muscle glycogen stores in these animals at the time of slaughter thus resulting in a lower final pH. There was no treatment effect on muscle pH. Breed and trial effects were noted on percent liver ether extract and moisture. No significant effects on muscle water holding capacity were found.

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Appendix A - Breed, Color of Lean, Quality Grade, Conformation Score, Maturity and Marbling Standards

Color of Lean	Breed	Quality Grade and Conformation Score
1) A^{-}	1) Hereford	24) Prime $^{+}$
2) A$^{(-)}$	2) Angus	23) Prime ^{0}
3) A	3) English Beef Breed Cross	22) Prime $^{-}$
4) A$^{(+)}$	4) Dairy-Beef Breed Cross	21) Choice $^{+}$
5) A^{+}		20) Choice ^{0}
6) B^{-}		19) Choice $^{-}$
7) B$^{(-)}$		18) Good $^{+}$
8) B		17) Good ^{0}
9) B$^{(+)}$		16) Good $^{-}$
10) B^{+}		

Maturity	Marbling		
1) A^{-}	30) Abundant $^{+}$		18) Modest $^{+}$
2) A^{0}	29) Abundant ^{0}		17) Modest ^{0}
3) A^{+}	28) Abundant $^{-}$		16) Modest $^{-}$
4) B^{-}	27) Moderately Abundant $^{+}$		15) Small $^{+}$
5) B^{0}	26) Moderately Abundant ^{0}		14) Small ^{0}
6) B^{+}	25) Moderately Abundant $^{-}$		13) Small $^{-}$
	24) Slightly Abundant $^{+}$		12) Slight $^{+}$
	23) Slightly Abundant ^{0}		11) Slight ^{0}
	22) Slightly Abundant $^{-}$		10) Slight $^{-}$
	21) Moderate $^{+}$		9) Traces $^{+}$
	20) Moderate ^{0}		8) Traces ^{0}
	19) Moderate $^{-}$		7) Traces $^{-}$

Appendix B - Trial 1 - Control

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
475	3	1290	1290	733	23	6	21	21
476	1	1105	1105	661	21	3	16	19
477	1	1270	1270	781	19	5	11	17
478	1	1070	1070	641	21	3	21	21
479	2	1270	1270	742	20	6	10	16
480	4	1460	1460	854	20	3	17	20
481	1	1150	1150	695	22	4	16	19
482	3	1255	1255	709	19	3	16	19
483	3	1255	1255	748	21	3	14	19
484	1	1150	1150	685	20	3	21	21
485	1	1250	1250	762	21	3	19	20
486	4	1275	1275	777	19	5	14	19
487	2	1155	1155	715	19	3	17	20
488	1	1245	1245	766	21	6	15	19
489	3	1245	1245	792	21	3	19	20
490	3	1230	1230	725	20	5	8	16
491	1	1340	1340	789	21	4	16	19
492	3	1035	1035	621	20	6	17	20
493	1	1280	1280	759	20	3	16	19
494	3	1310	1310	814	23	5	20	21
495	4	1460	1460	894	21	2	19	20
496	1	1095	1095	618	19	5	19	20
497	3	1140	1140	688	19	5	12	18
498	1	1080	1080	660	22	5	16	19
499	4	1295	1295	763	20	3	17	20
Eng. Mean		1228.40 lb.	1228.40 lb.	735.68 lb.	20.48	4.08	16.28	19.28
Metric Mean		557.09 kg.	557.09 kg.	333.64 kg.				

Appendix B - Trial I - Day I - Fasted

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Confor-mation Score	Color of Lean	Marbling Score	Final Grade
301	1	940	890	545	20	2	17	20
302	1	1195	1170	673	21	8	11	17
308	3	1350	1285	783	19	4	14	19
309	3	1110	1100	673	21	1	26	22
310	1	1170	1135	649	18	3	14	18
311	3	1070	1055	657	19	3	12	18
316	2	1170	1130	719	23	3	23	22
318	1	1150	1130	674	19	4	14	19
319	3	970	945	571	21	3	14	19
325	1	1270	1245	799	22	6	11	17
326	1	1010	975	582	19	5	14	19
328	1	1260	1220	736	21	5	16	19
330	1	1000	950	580	21	5	13	18
334	3	970	930	559	18	3	11	17
335	3	1150	1150	696	19	3	19	20
340	3	1170	1155	721	21	1	16	19
342	2	1060	1025	645	22	1	17	20
347	1	1220	1190	718	19	5	12	18
348	3	1175	1150	705	21	1	24	21
349	1	1005	990	698	18	5	11	17
351	1	1245	1225	746	22	5	14	19
353	1	1060	1060	670	22	3	18	20
357	1	1055	1035	659	21	3	17	20
362	3	1310	1285	829	22	2	15	19
368	3	1030	1000	628	20	5	11	17
Eng. Mean		1124.60 lb.	1097.00 lb.	676.60 lb.	20.36	3.56	15.36	18.96
Metric Mean		510.02 kg.	497.50 kg.	306.85 kg.				

Appendix B - Trial 1 - Day 1 - Fed

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
411	3	1130	1120	704	21	5	17	20
412	1	1010	1010	615	20	2	18	20
413	2	1210	1235	741	22	4	23	22
414	2	1300	1300	829	22	4	18	20
417	2	1100	1105	659	21	3	10	16
418	1	1270	1280	759	21	4	18	20
420	3	1160	1175	699	20	3	23	21
423 (NT)	1	1280	1275	758	21	4	11	17
426	1	1200	1205	731	21	3	13	18
428	1	1150	1145	682	21	5	19	20
429	3	1070	1075	616	21	4	14	19
434	1	1200	1200	680	18	4	14	18
435	1	1070	1080	665	22	4	16	19
437	1	1190	1205	741	19	4	11	17
443	3	1200	1200	745	21	4	14	19
444	3	1240	1260	726	20	3	20	21
445	1	1175	1200	707	20	3	20	21
452	1	1170	1175	681	21	8	12	18
454	1	1040	1060	626	20	4	19	20
457	1	1255	1265	755	22	5	13	18
458	3	1180	1195	701	19	5	11	17
465	1	1250	1270	742	19	5	18	20
470 (NT)	2	1100	1100	670	24	4	17	19
471	1	1210	1215	741	22	8	15	18
473	1	1145	1140	691	20	5	12	18
Eng. Mean		1172.20 lb.	1179.60 lb.	706.96 lb.	20.72	4.28	15.84	19.04
Metric Mean		531.60 kg.	534.96 kg.	320.62 kg.				

Appendix B - Trial I - Day II - Fasted

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
305	3	1250	1205	748	22	3	14	19
306	2	1110	1060	654	21	2	13	18
307	3	1030	1000	631	22	3	11	17
313	1	1330	1285	793	21	3	21	21
314	1	1180	1120	681	21	1	15	19
317	3	1250	1205	755	22	1	10	16
320	3	1130	1085	692	21	1	13	18
327	3	1195	1155	823	22	2	19	20
333	1	1270	1215	762	21	1	21	21
336	1	1195	1155	705	21	2	14	19
339	3	1190	1160	721	19	4	23	21
341	1	1080	1040	638	21	6	10	16
344	3	1000	965	587	20	8	17	20
346	3	1210	1165	742	22	2	15	19
350	2	1180	1130	644	20	3	14	19
352(377)	1	1225	1195	732	22	3	20	21
354(376)	1	1165	1125	686	20	4	14	19
355	3	1135	1095	682	21	4	12	18
364	3	980	930	532	19	5	9	16
365	1	1150	1105	720	21	2	14	19
366	1	1320	1290	778	20	5	15	19
367	4	1070	1010	601	19	3	12	18
369	3	1305	1260	799	22	3	18	20
370	1	1105	1065	631	20	4	17	20
374	2	1140	1095	676	20	2	14	19
Eng. Mean		1167.80 lb.	1124.60 lb.	696.52 lb.	20.80	3.08	15.00	18.88
Metric Mean		529.61 kg.	510.02 kg.	315.88 kg.				

Appendix B - Trial I - Day II - Fed

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
402	4	1185	1190	677	18	4	13	18
403	3	1185	1190	719	19	4	15	19
404(398)	2	1250	1230	740	22	5	17	20
405	1	1010	1020	569	18	3	10	16
407(394)	3	1035	1065	646	19	6	16	19
408	4	1260	1285	709	18	5	9	16
409	1	1160	1140	685	21	3	11	17
410	2	1070	1070	607	20	6	11	17
422	1	1210	1185	715	19	2	9	16
424	1	1280	1280	800	21	4	21	21
425	3	1235	1235	756	21	5	23	21
427(395)	2	1120	1125	665	19	3	16	19
433	3	1080	1085	636	19	5	9	16
438	1	1200	1185	750	22	3	20	21
440	1	1250	1260	778	19	5	11	17
441(399)	2	1230	1240	753	22	5	19	20
442(396)	1	1110	1100	636	21	5	12	18
449	4	1115	1145	626	18	6	16	18
455	2	1115	1135	690	22	3	21	21
459	2	1070	1075	645	20	3	15	19
462(397)	1	1240	1260	768	21	1	22	21
467	2	1210	1185	765	21	3	14	19
468	1	1220	1235	745	20	6	14	19
469	4	1190	1190	692	20	6	14	18
472	2	1445	1465	890	23	3	15	19
Eng. Mean		1179.00 lb.	1183.20 lb.	706.48 lb.	20.12	4.16	14.92	18.60
Metric Mean		534.69 kg.	536.59 kg.	320.40 kg.				

Appendix B - Trial I - Day III - Fasted

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
300(802)	1	1340	1245	767	21	3	15	19
303(812)	1	1310	1245	792	21	3	15	19
304(815)	2	1210	1165	665	18	5	14	18
312(804)	3	1275	1225	751	19	3	18	20
315(801)	2	1185	1115	685	19	4	19	20
321(800)	2	1130	1080	669	19	1	14	19
322	1	1120	1055	640	19	3	15	19
323(817)	4	1300	1260	754	19	2	9	16
324(806)	3	1085	1030	648	19	4	12	18
329(809)	1	1130	1050	634	22	5	11	17
331	1	1100	1085	650	20	5	18	20
332	1	1230	1155	729	20	4	17	20
337	1	1160	1100	698	22	2	12	18
338(816)	3	1060	1015	662	19	6	16	19
343(810)	4	1280	1205	719	18	5	18	19
345(814)	2	1260	1205	753	21	4	16	19
356(803)	1	1290	1235	758	22	4	14	19
358(811)	1	1100	1045	648	19	5	11	17
359(807)	4	1025	975	610	21	3	9	16
360	1	1230	1180	716	19	3	10	16
361(818)	4	1240	1205	760	21	5	15	19
363	3	1210	1165	722	19	4	15	19
371(805)	1	1130	1070	642	21	3	15	19
372(808)	1	1250	1170	703	19	3	14	19
373(813)	2	1290	1240	787	21	5	17	20
Eng. Mean		1197.60 lb.	1140.80 lb.	702.48 lb.	19.92	3.76	14.36	18.56
Metric Mean		543.12 kg.	517.36 kg.	318.58 kg.				

Appendix B - Trial I - Day III - Fed

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
400(898)	3	1360	1380	878	22	3	9	16
401	1	1060	1045	592	20	1	9	16
406	2	1340	1340	795	21	4	21	21
415(892)	1	1120	1125	675	19	3	12	18
416	1	1130	1155	690	19	5	11	17
419	3	1210	1200	737	22	4	9	16
421(895)	1	1230	1245	784	20	5	18	20
430(890)	1	1080	1100	672	19	5	14	19
431	3	1310	1315	798	21	5	14	19
432(897)	3	1060	1065	663	19	5	15	19
436	1	1030	1065	637	19	5	18	20
439(896)	1	1320	1330	820	21	5	18	20
446(899)	2	1050	1065	648	19	5	18	20
447	2	1275	1290	761	21	5	18	20
448	1	1225	1260	762	20	5	13	18
450(894)	1	1305	1325	848	22	3	14	19
451	2	1290	1300	758	18	5	13	18
453	4	1340	1355	782	19	4	11	18
456	4	1120	1135	675	18	3	14	18
460	3	1210	1220	722	19	4	17	20
461(889)	2	1110	1120	653	21	5	11	17
463	2	1190	1185	707	20	1	14	19
464(891)	1	1185	1185	672	22	8	11	17
466(893)	2	1120	1120	697	21	5	14	19
474	3	1140	1150	727	22	4	12	18
Eng. Mean		1192.40 lb.	1203.00 lb.	726.12 lb.	20.16	4.28	13.92	18.48
Metric Mean		540.77 kg.	545.57 kg.	329.31 kg.				

Appendix C - Trial II - Control

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
901	3	1135	1135	705	20	3	11	17
902	1	1180	1180	706	22	5	26	23
903	3	1220	1220	745	18	3	16	19
904	4	985	985	570	18	1	11	17
905	2	1110	1110	667	21	5	21	21
906	2	1035	1035	631	23	3	13	18
907	2	1240	1240	744	21	3	22	21
908	1	1260	1260	757	21	3	19	20
909	2	890	890	534	21	3	17	20
910	2	1110	1110	672	21	3	17	20
911	1	985	985	595	20	3	11	17
912	4	1155	1155	680	21	3	17	20
913	1	1025	1025	601	20	5	17	20
914	1	1330	1330	800	22	3	16	19
915	3	1065	1065	628	19	3	12	18
916	3	1200	1200	727	24	3	30	24
917	2	1180	1180	682	18	3	10	16
918	1	1180	1180	671	22	5	12	18
919	1	1185	1185	697	22	1	16	19
920	3	1145	1145	665	19	3	23	21
921	3	1110	1110	666	19	3	16	19
922	3	1175	1175	680	20	3	19	20
923	2	1185	1185	695	22	3	21	21
924	2	1045	1045	619	21	5	24	21
925	2	1335	1335	816	21	5	21	21
Eng. Mean		1138.60 lb.	1138.60 lb.	678.12 lb.	20.64	3.32	17.52	19.60
Metric Mean		516.37 kg.	516.37 kg.	307.54 kg.				

Appendix C - Trial II - Day I - Fasted

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
702(949)	1	1020	985	562	20	5	11	17
703(945)	4	1135	1090	670	20	3	12	18
706	1	1020	990	600	23	5	14	19
709(932)	3	1230	1155	723	21	5	18	20
712(943)	4	990	950	583	22	3	19	20
716(936)	2	1280	1220	763	21	5	26	21
717(946)	2	990	940	543	18	3	16	19
718(941)	1	1130	1045	634	21	1	18	20
720(938)	4	1310	1230	722	19	5	16	19
722(528)	2	1025	990	660	23	3	14	19
724	1	1200	1165	717	21	3	13	18
725	1	1325	1295	770	21	5	18	19
729(942)	3	1175	1140	684	22	1	18	20
730(947)	1	1240	1185	751	20	3	14	19
733(934)	3	1030	1005	617	20	5	12	18
736(940)	4	1115	1075	686	20	1	12	18
737	1	1345	1290	766	20	3	14	19
738(935)	3	1310	1275	794	20	3	22	21
740	3	1225	1195	744	21	3	15	19
741(944)	2	1195	1095	681	19	3	18	20
742	3	1100	1060	659	21	3	18	20
743(937)	2	1245	1165	680	19	3	13	18
748(948)	1	975	930	544	21	5	12	18
749(933)	3	1120	1065	648	20	3	11	17
710(939)	3	1260	1195	736	20	3	11	17
Eng. Mean		1159.60 lb.	1109.20 lb.	677.48 lb.	20.52	3.40	15.40	18.92
Metric Mean		525.89 kg.	503.03 kg.	307.25 kg.				

Appendix C - Trial II - Day 1 - Fed

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Confor-mation Score	Color of Lean	Marbling Score	Final Grade
950	1	1065	1030	617	21	5	16	19
951	2	1070	1080	648	20	3	16	19
954(930)	1	1175	1180	681	20	5	12	18
957	1	1305	1290	764	21	5	11	17
958	4	975	965	587	22	3	19	20
959	1	1150	1140	680	21	5	20	21
961	2	940	930	543	19	1	15	19
962	1	1060	1060	614	21	3	14	19
963	1	1120	1100	646	20	5	16	19
964	1	1065	1055	622	19	3	11	17
967	2	990	965	526	19	5	15	19
969	2	1365	1345	808	20	5	18	20
970	2	1140	1145	642	20	5	13	18
971	3	1300	1290	763	22	3	19	20
972	3	1245	1240	731	22	3	13	18
976	1	1000	985	587	20	3	9	16
978	2	1210	1230	753	21	6	20	20
979	1	1080	1080	651	21	3	10	16
981	1	1020	1020	585	20	5	20	21
984	1	1170	1165	711	21	5	16	19
986	1	1110	1110	633	20	3	15	19
988	3	1255	1245	749	23	5	21	21
989	3	1155	1140	702	23	1	15	19
990	1	1265	1265	713	20	5	12	18
998(931)	2	1050	1045	664	23	5	23	22
Eng. Mean		1143.00 lb.	1128.00 lb.	664.80 lb.	20.76	4.00	15.56	18.96
Metric Mean		518.36 kg.	511.56 kg.	301.50 kg.				

Appendix C - Trial II - Day II - Fasted

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
701(511)	2	1100	1015	634	19	3	18	20
704(514)	2	1285	1215	766	20	3	18	20
705(517)	3	1195	1155	718	20	3	16	19
707(508)	3	1195	1150	708	20	3	19	20
708(516)	3	1120	1060	641	19	1	18	20
711(513)	3	1350	1290	827	19	3	12	18
713(515)	1	1235	1150	717	21	5	11	17
714(507)	2	985	930	754	20	3	18	20
715(512)	1	1130	1040	638	20	5	20	21
719(518)	1	1255	1185	760	22	1	14	19
721(509)	1	1135	1080	654	18	5	15	18
723(522)	3	1410	1340	851	23	6	14	18
726(502)	4	1205	1150	708	19	3	19	20
727	3	1255	1210	622	22	3	11	17
728(503)	3	1290	1245	766	20	3	17	20
731(500)	1	1080	1065	649	21	1	19	20
732(506)	1	1170	1100	674	21	5	11	17
734(520)	3	1120	1080	680	22	1	18	20
735(505)	2	1245	1175	753	21	3	14	19
739(928)	1	1110	1085	661	23	3	14	19
744(521)	2	1095	1010	614	19	5	17	20
745(510)	2	1275	1205	778	21	5	21	21
746(927)	3	1200	1215	720	21	3	19	20
747(519)	1	1210	1140	723	19	3	19	20
750(523)	3	1340	1275	783	20	3	15	19
Eng. Mean		1199.52 lb.	1142.60 lb.	711.96 lb.	20.40	3.28	16.28	19.28
Metric Mean		544.00 kg.	518.18 kg.	323.62 kg.				

Appendix C - Trial II - Day II - Fed

Steer No.	Breed	Initial Weight	Weight Off Test	Chilled Carcass Weight	Conformation Score	Color of Lean	Marbling Score	Final Grade
952(553)	3	1075	1065	630	21	3	12	18
953(557)	2	855	860	473	19	1	21	21
955	3	1220	1215	717	18	3	15	18
956	1	1160	1145	693	21	5	17	20
960	1	1210	1170	691	20	5	14	19
965(560)	3	1180	1150	711	21	5	18	20
966(558)	2	1090	1060	614	20	3	19	20
968	3	1310	1280	808	22	5	18	20
973(552)	1	1035	1045	615	19	5	20	21
974	1	1190	1190	698	21	5	15	19
975	4	1000	995	571	18	3	17	19
977(507)	3	1090	1070	646	19	5	16	19
980	3	1320	1290	743	20	1	19	20
982	1	1185	1200	705	20	5	10	16
983(556)	3	1090	1065	638	21	3	19	20
985	3	1160	1145	706	22	3	16	19
987(551)	3	1305	1315	790	20	3	24	21
991(555)	3	1060	1040	608	19	5	15	19
992(562)	1	1095	1075	621	20	3	11	17
993(561)	1	990	985	556	20	6	11	17
994	1	1255	1240	743	21	5	12	18
995(554)	3	1435	1410	829	21	3	26	22
996(550)	2	1065	1050	614	20	5	19	20
997(559)	1	1100	1065	651	21	3	19	20
999(563)	3	1100	1075	590	19	6	16	18
Eng. Mean		1131.20 lb.	1124.00 lb.	666.44 lb.	20.12	3.96	16.76	19.24
Metric Mean		513.01 kg.	509.75 kg.	302.24 kg.				

PRESLAUGHTER FASTING OF BOVINE AND ITS EFFECT ON CARCASS CHARACTERISTICS

by

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B. S., Kansas State University, 1969

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ABSTRACT

This experiment was conducted to study the effects of fasting on various carcass characteristics. The project involved two separate trials and a total of 300 steers. Fed cattle were continued on a normal ration; the fasted cattle were simply removed from feed. The treatment group was fasted for one, two and three days in trial one, while in trial two, the group was fasted for one and two days. Both treatments had water available ad libitum. The cattle were transported 20 miles and slaughtered at the Excel Packing Company in Wichita, Kansas. Carcasses were chilled for 24 hours and complete carcass data was collected.

Treatment had a highly significant ($P < .01$) effect on slaughter weight and a significant ($P < .05$) effect on hot and chilled carcass weight. Highly significant ($P < .01$) breed effects on hot and chilled carcass weight were also noted. The English-beef crossbred steers had significantly ($P < .05$) greater hot and chilled carcass weights compared to the dairy-beef crossbred steers. Trial had a highly significant ($P < .01$) effect on slaughter weight, hot carcass weight, and chilled carcass weight.

Treatment had a significant ($P < .05$) effect on color of lean with the fasted cattle possessing the most desirable color of lean.

Treatment significantly ($P < .05$) affected marbling scores, while breed had a highly ($P < .01$) significant relationship with this carcass characteristic. There was no trend in comparing the amount of marbling in the fasted and fed cattle; however, the Angus steers possessed a significantly ($P < .05$) greater amount of marbling than did the other breeds.

A significant ($P < .05$) breed effect on final grade occurred with the

Angus cattle being significantly ($P < .05$) higher grading compared to the other breeds.

Treatment had a highly significant ($P < .01$) effect on percent moisture in muscle tissue with the fasted cattle having the lowest moisture percentages.

Treatment, trial and treatment-breed interaction all had a highly significant ($P < .01$) effect on percent ether extract in the liver, while breed had a significant ($P < .05$) effect on this characteristic. The fasted cattle had a significantly ($P < .05$) greater amount of ether extract than the fed cattle.

A highly significant ($P < .01$) decrease in glycogen content of the liver was noted in the fasted cattle compared to the fed; trial and breed had no significant effects.

Treatment and trial had a highly significant ($P < .01$) effect on percent liver moisture; while breed, treatment-breed interaction, and trial-breed interaction were all significantly ($P < .05$) related to percent liver moisture. The fasted cattle generally had a lower liver moisture percentage than did the fed.

Trial had a highly significant ($P < .01$) effect on muscle pH with trial 1 having significantly higher muscle pH values than trial 2. The use of two different muscles for determining muscle pH may have caused the significant effect.

Breed was also significantly ($P < .05$) related to muscle pH. The straight-bred cattle had significantly ($P < .05$) higher muscle pH values compared to the beef crossbred cattle.

No significant effects on muscle water holding capacity were found.