VARIATION IN PERFORMANCE AND CARCASS CHARACTERISTICS OF LITTERMATE SWINE

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Larry K. Johnston

1957

VARIATION IN PERFORMANCE AND CARCASS CHARACTERISTICS OF LITTERMATE SWINE

By

Larry K. Johnston

AN ABSTRACT

Submitted to the College of Agriculture
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Animal Husbandry

1957

This study was originated to supplement and increase the amount of data reported by Vorkapich (42) in an earlier and similar study. A litter of purebred Duroc pigs was put on test in the fall of 1955 and a litter of purebred Hampshires was started in the spring of 1956. Both litters were individually fed, with the Durocs having free access to a self-feeder and the Hampshires having limited access to a self-feeder. The main object of this experiment was to study the within-litter variation of performance and carcass characteristic data as they may affect swine evaluation programs along with existing relationships between various measurements.

Some results reported in this study were not in accordance with those found by Vorkapich (42). Some measurements showed a significant amount of variation between breeds, and in all cases there was considerable variation within the litter for any characteristic considered. No significant differences between breeds was found for feedlot weight, slaughter weight, carcass length, fat trim percentage or shear value of the roasted chop.

Differences between breeds which were significant were chilled carcass weight and cooking loss by roasting. Highly significant differences between breeds were found for initial weight, days on feed, average daily gain, feed consumed per 100 pounds of gain, slaughter age, dressing percentage, live probe, backfat thickness, loin lean area of the 10th and last ribs, primal cut-out live and carcass bases, lean cut-out live and carcass bases, specific gravity of the *Longissimus dorsi* (center portion), shear value of the deep fat fried chop and cooking loss of the deep fat fried chop.

The live probe estimate of backfat thickness seemed to be a valid one, due to the highly significant relationship between the two. Live probe proved only slightly less reliable in predicting other carcass traits than actual carcass backfat. Both live probe and backfat thickness gave high negative correlation coefficients with primal and lean cut-outs on live and carcass bases, loin lean area of the 10th and last ribs and fat trim. Backfat thickness yielded a highly significant negative relationship with specific gravity of the Longissimus dorsi (center loin portion), whereas live probe yielded a lower but significant negative relationship.

The area of lean in the loin measured at either the 10th or last rib was highly related with primal and lean cut-out percentages for both live and carcass bases. However, the last rib gave consistently higher relationships with all measures than the 10th rib. Significant correlation coefficients were found between either loin lean area and the specific gravity of the Longissimus dorsi muscle (center loin portion). The specific gravity of this muscle portion did not prove to have an exceptionally high relationship with any of the other measures. Backfat thickness, live probe, and loin lean area of the 10th and last ribs proved the best estimates of primal and lean cut-out on both bases.

Significant differences between litters for cooking loss and shear values were found for both roasting and deep fat frying. No significant difference in shear value was noted between deep fat frying and roasting, indicating that both had the same effect on tenderness. Cooking loss difference was significant at the 5 percent level between deep fat frying and roasting. The effect of season, feeding method, and breed could not be separated for statistical analysis.

VARIATION IN PERFORMANCE AND CARCASS CHARACTERISTICS OF LITTERMATE SWINE

By

Larry K. Johnston

A THESIS

Submitted to the College of Agriculture
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Animal Husbandry

1957

ACKNOWLEDGEMENT

The author is deeply indebted and wishes to express his sincere appreciation to L. J. Bratzler, Professor of Animal Husbandry, for his interest, patience and constructive suggestions throughout this study and for his aid in the critical reading and preparation of this manuscript. A large debt of gratitude is also owed Dr. A. M. Pearson, Associate Professor of Animal Husbandry, for his aid in the collection of data and for his many suggestions regarding the writing of this manuscript.

Acknowledgement and appreciation is also due to Mrs. Beatrice Eichelberger for her effort and aid given in the typing and final preparation of this study. A word of appreciation is also extended to all other persons who so willingly gave their time to make this manuscript a reality.

Last, but not least, this writer offers everlasting thanks and gratitude to his parents, whose never-ending encouragement and assistance has been invaluable.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

INTRODUCTION

Never in the history of the swine industry has there been such widespread interest in obtaining performance and carcass value information to help the breeder and producer do a better job of selecting and mating for improvement. This interest has stemmed from the increasing consumer preference for leaner, heavier-muscled pork; and from the surplus lard problem which has put so much emphasis on the production of so called "meat-type" hogs. At present, most breed associations have adopted some kind of a recognition program for searching out and developing meat-type hogs. Experiment stations, extension workers and organized swine producing groups have established testing and recognition programs.

There has long been a need for such work and its possibilities are unlimited. Hog growers have been asking for more effective information about potential breeding animals. The Certified Meat Hog Program has demonstrated that both breeders and commercial hog growers want seed stock of proven merit and will pay to get it when they have some assurance that they are actually getting something superior. However, with any program many problems and inconsistencies are bound to develop. It was the purpose of this experiment to study and evaluate just a few of these problems.

Zobrisky et al. (48) stated that the solution to the production of a meat-type hog does not lie solely in a specific plan of management or in any given breed. Rotational cross breeding programs, selection and breeding for meatiness, controlled feeding or any combination of these have been suggested as means of producing and marketing leaner, meatier

hogs. They defined a meat-type hog as well balanced, heavily muscled, well developed in the ham and loin, firm in flesh, trim of underline and jowl and carrying enough finish to produce a firm, high quality, high yielding carcass. As many ideas, definitions, and standards exist for meat-type hogs as there are truly "meat-type" hogs.

It is unfortunate that there is so much variation in the required standards (on the same factors) set up by present testing and evaluation programs. However, due to the relative newness of the program and lack of data to support any specific standards, there must be some point from which to begin. Standardization of factors involved will come whenever conclusive data are presented to support such standards.

Most States which now have hog evaluation programs require the submission of a barrow and gilt from each litter for evaluation purposes. The entire litter must meet certain standards, such as, weight for age, soundness and number weaned. The two littermates submitted by the producer must conform to certain requirements for rate of gain, feed efficiency and carcass excellence to qualify for litter Certification. In Michigan, to become Certified "Meat-type", the two test pigs must: average 200 pounds at 6 months of age; make 100 pounds of gain on 370 pounds of feed; have a primal cut yield of 49 percent based on shrunk slaughter weight; have a maximum backfat thickness of 1.75 inches; have a minimum carcass length of 28.5 inches; and have a loin eye area of 3.5 square inches or more.

These testing and evaluation programs have greatly increased the need for simple and accurate methods for estimating the desirable traits

of swine to serve as a guide in discovering and selecting these leaner, meatier pigs. Price (38) stated that a simple tool for evaluation of the desirable carcass qualities must measure cutting percentages and provide an estimate of muscling. Therefore, it is easily seen that objective swine carcass evaluation is an important and vexing problem which must receive considerable attention if the Meat Type Hog Program is to progress rapidly and accurately.

Hetzer _et al_. (26) found that certain external live measurements showed a definite relationship with yield and muscling but their usefulness was limited at best both by lack of accuracy and repeatability. Bratzler and Margerum (3) concluded that considerable training was needed to accurately grade live hogs of all weights by eye appraisal. A great deal of variation was found within weight groups and other economically important traits were difficult to estimate accurately and consistently.

Studies have shown that some measures are highly significant in evaluating pork carcasses. Specific gravity, live hog probe, primal cut yield, lean cut yield and loin lean area have all been used with some degree of success in evaluating carcasses for leanness and meatiness. Backfat thickness and carcass length as now used in the U.S.D.A. Grade Standards for pork carcasses do not closely predict many of the desirable carcass traits.

This study was undertaken to: (a) increase the amount of data obtained by Vorkapich (42) in a similar study; (b) evaluate the existing relationships of certain live hog and carcass measurements to the yield of primal and lean cuts; (c) determine the effect of different cooking

methods on tenderness measures; (d) study variation in performance and carcass characteristics of littermate swine.

REVIEW OF LITERATURE

Nutrition

Various attempts have been made to produce leaner, meatier hogs by (1) restricting feed intake, (2) addition of fibrous material to the ration and (3) addition of minerals to make the ration less palatable. Crampton (9), studying the effect of self versus hand feeding on carcass measurements and quality, found that the self-fed hogs gained less and required longer to reach market weight. They also required 50 pounds more feed to reach market weight. The self-fed pigs were shorter by about 7/8 inch but otherwise no significant carcass differences were noted.

Crampton (10) stated that rate of gain could not safely be taken as an index of probable ultimate carcass quality. It was further evidenced by simple correlation that rate of gain was not related to the length of side nor to the leanness of the carcass. Length was not associated significantly with leanness and there was no relationship between rate of gain and carcass excellence.

Crampton *et al.* (11) reported that the restriction of feed intake during the finishing period increased the quality of the hog carcasses for bacon by reducing the deposition of fat and increasing the size of the *Longissimus dorsi* muscle. They concluded that unless the restriction in feeding can result in a decline in growth rate (25%) there is no practical effect of feed intake on carcass grade; and that it makes little difference what factor causes reduction in weight gains during the finishing

period to obtain a leaner carcass. Lean-fat proportions of the hog carcass were correlated with the size of the loin muscle (Longissimus dorsi).

Leaner market hog carcasses were produced when the energy level of the rations was appreciably reduced, according to Jordan et al. (28). This was accomplished by eliminating grain from the ration; limiting corn intake by hand feeding and mixing high levels of minerals with ground corn. Fifty to 70 percent of full-feed was desirable to increase proportion of lean to fat in the carcasses without seriously reducing rate of gain or lengthening the feeding period. A decreased feed efficiency was noted.

Headley (24) found a straight line relationship between feeding level and daily gain; and a curvilinear relationship between daily gain and liveweight. Variations in gain were due in part to differences in quality and quantity of protein, feed composition, and inherited characteristics of the individual animal and breed. Winters et al. (47) concluded that somewhat effective selection could be accomplished on the basis of high feed efficiency records because less nutrients were required to produce a pound of lean than a pound of fat. Pigs self-fed the entire feeding period yielded the fattest carcasses while pigs fed 3 percent of body weight the entire feeding period yielded the leanest carcasses. Pigs fed by methods between these two groups were similar and intermediate in fatness.

Rust (40), studying the effects of delayed castration and restricted feeding on the growth and carcass characteristics of hogs, found that the restriction of feed intake increased the efficiency of production of pounds of pork when accomplished by limited hand-feeding (75% full feed)

and by bulking the ration. Restriction of feed intake significantly slowed rate of gain and both castration and restricted feeding increased leanness, primal cut yield and lean cut yield as well as a higher percentage lean area of the rough loin. No significant differences were noted in body length, leg length, average backfat thickness or dressing percentage.

Merkel *et al.* (34), using high fiber rations to reduce T.D.N., noticed that restriction of T.D.N. caused an increase in the length of feeding period and depressed daily gain. Dressing percentage and backfat thickness were decreased and significantly leaner, firmer, superior grading carcasses were produced with the exception of the low T.D.N. lot (62%). Length was significantly increased and no difference was noted in color of lean or the loin lean area.

Crampton *et al.* (12) found that the quality of the bacon carcass could be improved by "diluting" relatively highly digestible rations with fibrous feeds during the finishing period. Carcass improvement was accompanied by a decrease in rate of gain and an increase in the length of feeding period. Some inconsistencies arose and presumably other factors inherent in the specific ration combinations exerted an effect on the extent of fat deposition in the body.

Breeding

Dickerson *et al.* (15), selecting for efficiency of gain in Duroc swine, found the correlation between littermates, among progeny of the same strain and year of dam and progeny was .23 for feed requirements,

and .37 for daily gain. Selection was based largely on differences between littermates. These differences were found to be about 24 percent heritable. Dickerson *et al.* (16), in a further and more complete study, reported that different genes affect muscle growth and fat deposition. Heritable increases in rate of gain were associated with more fat and less muscle and bone in the carcass.

Herbert and Crown (25), studying carcass quality characteristics of market barrows and gilts, found that gilt carcasses yielded a higher percentage of ham and loin, larger lean loin area and a higher percentage of separable lean in the hams than did barrows. The difference was highly significant and average backfat was significantly greater in barrows than in gilts.

Live Animal Evaluation

Ferrin (17) stated that changes in swine type which have been made were the results of fads and fancies to a larger extent than they were dictated by consumer preference. It was reported that hogs weighing 225 pounds, measuring 46 to 48 inches in body length and 29 to 31 inches in carcass length produced a higher proportion of desirable carcasses than hogs longer than 48 inches in body or 31 inches in the carcass. According to Hammond and Murray's findings (20), the live weight of the hog affects dressing percent more than breed or type. They stated that the subcutaneous fat develops earliest at the shoulder, next over the rump and last on the loin. The slackening of growth was greatest in the shoulders and least in the loin. The region of the last rib is the latest maturing part

of the body; therefore, the carcass should be cut at this point to obtain a proper estimate of its development. Backfat thickness varied in the different breeds for any given length of side.

Loeffel et al. (31) concluded that the predictive value of weight as an indicator of leanness was inadequate when working in a narrow weight range. As pigs progressed in weight the thickness of backfat increased and percentage lean cuts decreased. Hankins and Ellis (21) reported that backfat thickness was more closely related to carcass fatness than were weight and linear measures. Backfat thickness provided a +0.84 correlation with percent fat or ether extract in the edible portion of the carcass. Slightly less than 50 percent of the variation in fat content of the carcass was associated with weight alone, when the latter was regarded as an independent factor.

McMeekan (33) found that external measurements of the carcass did not provide reliable indications of carcass quality as estimated by visual appraisal. Visual observations were indicative of skeletal development, but showed little promise in prediction of carcass composition. Hetzer et al. (26) reported on the study of eight live hog measurements. Depth of middle was the most important item in determining the primal cut yield. They concluded that although certain body measurements showed a definite relationship with yield, their usefulness was rather limited. Bratzler and Margerum (3) concluded from their study that live hog evaluation was inadequate for accurate estimation of pork carcass value. The estimation of preferred cut yield proved the most difficult, while a closer

relationship between live scores for finish and length and carcass measurements was obtained with lighter weight hogs.

Cole *et al.* (8) reported a highly significant correlation between type and dressing percentage. Rangy hogs were found to have a higher percentage of their live weight in primal cuts, with the advantage diminishing as the live hog approached 300 pounds. Kill weight was probably a more constant basis for determining cutting yields as the total percent of primal cuts based on packer or shipper style carcasses decreased as the live hog weight increased. Lasley *et al.* (30) proved that carcass weight was more highly correlated with most traits than was shrunk liveweight. Squared multiple correlation coefficients gave a .44 percentage figure when shrunk live weight and live probe were correlated with lean cut percentages.

Live Probe

In an attempt to find a rapid and accurate method of measuring carcass value in prospective breeding animals, Hazel and Kline (22) developed the live probe method for estimation of backfat thickness. A correlation of +0.81 was found between live probe and actual backfat measures. Four sites were chosen for probing, these being: behind the shoulder, middle of the back, middle of the loin and middle of the loin over the lumbar vertebra. The location behind the shoulder was the most accurate single indication of carcass fatness and the middle of the back the least accurate. The average of the four live probes appeared to be a more accurate indicator of leanness and carcass value than did the carcass backfat mea-

surements. All correlations involving backfat measurements and carcass value were negative. These results were substantiated by Zobrisky et al. (48). Significant negative correlations were found between the live probe and lean cut-out with similar but somewhat lower relationships for live probe with primal cut-out and live probe versus total fat.

Hazel and Kline (23), in a further study, reported correlations between the percent lean cuts, percent fat cuts and the live probe as follows: behind shoulder over Longissimus dorsi, -0.69, +0.79, middle of the back, -0.55, +0.54, middle of the loin, -0.70, +0.76, middle of the loin over the lumbar vertebra, -0.48, +0.53. The correlations between four carcass backfat measurements and the percentages of lean cuts and fat cuts were -0.75 and +0.79, respectively. The sites behind the shoulder, over the loin, and top of the ham had the greatest accuracy. Some sites reflected fatness and leanness as accurately as backfat measurements.

Depape and Whatley (14), in a study of the live probe used at monthly intervals from 56 pounds to market weight, reported that probing at earlier ages to be low in predictive value. A combination of probes behind the shoulder and over the loin on both sides proved to be the most useful studied. A correlation coefficient of +0.69 was observed between live probe and carcass backfat measurements. This study further substantiated the results of Hazel and Kline (23). The average of 6 probes was more highly correlated with percent primal cuts, carcass index and ham specific gravity than was actual carcass backfat thickness. They further reported that all correlations rose as the ages and weight of the animals increased.

No significant correlations were found by Vorkapich (42) between carcass backfat thickness and average live probe, shoulder probe or last lumbar probe. Pearson et al. (37) reported a correlation of +0.78 between the lean meter and live probe for usefulness in predicting carcass measurements. Results indicated a slight advantage for the live probe over the lean meter. A correlation of +0.70 and +0.71 between carcass backfat and live probe and lean meter, respectively, was observed.

Hetzer et al. (27), studying live probe at various weights and locations, found the correlation increased from +0.32 to +0.72 as the pigs grew from 150 to 225 pounds between live probe and carcass backfat measurements. Gilts were found to possess significantly less average backfat than barrows. Zobrisky et al. (48) stated that a reasonably accurate estimate of the live hog's value could be determined from the live probe or carcass backfat measurements. Yields of fat could be more easily and accurately determined than the yield of lean.

Carcass Evaluation

Hankins and Ellis (21) found a correlation coefficient of +0.77 between the percentage fat and backfat thickness at the seventh vertebra. In this study, backfat thickness was more highly correlated with percentage fat than any other measure tested. Warner et al. (43) found that percentage fat cuts was correlated with percentage fat in the edible portion as determined by chemical analysis. They concluded these measures to be more reliable than percentage belly or backfat thickness.

McMeekan (32) postulated that most of a pig's skeletal and muscular growth is made during the first 116 to 120 days of age and after that most of the weight increase is due to fat deposition. McMeekan (33) obtained a +0.95 correlation between backfat thickness and weight of the fat. He, also, reported a correlation of +0.81 between the psoas major muscle weight and total carcass muscle (lean) weight. His correlations between various measures of the backfat thickness and total fat weight in the carcass were particularly strong and for the most part strongly approached unity.

Aunan and Winters (1) studied the relationship between lean, fat and bone content and carcass measurements. They found that uniformity of backfat thickness did not have any significant relationship with the lean content of the carcass or the yield of the primal cuts. A high yield of primal cuts was found to be associated with a high lean content of the carcass. Average backfat thickness was associated with the fat and lean content of the carcass, percentage primal cuts and dressing percentage.

Cummings and Winters (13) stated that the use of simple carcass measurements to predict yields apparently has limitations. The most reliable results were obtained by work with hogs of similar weight and other likenesses. The best carcasses were from groups making the fastest gain from birth to slaughter. Use of the total yield of the primal cuts as the sole form of appraisal for carcass excellence was inadequate and the length of carcass did not show a high degree of relationship with the percentage primal cut yield. However, the yield of primal cuts was strongly correlated with carcass weight and live weight at slaughter. A one inch increase in the average backfat thickness resulted in a 5 percent decrease in the yield of primal cuts. Brown et al. (5) found a high negative correlation

between percent lean cuts and average backfat thickness. A high positive correlation existed between average backfat thickness and weight per unit of carcass length and between percent lean cuts and the loin eye muscle area at the 3rd and 4th lumbar vertebrae.

Aunan and Winters (2), using core sampling at different sites to measure fat and lean tissue in carcasses, reported a +0.70 correlation between average backfat thickness and fat content of the carcass. A 5-6 rib lean sample of the belly had the highest association with the lean content of the carcass and a correlation coefficient of +0.79. The correlation between the primal cuts and the lean of the same core was +0.61. Correlation coefficients between fat content of the core samples and fat content of the carcass were not as high as those for lean content of the carcass. A high association between the lean content of all sample sites and percentage primal cuts was observed. Multiple correlations were not sufficiently higher than gross correlations to justify using more than one probe sample to predict lean content of the carcass.

Robison _et_ _al_. (38) noted that as weight increased, the percentage of lean and total cuts decreased and percentage fat trim to total cuts increased. As length increased and as backfat thickness decreased, the percentage of lean cuts increased and the percentage of fat trim decreased. Zobrisky _et_ _al_. (48) stated that the yield of any one component of the carcass (or live hog) is influenced by several factors. Therefore, the larger the number of these influencing factors considered in the method of analysis the more reliable are the results if the additional variables contribute significantly.

Whiteman and Whatley (45) assumed that percentage lean cuts was the best measure of carcass leanness. However, they found this was not always true as certain hogs have a tendency to deposit more of their fat in their muscular tissue. Lasley _et al._ (30) obtained correlation coefficients between lean cut percentage and: ham, +0.88; loin, +0.78; loin lean area, +0.69; live probe, -0.57; backfat thickness, -0.51; and length, +0.38.

Jordan _et al._ (28) reported the yield of lean cuts as a percentage of chilled carcass weight to be a more accurate estimate of the leanness of carcasses than the average backfat thickness. Pearson _et al._ (36), considering the relationship between either carcass length or dressing percentage and carcass cut-out, indicated that major emphasis should be placed on other methods of measuring leanness.

Loin Lean Area

The loin muscle area as calculated by the product of length times width of the muscle was found by Stothart (41) to decrease as the shoulder fat depth increased. Aunan and Winters (1) stated that the loin lean area, with the effect of carcass weight removed, was an indication of the relative amounts of lean in the carcass. The loin lean area was related to carcass length, but not to lean content as such.

Whiteman and Whatley (45) found that estimates of association with other measures of carcass leanness as shown by the two measures of loin lean area (planimeter reading versus length times width measurements of the loin eye at the last rib) to be of little difference in relative value. A significant correlation of specific gravity with loin lean area

was noticed. Inclusion of loin lean area with specific gravity raised the predictability of percentage lean cuts from 75 percent to 79 percent. Brown et al. (4) found a higher correlation (+0.84) between specific gravity of the carcass and percentage lean cuts than between specific gravity and loin lean area (+0.51). A correlation of +0.794 was found by Fredeen (18) between lean area of the ham and loin lean area.

McMeekan (33) found that using two times the length plus the width of the eye muscle as a loin index was highly correlated with weight of lean. This loin index was more highly correlated with weight of lean than was loin lean area as determined by the product of length times width. Cahill et al. (6) stated that the lean area of the loin taken in cross-section between the 10th and 11th ribs may serve as an index of the amount of lean in the carcass. The area was significantly correlated with the weight of primal cuts carcass and live weight bases, and with the lean cuts carcass and live bases.

Differences between pigs were striking for all carcass traits studied, while differences between sides and the interactions were negligible as reported by Kline and Hazel (29). The loin area at the last rib was consistently larger than the loin area at the 10th rib. No difference was noted among the correlations between percentage lean cuts and loin lean area at either location. The last rib lean area more closely predicted percent loin and all correlations varied from +0.65 to +0.74. There was no difference among the correlations in regards to whether the traits considered were measured on the same or opposite side of the carcass. Due to the high correlation +0.88 between loin areas on the same carcass, there

was little increase in accuracy of predicting lean cuts from measuring the loin area in more than one place.

Pearson et al. (36) found that the loin lean area at the 10th rib or last rib to be only slightly less reliable than the ratio of fat to lean in the loin in estimating cut-out values. The correlations ranged from -0.62 between fat-lean ratio of the loin and percentage lean cuts on the live basis to -0.23 between fat-lean ratio and length of carcass. Relationships between fat-lean ratio and percentage lean cuts and percentage primal cuts on both live and carcass bases were practically identical, varying from -0.60 to -0.62. Fat-lean ratio of loin may be used when it is impossible to obtain cutting information. Rust (40) reported a significant correlation between percent loin lean area and carcass primal cut yield. He found no correlation between loin lean area and live weight percent primal cut yield.

Zobrisky et al. (48) reported that of all internal carcass measurements studied, the cross-section area of the loin eye gave the highest correlation with the yield of lean.

Specific Gravity

Brown et al. (4) first attempted to evaluate pork carcasses by specific gravity to measure their fat content or relative value. Intragroup correlations of specific gravity with area of loin eye (+0.46), percentage primal cuts (+0.86), percentage lean cuts (+0.84) and carcass length (+0.56) were found. Highly significant negative correlations were reported between specific gravity and average backfat thickness (-0.68), percentage fat cuts (-0.78) and carcass weight (-0.42). These correlations indicated

that the fat or lean content of the carcass might be as accurately estimated by the specific gravity as by the percent fat or lean cuts. Carcass weight showed little effect on correlations between the various items measured. Percent lean cuts was more highly correlated with specific gravity (+0.84) than it was with backfat thickness (-0.72) or area of loin eye (+0.51). Similar results were noted for the fat cuts percentage. It appeared that actual leanness or fatness of the carcass was as accurately estimated by percentage fat or lean cuts as by chemical determination. A high correlation of +0.95 and -0.95 were found between specific gravity and percent protein and ether extract, respectively.

Whiteman et al. (46) obtained a correlation coefficient +0.942 between the specific gravity of the right ham and the rest of the carcass. Percentage lean and fat was much more closely associated with specific gravity than was percentage bone. Highly significant correlation coefficients of +0.87; +0.89, and +0.69 were found with specific gravity of the carcass and lean cuts, percentage weight ham and loin, and loin lean area, respectively. Significant correlations were also reported between carcass specific gravity and percentage moisture (+0.83), protein (+0.82), and ether extract (-0.868) of the ham. It was concluded that the ham tissues were indicative of the proportions of the respective tissues on the entire carcass, and that specific gravity measured the proportion of these tissues very closely.

The specific gravity of the ham, loin and shoulder was closely associated with the specific gravity of the entire carcass with +0.94, +0.96, +0.92, respectively, when both cuts were used as reported by Pearson <u>et al</u>.

(35). Specific gravity of the single cuts was also highly correlated with carcass specific gravity, with coefficients of +0.96, +0.91 and +0.87 for ham, loin, and shoulder, respectively. Specific gravity of either the entire carcass or a single ham proved to be superior to backfat thickness as a measure of carcass leanness. Correlation coefficients indicated that backfat thickness and carcass length were better measurements of leanness for lighter weight pigs. The longer hogs tended to be leaner at lighter weights, while at heavier weights carcass length was not so closely associated with degree of leanness. The specific gravity correlation with the loin lean area at the 10th and last ribs was +0.55 and +0.53, respectively. Highest correlation coefficients for various carcass measures of leanness were found between carcass specific gravity and percent lean cuts minus fat trim. Carcass specific gravity was negatively correlated with backfat thickness, percentage fat trim, and live probe.

Price (38) found the specific gravity of the untrimmed right ham to be closely associated with the specific gravity of the entire carcass with a correlation coefficient of +0.86. Carcass cut-out was more closely associated with live probe and backfat thickness than specific gravity of the ham. Specific gravity of the ham or carcass was a more reliable indicator of muscling than live probe or backfat thickness. Carcass length showed no significant relationship with cut-out, chemical composition or exterior fat thickness. The lean area of the loin measured at the 10th rib more closely predicted cut-out than the same area measured at the last rib. In general, lean cut-out was more closely associated with other measures of leanness than primal cut-out.

Cooking

Weir (44), in a study of the variation in tenderness in the Longissimus dorsi muscle of pork, reported that organoleptic and shear force values made it apparent that the anterior and posterior portions of the muscle were more tender than the central portion of the loins. Roasting was accomplished at 300°F oven temperature until the internal temperature of the loin reached 170°F.

Tenderness differences between certain positions within the loin were highly significant. Variations in tenderness between animals were shown to be significant by the organoleptic test and highly significant by the shear values. Organoleptic tests showed little variation between right and left sides, but the shearing data showed a highly significant variance. No explanation for this discrepancy was given.

EXPERIMENTAL PROCEDURE

Animals Used and General Procedure

TRIAL I

On October 28, 1955, nine purebred Duroc littermate swine were divided into nine lots and placed on a self-fed ration. The litter consisted of two barrows and seven gilts with an average weight of 30.4 pounds. The pigs received a 15 percent protein ration containing: 1580 lbs. corn, 209 lbs. soybean oil meal, 76 lbs. meat and bone scrap, 57 lbs. alfalfa meal, 38 lbs. wheat middlings, 16 lbs. dicalcium phosphate plus zinc, 12 lbs. limestone, 12 lbs. trace mineralized salt, 1 lb. aurofac, 1 lb. vitamin mix 58C and 0.5 lbs. vitamin A and D.

At approximately 140 pounds of weight, the ration was reduced to 11 percent protein by reducing the amount of soybean oil meal and increasing the amount of corn. Water was available ad libitum.

The pigs were weighed bi-weekly and tabulations of feed consumption were recorded for each two week period. These figures were then used to calculate rate of gain and feed efficiency for each two week period along with a computation of the cummulative total for rate of gain and feed efficiency up to any given weight.

TRIAL II

On April 14, 1956, nine purebred Hampshire littermate swine averaging 25.1 pounds were lotted in the same manner as those in Trial I. All were gilts and received the same ration as those in Trial I. All records, weights, tabulations and calculations followed the same procedure followed in Trial I.

Although Trial II littermates received the same ration as Trial I littermates, the actual feeding procedure was somewhat different. In an attempt to reduce feed wastage, feed spoilage (due to drinking water in the feed), lameness, and the fatness of the pigs which was noticeably evident in Trial I, the following feeding prodedure was followed. All littermates were allowed to exercise in the same pen between feedings which gave a great deal more freedom of movement than was afforded those pigs in Trial I. At feeding time the pigs were allowed to enter their individual pens for feeding. The pigs were allowed access to a self-feeder three times daily (8:00 A.M., 12:00 noon, and 4:00 P.M.) to approximately 135 pounds in weight. After 135 pounds, they were fed twice daily to slaughter weight. They were allowed to eat for 30-45 minutes and this length of time seemed more than sufficient to satisfy their hunger.

<u>Slaughter Procedure</u>

All animals were taken off feed 24 hours prior to slaughter when their feedlot weight reached 220 lbs., or as near that point as was practicable with the weekly slaughter schedule of the Michigan State University Meats Laboratory. Fresh water was available to all animals during the pre-slaughter period. Both feedlot weight and weight prior to slaughter (shrunk live weight) were taken. Shrunk live weight was used in computing dressing percentage, feedlot shrink, primal cut-out live weight basis, and lean cut-out live weight basis.

Immediately prior to slaughter, all hogs were probed in an effort to estimate or predict backfat thickness. The method used was the live probe method similar to that employed by Hazel and Kline (22); and the same as that of Price (38). Six probes (three per side) were made approximately $1\frac{1}{2}$ inches off the midline of the back using a lancet and a 6 inch steel ruler. Measurements were taken and recorded to the nearest 0.1 of an inch. The sites used for probing were just behind the shoulder, over the middle of the back and just posterior to the center of the loin. The six live probe measurements were then averaged to give the approximate backfat thickness.

All animals were slaughtered packer style, with head off, jowls attached, leaf fat and kidney in and hams faced but the facing left attached. The carcasses were weighed hot and then chilled at 34-36°F for 48 hours prior to cutting.

Carcass Measurements

All carcass measurements were recorded in millimeters and later converted to inches. The length of carcass was measured from the anterior edge of the first rib to the anterior tip of the aitch bone. Backfat measurements were taken opposite the first, seventh and last ribs, and opposite the last lumbar vertebra. The backfat thickness was calculated by averaging these four measurements.

The chilled carcass weight was obtained by removing the leaf fat and kidney and was used in calculating the dressing percentage, cooler shrink, percentage primal cuts carcass basis, percentage lean cuts carcass basis and percentage fat trim. The leaf fat and kidney weight were included in determining percentage fat trim.

Cutting Procedure

The carcasses were broken into the rough primal cuts (New York shoulder, loin, ham and belly) using the method similar to that given by Cole (7) and identical with that of Price (38). A $2\frac{1}{2}$ rib New York style shoulder was cut perpendicular to the top line of the carcass and the forefoot removed from the shoulder $\frac{1}{2}$ inch above the knee joint. The neckbones, collar, jowl and clear plate were removed. The jowl was taken off by cutting parallel to the loin cut and through the natural groove 1 inch above the atlas joint. The jowl was squared and trimmings from it were included in either fat or lean trim. The clear plate was removed starting at a point 1 inch below the ventral edge of the blade bone and continuing the cut to the top of the shoulder just deep enough to expose the layer of false lean.

The ham was taken off by sawing between the 2nd and 3rd sacral vertebrae perpendicular to the line of the shank. The hind foot was removed by sawing through the hock, splitting the inside bony projection. The ham facing loosened at slaughter was removed and the ham skinned by starting at a point 2/3 the length of the ham from the butt-end and trimming towards the butt. A 1/4 inch of fat was left on the skinned ham. The tail and sacral vertebrae were also removed.

The rough loin and belly were separated by cutting from a point just below the psoas major muscle at the posterior end of the loin to a point just below the backbone-rib attachment on the blade end. The cut was made perpendicular to the table with the loin and belly laying in a natural

position and by following the general curvature of the back. The backfat was removed exposing the false lean on the blade end of the loin and leaving an approximate fat thickness of 1/4 inch.

The trimmed belly was made by removing the spareribs, cutting as close to the teat line as possible and by squaring the flank end. Lean trim was composed of small pieces of lean acquired during the cutting process and fat trim included all cutting fat plus the leaf fat and kidney.

Cutting Data

The weights for skinned New York shoulders, trimmed loins, trimmed bellies and skinned hams were taken and totaled for computation of primal cut percentages on both live and carcass bases. Lean cut percentages on live and carcass bases were calculated using both New York shoulders, loins and hams. No weights or records of other miscellaneous cuts were kept. All cuts were weighed to nearest 0.1 pound.

Calculations included feedlot shrink, cooler shrink, dressing percentage, ham specific gravity, primal cuts live and carcass bases, lean cuts live and carcass bases, fat trim percentage and lean trim percentage.

Before trimming the loin in the cutting process, cross sections at the 10th and last ribs from the right rough loin were cut and tracings of the loin lean area were made on acetate paper for future reference. The loin lean areas were measured by the use of a compensating polar planimeter giving the total area in square inches. The average of three planimeter readings was used.

Immediately following the cutting process, the whole loins from both right and left sides were wrapped in freezer paper and frozen for future use.

Specific Gravity

During the cutting process, the specific gravity of the right ham was recorded. This was achieved before skinning and was used to predict certain carcass characteristics as presented by Price (38). Weight under water was recorded to the nearest gram and all specific gravity determinations were made according to this formula:

$$\frac{\text{wt. in air (gms.)}}{\text{wt. in air (gms.)} - \text{wt. in water (gms.)}} = \text{specific gravity}$$

After thawing the frozen loins and prior to the cooking portion of the experiment, the specific gravity of the *Longissimus dorsi* muscle was taken at two sites. The sample sites were immediately posterior to the blade cartilage and the 11-13th rib section. The samples ranged from 50 to 90 grams in weight when weighed to the nearest 0.1 gram and were weighed to the nearest .01 gram in water. The right loin was used in specific gravity determination and the calculations were the same as that used for ham specific gravity. Care was taken to insure that only the *Longissimus dorsi* was used in the specific gravity determinations.

Cooking Procedure

The cooking procedure followed that used by Weir (44). The loins were thawed at 34^{o}F (cooler temperature) for forty-eight hours prior to cooking. A 1 inch thick chop from the left loin was removed at the be-

ginning of the tenderloin muscle just anterior to the last rib. This chop was then deep fat fried at 300°F to an internal temperature of 170°F. Tenderness measures were taken on $\frac{1}{2}$ inch diameter core samples removed parallel with the grain of the meat with the Warner-Bratzler shear.

The 10th to last rib section of the right loin was roasted at 300°F to an internal temperature of 170°F. A 1 inch thick chop was removed from the posterior portion of the roast to correspond with the deep fat fried chop. The same procedure was used for testing the tenderness of the roasted chop as that used for the deep fat fried chop. Five core samples were taken from each chop and the five recordings averaged to give the tenderness reading for a particular chop. Cooking loss was calculated for both cooking methods by weighing before and after cooking. Moisture loss data were also available.

Statistical Analysis

Statistical analysis of data included means, ranges, standard deviations, standard errors, analyses of variance and correlation coefficients. Standard deviations from the mean and standard errors were computed on all measurable characteristics and are reported in the results. Analysis of variance between breeds was calculated for the more important criteria and correlation coefficients were computed for a few of the more important measurements.

Formulae used in statistical analysis as outlined by Goulden (19) were as follows:

Standard deviation

$$S_x = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N-1}$$

Standard error

$$e = \frac{S_x}{\sqrt{N}}$$

Analysis of variance

$$X^2 - \frac{\Sigma X^2}{N} = \text{Total sum of squares}$$

$$\frac{(\Sigma X)^2}{N_1} + \frac{(\Sigma X_2)^2}{N_2} + \cdot \cdot \cdot \cdot \frac{(\Sigma X_n)^2}{N_n} - \frac{\Sigma X^2}{N} = \text{Between sum of squares}$$

Total sum of squares - between sum of squares = Error

Correlation Coefficient

$$\text{"r"} = \frac{XY - \frac{(\Sigma X)(\Sigma Y)}{N}}{\sqrt{\Sigma X^2 - \frac{(\Sigma X)^2}{N} \quad \Sigma Y^2 - \frac{(\Sigma Y)^2}{N}}}$$

DISCUSSION AND RESULTS

Though some of the data presented herein were significant and some non-significant as computed by analysis of variance between litters, all characteristics measured showed that there was considerable variation within each litter for any particular characteristic. Therefore, an absence or presence of significance between litters does not necessarily denote absence or presence of variation within the individual litter *per se*.

Feedlot Data

The Duroc littermates (Trial I) were individually fed, had free access to feed, and had an average initial weight of 30.4 pounds. The Hampshire littermates (Trial II) were also individually fed, but allowed limited access to feed, and had an average initial weight of 25.1 pounds. The range was lower and the standard deviation in initial weight was smaller for the Hampshires. The Durocs and Hampshires were 53 and 50 days of age, respectively, at the start of each trial. Initial weight for the two litters was significantly different at the 1 percent level (Table 1).

Table 1. Means, Ranges, Standard Deviations, and Standard Errors for Feedlot Data

	Means		Range		Std.Deviation		Std. Error	
	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.
Initial wt.(lbs.)	30.4**	25.1	9	6	3.54	2.37	1.18	.79
Days on feed	111**	150	29	42	10.3	12.6	3.4	4.2
Av.daily gain (lbs.)	1.74**	1.31	.47	.26	.17	.09	.06	.03
Feed per 100 lbs. gain (lbs.)	359.9	356.7	46.0	71	16.0	22.9	5.3	7.63

** Difference significant at the 1 percent level.

The Durocs required less time to reach market weight and this may have been partially caused by the difference in method of feeding. The Durocs averaged 111 days on feed as compared to 150 days for the Hampshires. Standard deviation for the two litters was similar, but the Hampshires showed a much greater range in days on feed. Litter difference for days on feed was highly significant (Table 1).

A portion of the difference between these two trials may be associated with climatic conditions as the Duroc trial was completed during cool weather and the Hampshire trial during warm weather. Average daily gain was 1.74 pounds for the Durocs and 1.31 for the Hampshires. Some of this difference can probably be explained by the difference in method of feeding. Less variation in average daily gain was noted for the Hampshires as measured by standard deviation. A lower range for the Hampshires was also observed and they were noticeably more uniform in their gain pattern from weigh period to weigh period (Table 1). A highly significant difference between the two litters for average daily gain was found (Table 2). Vorkapich (42), in an earlier and similar study, reported no significant difference for average daily gain between Duroc-Berkshire cross, Yorkshire-Chester White cross and Chester White hogs.

Table 2. Analysis of Variance for Daily Gain and Feed Consumed for 100 Pounds of Gain

		Daily Gain		Feed Consumed per 100 Pounds Gain	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	1.11		6293.8	
Breed	1	.83	.83**	46.7	46.7
Error	16	.28	.018	6246.9	390.4

** Significant at the 1 percent level.

Though the Hampshires were allowed limited access to a self-feeder in an attempt to control and reduce feed wastage and spoilage, there was no significant difference between litters in feed consumed per 100 pounds of gain (Table 2). This finding did not agree with that of Vorkapich (42), who found a significant difference at the 5 percent level. The Durocs averaged 359.9 pounds of feed per 100 pounds of gain with a range of 46.0 pounds and the Hampshires averaged 356.7 pounds with a range of 71.0. Standard deviation showed that there was less variation for feed consumed per 100 pounds of gain within the Duroc litter (Table 1).

Slaughter Data

The Durocs averaged 222.7 pounds at market (feedlot) weight and the Hampshires 220.4 pounds. Variation within each litter according to standard deviation and range for market weight was similar. No significant difference was found between the litters for market weight (Table 3). Also, no significant difference was found for slaughter weight with the Durocs averaging 212.8 pounds and the Hampsires 209.2 pounds. The Hampshires showed more variation and a higher range for slaughter weight. However, the difference between litters did approach significance (Table 3).

Average age at slaughter was 162 days for the Durocs and 200 days for the Hampshires. The cut-out values did not necessarily increase as age at slaughter increased and the highly significant difference in age at slaughter can be partially explained by the difference in feeding methods (Table 4). Standard devitaion showed the Hampshires to have more

variation than the Durocs. The range was 29 days for the Durocs and 42 for the Hampshires (Table 3). Vorkapich (42) found no significant difference in age at slaughter.

Table 3. Means, Ranges, Standard Deviations and Standard Errors for Slaughter Data

	Means		Range		Std. Dev.		Std. Error	
	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.
Feedlot wt. (lbs.)	222.7	220.4	10	6	3.5	3.65	1.17	1.22
Slaughter wt. (lbs.)	212.8	209.2	9	12	3.1	4.1	1.03	1.36
Slaughter age (days)	162.2**	199.7	29	42	9.8	12.6	3.3	4.2
Chilled carcass wt. (lbs.)	164.1*	158.6	9	10	3.5	3.38	1.17	1.13
Dressing percent	77.1**	75.8	2.1	2.6	.76	.86	.25	.28
Live probe	2.03**	1.70	.88	.67	.25	.23	.08	.08

* Difference significant at the 5 percent level.
** Difference significant at the 1 percent level.

Table 4. Analysis of Variance for Age at Slaughter and Dressing Percentage

		Age at Slaughter		Dressing Percentage	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	8341		18.2	
Breed	1	6309	6309**	7.7	7.7**
Error	16	2032	127	10.5	.66

**Significant at the 1 percent level.

Chilled carcass weight showed a significant difference between litters at the 5 percent level (Table 3). Consequently, there was a highly significant difference between litters for dressing percentage (Table 4).

Average dressing percentage was 77.1 for the Durocs and 75.8 for the Hampshires. Both were similar in variation and range for dressing percentage. These data would, therefore, substantiate the theory that fatter hogs have a higher dressing percentage generally than do leaner hogs. Vorkapich (42) found no significant difference in dressing percentage between Duroc-Berkshire cross, Yorkshire-Chester White cross and Chester White hogs.

Average live probe was 2.03 inches for the Durocs and 1.70 inches for the Hampshires. Live probe showed a great deal of variation within both litters as measured by standard deviation and the Durocs exhibited a greater range (Table 3). A highly significant difference between litters was found for live probe (Table 6).

Carcass Data

Generally, live probe resulted in a lower average backfat thickness than did actual average carcass backfat thickness. The Durocs had an average backfat thickness of 2.08 inches as opposed to 1.71 inches for the Hampshires. As with live probe, a significant difference between litters for average backfat thickness was noted (Table 6). Standard deviation and range were similar for both litters with considerable variation noted within each litter (Table 5). Vorkapich (42) noted a difference at the 5 percent level between breeds for backfat thickness.

Standard deviations showed that there was more variation within the Hampshire litter for carcass length than in the Duroc litter. The range was also greater for the Hampshires.(Table 5). No significant difference

in carcass length was found between litters (Table 7). Vorkapich (42) also found no significant difference between litters in his study for carcass length. The Durocs averaged 29.2 inches in carcass length and the Hampshires 28.7 inches (Table 5). This observation would agree with that of Price (38), who found that length per se is not necessarily a good indication of carcass superiority and leanness.

Table 5. Means, Ranges, Standard Deviations and Standard Errors for Carcass Data

	Mean		Range		Std. Dev.		Std. Error	
	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.
Av. backfat thickness (in.)	2.08**	1.71	.50	.50	.19	.16	.062	.053
Carcass length (in.)	29.2	28.7	2.4	2.8	.64	.91	.21	.33
Loin lean area 10th rib (sq. in.)	3.20**	3.90	1.36	.90	.45	.31	.15	.10
Loin lean area last rib (sq. in.)	3.38**	4.14	1.37	.77	.44	.35	.15	.11

** Significant at the 1 percent level.

Table 6. Analysis of Variance for Live Probe and Average Backfat Thickness

		Live Probe		Av. Backfat Thickness	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	1.39		1.07	
Breed	1	.49	.49**	.59	.59**
Error	16	.90	.056	.48	.03

** Significant at the 1 percent level.

Kline and Hazel (29) reported a highly significant difference between the loin lean area of the 10th rib and the loin lean area of the last rib with the area of the last rib being the larger. The data in

Table 5 substantiate their finding that the last rib was larger but the data in Table 7 showed that the difference was not significant. Highly significant differences between the Durocs and the Hampshires for both the 10th and last rib lean loin area was found (Table 8). The Durocs averaged 3.20 square inches for the 10th rib loin lean area and 3.38 square inches for the last rib loin lean area, while the Hampshires averaged 3.90 square inches and 4.14 square inches for the same sites. The Durocs exhibited greater variation for both sites and had a much greater range than the Hampshires.

Table 7. Analysis of Variance for Carcass Length and Area 10th versus Area Last Rib

Source of Variation	Carcass Length			Area 10th vs. Area Last Rib[1]		
	Degrees of Freedom	Sum of Squares	Mean Square	Degrees of Freedom	Sum of Squares	Mean Square
Total	17	14.3		35	9.8	
Breed	1	1.0	1.0	1	.4	.4
Error	16	13.3	.83	34	9.4	.28

[1] Combination of both litters.

Table 8. Analysis of Variance for Area of the 10th Rib and Area of the Last Rib

Source of Variation	Degrees of Freedom	Area 10th Rib		Area Last Rib	
		Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	4.4		5.0	
Breed	1	2.3	2.3**	2.5	2.5**
Error	16	2.1	.13	2.5	.16

**Significant at the 1 percent level.

Cutting Data

Highly significant differences between the Hampshires and Durocs for primal cut-out on both live and carcass bases were found (Table 10).

Average primal cut percentage was 46.1 and 49.3 for the Durocs and Hampshires, respectively, on a live basis; and 60.2 and 65.0, respectively, on a carcass basis. The Durocs showed from standard deviation data in Table 9 that they were more variable in respect to primal cut-out on either basis.

Table 9. Means, Ranges, Standard Deviations, and Standard Errors for Cutting Data

	Mean		Range		Std. Dev.		Std. Error	
	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.
% Primal cuts (live)	46.1**	49.3	4.6	3.0	1.4	.97	.47	.32
% Primal cuts (carcass)	60.2**	65.0	7.4	3.6	2.24	1.33	.75	.44
% Lean cuts (live)	34.7**	38.3	5.7	3.1	1.97	.99	.66	.33
% Lean cuts (carcass)	45.0**	50.6	6.9	3.9	2.43	1.35	.80	.45
% Fat trim (carcass)	29.2	26.8	11.1	5.2	3.40	1.97	1.13	.66

**Difference significant at the 1 percent level.

Table 10. Analysis of Variance for Primal Cut-Out Percentage Live Weight Basis and Carcass Weight Basis

		Live Weight Basis		Carcass Weight Basis	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	64		164.3	
Breed	1	45	45**	102.4	102.4**
Error	16	19	1.19	61.9	3.87

**Significant at the 1 percent level.

Essentially the same results were observed between the litters on lean cut-out both bases as for primal cut-out. The Durocs averaged 34.7 percent lean cuts on the live basis and 45.0 percent on the carcass basis; while the Hampshires averaged 38.3 percent and 50.6 percent, respectively, for the same traits. Highly significant differences for both bases between litters was found (Table 11). Vorkapich (42) also found highly significant differences between trials for primal and lean cut percentage on both the live and carcass bases. Again the Durocs showed more variation within the litter on both bases as measured by standard deviation and also a greater range (Table 9). However, the Hampshires also contained considerable variation within the litter for all cut-out data. The Durocs averaged 29.2 percent fat trim and the Hampshires 26.8 with no significant difference between the two litters (Table 9) although the value did approach significance.

Table 11. Analysis of Variance for Lean Cut-Out Percentage Live Weight Basis and Carcass Weight Basis

Source of Variation	Degrees of Freedom	Live Weight Basis: Sum of Squares	Live Weight Basis: Mean Square	Carcass Weight Basis: Sum of Squares	Carcass Weight Basis: Mean Square
Total	17	98.7		202.2	
Breed	1	59.4	59.4**	140	140**
Error	16	39.3	2.46	62.2	3.9

**Significant at the 1 percent level.

Cooking Data

In addition to cooking data, the specific gravity of the *Longissimus dorsi* at two sites was determined. As various workers have found highly significant relationships between other specific gravity determinations and important carcass characteristics, it was decided to test the measure as a means of measuring or predicting other carcass measures. The Durocs averaged 1.063 and the Hampshires 1.072 for the specific gravity of the Longissimus dorsi (center loin portion.) A highly significant difference between litters was observed, with the variation and range within each litter approximately the same (Table 12). No significant difference between litters was found for the specific gravity of the blade portion of the Longissimus dorsi.

Table 12. Means, Ranges, Standard Deviations and Standard Errors for Cooking Data.

	Mean		Range		Std. Dev.		Std. Error	
	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.	Duroc	Hamp.
Specific gravity (Center loin)	1.063**	1.072	.015	.017	.0063	.0062	.0021	.0021
Specific gravity (blade)	1.060	1.063	.013	.019	.0061	.0063	.0020	.0021
Shear value roast (lb.)	7.38	7.95	3.25	2.75	1.16	.85	.39	.28
Shear value deep fat (lb.)	7.20**	8.90	3.70	1.75	1.51	.71	.50	.23
Cooking loss roast (%)	16.7*	19.5	10.0	8.3	2.9	2.87	.97	.96
Cooking loss deep fat (%)	16.9**	27.3	6.7	7.5	2.68	2.80	.89	.93

* Difference significant at the 5 percent level.
** Difference significant at the 1 percent level.

The shear value of the roasted chop versus the shear value of the deep fat fried chop was not significantly different (table 14). The litters were not significantly different in regard to shear value of the roasted chop but were significantly different for the shear value of the deep fat fried chop (Table 13). No reason for this discrepancy can be given. The Durocs exhibited a higher range and more variation for both cooking methods than did the Hampshires (Table 12). Averages were 7.38 and 7.95 pounds for the Durocs and Hampshires, respectively, for the shear value of the roasted chop and 7.20 and 8.90 pounds, respectively, for the deep fat fried chop shear values. Some of the difference in tenderness may have been explained by the difference in marbling between the two litters, as measured entirely by visual appraisal.

Table 13. Analysis of Variance for Shear Value of Roasted Chop and Shear Value of Deep Fat Fried Chop.

		Roast Shear Value		Deep Fat Shear Value	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	17	18.4		35.4	
Breed	1	1.4	1.4	13.1	13.1**
Error	16	17.0	1.06	22.3	1.39

**Significant at the 1 percent level.

Table 14. Analysis of Variance for Shear Value Deep Fat Fried Chop Versus Shear Value Roasted Chop and Cooking Loss Deep Fat Frying Versus Cooking Loss of Roasting.

		Shear Value Deep Fat vs. Roast		Cooking Loss Deep Fat vs. Roast	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	35	55.1		929.9	
Cooking Method	1	3.0	3.0	148.9	148.9*
Error	34	52.1	1.53	781	23.0

*Significant at the 5 percent level.

Between breed cooking loss by roasting was significant at the 5 percent level and significant at the 1 percent level by deep fat frying (Table 12). Cooking loss by roasting versus that by deep fat frying was significant at the 5 percent level (Table 14). Variation and range between the litters were similar (Table 12). The average cooking loss by roasting of the Durocs was 16.7 percent and the Hampshires 19.6, while for deep fat frying the loss was 16.9 and 27.3, respectively. No explanation for the large cooking loss of the Hampshires for deep fat frying can be given unless possibly an error was involved in determining the thickness of the chop. Had any trait caused this large cooking loss, it should, therefore, have shown itself in the cooking loss derived by roasting. Again, a large variation within litters was noted for cooking loss by either method.

Correlation Coefficients

Table 16 gives the correlation coefficients between a few of the more important measures for carcass leanness or fatness and superiority, while Table 15 lists the symbols used for these measures in Table 16. A correlation coefficient of +0.85 was found between average live probe and average carcass backfat thickness. This finding agreed closely with that of Price (38), who found a +0.865 correlation coefficient for the same two measures. This indicated that 74.7 percent of the variation in average live probe was accounted for by a similar variation in average carcass backfat thickness. Contrary to the results found by Price (38), average backfat thickness was a better estimate of cut-out value in all cases than was average live probe. These differences were not great, but were consistent. Vorkapich (42) found no significant correlation between live probe and backfat thickness.

Table 15. Key to Symbols Used for Correlation Coefficients in Table 16.

Symbols	
LP	Live Probe (in.)[1]
BF	Backfat thickness (in.)[2]
LCL	Lean cuts - live basis (%)
LCC	Lean cuts - carcass basis (%)
PCL	Primal cuts - live basis (%)
PCC	Primal cuts - carcass basis (%)
A_{10}	Area of lean in the loin at the 10th rib (sq. in.)
A_L	Area of lean in the loin at the last rib (Sq. in.)
S_R	Shear value roasted chop (lbs.)
S_{DF}	Shear value deep fat fried chop (lbs.)
SG_B	Specific gravity blade portion of _Longissimus dorsi_
SG_L	Specific gravity center loin portion of _Longissimus dorsi_
SG_H	Specific gravity of right ham
FT	Fat Trim (%)

[1]Average of 6 probes.
[2]Average of 4 measurements.

Also contrary to the results found by Price (38), cut-out values with the effect of dressing percentage removed (carcass basis) gave higher correlation coefficients in all cases with various other measures than with the effect of dressing percentage included (live basis). Live probe and backfat thickness gave negative correlation coefficients of -0.79 and -0.82, respectively, with lean cut-out live basis and -0.82 and -0.88, respectively, with lean cut-out carcass basis. This would indicate that cut-out values showed more relationship with backfat thickness than with live probe and cut-out values on a carcass basis gave higher correlations than cut-out values on a live basis.

Table 16. Correlation Coefficients for Various Measurements[1]

	LP	BF	A_{10}	A_L	SG_L	S_R	FT
LP	---	+0.85**	-0.76**	-0.79**	-0.49*	---	+0.88**
BF	+0.85**	---	-0.74**	-0.83**	-0.69**	---	+0.70**
LCL	-0.79**	-0.82**	---	---	---	---	---
LCC	-0.82**	-0.88**	+0.86**	+0.94**	+0.54*	---	-0.75**
PCL	-0.85**	-0.81**	---	---	---	---	---
PCC	-0.87**	-0.85**	+0.87**	+0.94**	+0.72**	---	-0.86**
A_{10}	-0.76**	-0.74**	---	+0.92**	+0.48*	---	---
A_L	-0.79**	-0.83**	+0.92**	---	+0.49*		---
S_R	---	---	---	---	+0.10	---	---
S_{DF}	---	---	---	---	+0.02	+0.58**	---
SG_B	---	---	---	---	+0.69**	---	---
SG_H	---	---	---	---	+0.47*	---	---

[1]Refer to Table 15 for key to symbols.
* Significant at the 5 percent level.
** Significant at the 1 percent level.

Highly significant negative correlations were found between live probe and primal cut-out live and carcass bases, being -0.85 and -0.87, respectively. The same was true between backfat thickness and primal cut-out live and carcass bases with -0.81 and -0.85, respectively. All cut-out values gave highly significant correlation coefficients with both live probe and backfat thickness. Primal cut-out on both bases gave higher relationships with other measures than lean cut-out on both bases with the exception of backfat thickness.

Although Price (38) found no significant relationship between backfat thickness and loin lean area at the 10th and last ribs, highly significant negative correlation coefficients were found in this study. Correlation coefficients between backfat thickness and loin lean area at the 10th and last ribs were -0.74 and -0.82, respectively. Between live probe and loin lean area at the 10th and last ribs, the correlation coefficients were -0.76 and -0.79. In this study, and opposite to the correlations found by Price (38), the last rib loin lean area was more closely related to cut-out percentages and other measures than the 10th rib loin lean area. Highly significant positive correlations were found between loin lean area of the 10th rib and lean cut-out carcass basis and primal cut-out carcass basis with coefficients of +0.86 and +0.87, respectively. Congruously, highly significant positive relationships were found between loin lean area of the last rib and lean cut-out carcass basis and primal cut-out carcass basis with correlation coefficients of +0.94 and +0.94, respectively. Significant correlation coefficients at the 5 percent level were found between specific gravity of the center loin portion of the *Longissimus dorsi* and loin lean area of the 10th and last ribs with respective coefficients of +0.48 and +0.47. These values were on the borderline of significance. The loin lean area of the 10th rib and loin lean area of the last rib gave a correlation coefficient of +0.92.

The fat trim provided highly significant negative correlation coefficients with lean cut-out carcass basis and primal cut-out carcass basis of -0.75 and -0.86, respectively. Highly significant and positive relationships between fat trim, live probe, and backfat thickness were observed with respective correlation coefficients of +0.70 and +0.88. No reason can be given for the unusually wide difference in relationship here whereas they were relatively close in regard to all other measurement relationships.

The specific gravity of the center loin portion of the *Longissimus dorsi* muscle was most highly correlated with primal cut-out carcass basis of all relationships tested with a coefficient of +0.72. This specific gravity measurement was not an exceptionally good indicator of any carcass trait. A negative correlation coefficient of -0.49, which was significant at the 5 percent level, was found between the specific gravity of the center loin (*Longissimus dorsi*) and live probe. Backfat thickness relationship with the specific gravity of the center loin portion of the Longissimus dorsi was highly significant with a coefficient of -0.69. No reason can be given for the large difference between live probe and

backfat thickness when correlated with the specific gravity of the Longissimus dorsi (center loin portion). The specific gravity of the center loin and lean cut-out carcass basis yielded a correlation of +0.54 which was significant at the 5 percent level.

No significant correlation was found between either the shear value of the roasted chop or the shear value of the deep fat fried chop and the specific gravity of the center loin. This was not as expected as specific gravity should measure marbling by giving a lower specific gravity reading, and marbling is generally associated with tenderness to some degree. The specific gravity of the right ham and the specific gravity of the Longissimus dorsi (center loin portion) showed a correlation coefficient of only +0.47. The specific gravity of the blade portion of the Longissimus dorsi and the specific gravity of the center loin Longissimus dorsi gave a lower than expected correlation coefficient of +0.69. Therefore, only 48 percent of the variation in one was accounted for by a similar variation in the other.

A highly significant correlation was found between the shear value of the roasted chop and the shear value of the deep fat fried chop with a value of +0.58. This again was not as high as expected, but no definite reason could be given.

SUMMARY AND CONCLUSIONS

Though this study was originated to supplement and increase the amount of data reported by Vorkapich (42), all results reported were not in agreement with his findings. In some of the measurements reported, there was a significant amount of variation between breeds, and in all cases there was considerable variation within the litter for any characteristic considered. It may be necessary in the future to test more than two pigs from a litter if the parents are to be evaluated most accurately.

No significant differences between breeds were found for feedlot weight, slaughter weight, carcass length, fat trim percentage or shear value of the roasted chop. Differences between breeds which were significant were chilled carcass weight and roast cooking loss. Highly significant differences between breeds were found for initial weight, days on feed, average daily gain, feed consumed per 100 pounds of gain, slaughter age, dressing percentage, live probe, backfat thickness, loin lean area of the 10th and last ribs, primal cut-out live and carcass bases, lean cuts live and carcass bases, specific gravity of the Longissimus dorsi (center loin portion), shear value of the deep fat fried chop and cooking loss of the deep fat fried chop.

The live probe estimate of backfat thickness seemed to be a valid one, due to the highly significant relationship between the two. Live probe proved only slightly less reliable in predicting other carcass traits than actual carcass backfat. Both live probe and backfat thickness gave high negative correlation coefficients with primal and lean cut-outs on live and carcass bases, loin lean area of the 10th and last ribs and fat trim. Backfat thickness yielded a highly significant negative relationship with specific gravity of the *Longissimus dorsi* (center loin portion), whereas live probe yielded a lower but significant relationship.

The area of lean in the loin measured at either the 10th or last rib was highly related with primal and lean cut-out values on both live and carcass bases. However, the last rib gave a consistently higher relationships with all measures than the 10th rib. Significant correlation coefficients were found between either loin lean area and the specific gravity of the *Longissimus dorsi* muscle (center loin portion). The specific gravity of the *Longissimus dorsi* muscle (center loin portion) did not prove to have an exceptionally high relationship with any of the other measures. Backfat thickness, live probe, and loin lean area of the 10th and last ribs proved the best estimate of primal and lean cut-out on both bases.

Significant differences between litters for cooking loss and shear values were found for both roasting and deep fat frying. No significant difference in shear value was noted between deep fat frying and roasting, indicating that both had the same effect on tenderness. Cooking loss difference was significant between deep fat frying and roasting. This may be explained by the deep fat frying exposing more of the meat surface directly to the heat. The effect of season, feeding method, and breed could not be separated for statistical analyses, and therefore all probably had some effect on the results of this study.

LITERATURE CITED

(1) Aunan, W. J. and L. M. Winters. 1949. A study of the variations of muscle, fat and bone of swine carcasses. Jour. An. Sci. 8:183.

(2) Aunan, W. J. and L. M. Winters. 1952. A method for measuring the proportion of fat and lean tissue in swine carcasses. Jour. An. Sci. 11:319.

(3) Bratzler, L. J. and E. P. Margerum, Jr. 1953. The relationship between live hog scores and carcass measurements. Jour. An. Sci. 12:857.

(4) Brown, C. J., J. C. Hillier and J. A. Whatley. 1951. Specific gravity as a measure of the fat content of the pork carcass. Jour. An. Sci. 10:97.

(5) Brown, W. L., H. A. Stewart and T. N. Blumer. 1951. A study of some factors involved in pork carcass evaluation. Jour. An. Sci. 10:1023. (Abstract)

(6) Cahill, V. R., T. S. Sutton and L. E. Kunkle. 1953. Relationship of area of _Longissimus dorsi_ muscle to other carcass characteristics. Jour. An. Sci. 12:899. (Abstract)

(7) Cole, J. W. 1951. Slaughtering, chilling and cutting methods for pork carcass evaluation. Proc. Fourth Ann. Recip. Meat Conf. 4:111.

(8) Cole, J. W., C. E. Riley, H. J. Smith and C. S. Hobbs. 1953. The effect of type and weight on the yield of primal and miscellaneous pork cuts. Jour. An. Sci. 12:900. (Abstract)

(9) Crampton, E. W. 1937. Self versus hand-feeding for market hogs, with particular reference to effects on carcass measurements and quality. Sci. Agriculture, 17:529.

(10) Crampton, E. W. 1940. Hog carcass studies. Sci. Agriculture, 20:592.

(11) Crampton, E. W., G. C. Ashton and L. E. Lloyd. 1954. The effect of restricting feed intake of market hogs during the finishing period on the quality of the bacon carcass. Jour. An. Sci. 13:321.

(12) Crampton, E. W., G. C. Ashton and L. E. Lloyd. 1954. Improvement of bacon carcass quality by the introduction of fibrous feeds into the hog finishing ration. Jour. An. Sci. 13:327.

(13) Cummings, J. N. and L. M. Winters. 1951. A study of factors related to carcass yields in swine. Minn. Ag. Exp. Sta. Tech. Bul. 195.

(14) DePape, J. G. and J. A. Whatley, Jr. 1956. Live hog probes at various sites, weights and ages as indicators of carcass merit. Jour. An. Sci. 15:1029.

(15) Dickerson, G. E. and J. C. Grimes. 1947. Effectiveness of selection for efficiency of gain in Duroc swine. Jour. An. Sci. 6:265.

(16) Dickerson, G. E. 1947. Composition of hog carcasses as influenced by heritable differences in rate and economy of gain. Iowa Ag. Exp. Sta. Res. Bul. 354.

(17) Ferrin, E. F. 1939. A factual basis for changing swine types. Proc. Am. Soc. of An. Prod. 1937:125.

(18) Fredeen, H. T., G. H. Bowman and J. G. Stothart. 1955. Relationships between certain measurements of ham and carcass quality. Can. Jour. Ag. Sci. 35:95.

(19) Goulden, C. H. 1952. Methods of Statistical Analysis. Second Ed. John Wiley and Sons, Inc., New York.

(20) Hammond, J. and G. N. Murray. 1937. Body proportions of different breeds of bacon pigs. Jour. of Agr. Sci. 27:394.

(21) Hankins, O. G. and N. R. Ellis. 1934. Physical characteristics of hog carcasses as measures of fatness. Jour. Agr. Res. 48:257.

(22) Hazel, L. N. and E. A. Kline. 1952. Mechanical measurement of fatness and carcass value on live hogs. Jour. An. Sci. 11:313.

(23) Hazel, L. N. and E. A. Kline. 1953. Accuracy of eight sites for probing live pigs to measure fatness and leanness. Jour. An. Sci. 12:894. (Abstract)

(24) Headley, F. B. 1947. Effect of feeding level and liveweight on daily gains of pigs. Jour. An. Sci. 6:379.

(25) Herbert, O. J. and R. M. Crown. 1956. Carcass quality characteristics of market barrows and gilts. Jour. An. Sci. 15:1269. (Abstract)

(26) Hetzer, H. O., O. G. Hankins, J. X. King and J. H. Zeller. 1950. Relationship between certain body measurements and carcass characteristics in swine. Jour. An. Sci. 9:37.

(27) Hetzer, H. O., J. H. Zeller and O. G. Hankins. 1956. Carcass yields as related to live hog probes at various weights and locations. Jour. An. Sci. 15:257.

(28) Jordan, C. E., W. M. Beeson and J. R. Riley. 1956. Producing leaner market hogs by different feed combinations and controlled corn intake. Jour. An. Sci. 15:369.

(29) Kline, E. A. and L. N. Hazel. 1955. Loin area at tenth and last rib as related to leanness of pork carcasses. Jour. An. Sci. 14:659.

(30) Lasley, C. L., L. N. Hazel and E. A. Kline. 1956. Predicting lean cuts from live hog and easily measured carcass traits. Jour. An. Sci. 15:1268. (Abstract)

(31) Loeffel, W. J., W. W. Derrick and M. Peters. 1943. Weight of pigs as it affects gains and carcass qualities. Neb. Exp. Sta. Bul. 351.

(32) McMeekan, C. P. 1940. Part I. Growth and development in the pig, with special reference to carcass quality characters. Jour. Agr. Sci. 30:276.

(33) McMeekan, C. P. 1941. Part IV. Growth and development in the pig, with special reference to carcass quality characters. Jour. Agr. Sci. 31:1.

(34) Merkel, R. A., R. W. Bray, R. H. Grummer, P. H. Phillips and G. Bohstedt. 1953. The influence of limited-feeding, by the use of high fiber rations upon growth, fattening and carcass characteristics of swine. Jour. An. Sci. 12:903. (Abstract)

(35) Pearson, A. M., L. J. Bratzler, R. J. Deans, J. F. Price, J. A. Hoefer, E. P. Reineke and R. W. Luecke. 1956. The use of specific gravity of certain untrimmed pork cuts as a measure of carcass value. Jour. An. Sci. 15:86.

(36) Pearson, A. M., L. J. Bratzler, J. A. Hoefer, J. F. Price, W. T. Magee and R. J. Deans. 1956. The fat-lean ratio in the rough loin as a tool in evaluation of pork carcasses. Jour. An. Sci. 15:896.

(37) Pearson, A. M., J. F. Price, L. J. Bratzler, W. T. Magee and J. A. Hoefer. 1956. A comparison of the live probe and lean meter for predicting carcass measurements of swine. Jour. An. Sci. 15:1270. (Abstract)

(38) Price, J. F. 1956. Specific gravity and chemical composition of the untrimmed ham as related to leanness of pork carcasses. M.S. Thesis. Mich. State Univ.

(39) Robison, W. L., L. E. Kunkle and V. R. Cahill. 1952. The influence of various factors on the yields of pork cuts. Jour. An. Sci. 11:752. (Abstract)

(40) Rust, R. E. 1953. Effects of delayed castration and restricted feeding upon the growth and carcass characteristics of swine. M.S. Thesis. Mich. State Univ.

(41) Stothart, J. G. 1938. A study of factors influencing swine carcass measurements. Sci. Agr. 19:162.

(42) Vorkapich, M. 1955. Variation in feed efficiency and carcass characteristics of individually fed swine. M.S. Thesis. Mich. State Univ.

(43) Warner, K. F., N. R. Ellis and P. E. Howe. 1934. Cutting yields of hogs as an index of fatness. Jour. Agr. Res. 48:241.

(44) Weir, C. E. 1953. The variation in tenderness in the <u>Longissimus dorsi</u> muscle of pork. Food Tech. 7:500.

(45) Whiteman, J. V. and J. A. Whatley. 1953. An evaluation of some swine carcass measurements. Jour. An. Sci. 12:591.

(46) Whiteman, J. V., J. A. Whatley, and J. C. Hillier. 1953. A further investigation of specific gravity as a measure of pork carcass value. Jour. An. Sci. 12:859.

(47) Winters, L. M., C. F. Sierk and J. N. Cummings. 1949. The effect of plane of nutrition on the economy of production and carcass quality of swine. Jour. An. Sci. 8:132.

(48) Zobrisky, S., J. F. Lasley, D. E. Brady and L. E. Weaver. 1954. Pork carcass evaluation. Mo. Ag. Exp. Sta. Res. Bul. 554.

APPENDIX - Table I

Feedlot Data - Trial I

Hog No.	Initial Weight (lbs.)	Total Gain (lbs.)	Total Days on Feed	Average Daily Gain (lbs.)	Total Feed Consumed (lbs.)	Feed per Hundred pounds Gain (lbs.)
*19-10	33	197	104	1.88	730	371
*19-9	34	186	93	2.00	649	349
19-8	25	199	104	1.91	652	328
19-1	25	196	104	1.61	725	370
19-6	32	188	122	1.54	675	359
19-2	28	198	115	1.72	684	345
19-4	33	187	122	1.53	697	373
19-7	31	192	115	1.68	722	374
19-3	33	187	104	1.80	691	370
Mean	30.4	192.2	111	1.74	691.7	359.9

*Barrows

Trial II

Hog No.	Initial Weight (lbs.)	Total Gain (lbs.)	Total Days on Feed	Average Daily Gain (lbs.)	Total Feed Consumed (lbs.)	Feed per Hundred pounds Gain (lbs.)
0-1	22	201	149	1.35	713	355
0-2	27	190	149	1.28	725	383
0-4	26	196	149	1.32	686	350
0-5	28	190	134	1.42	628	331
0-6	25	194	142	1.37	670	345
0-7	28	197	156	1.26	776	394
0-8	25	193	136	1.42	624	323
0-9	23	193	156	1.24	707	366
0-10	22	204	176	1.16	741	363
Mean	25.1	195.3	150	1.31	696.7	356.7

APPENDIX - Table II

Slaughter Data - Trial I

Hog No.	Feedlot Weight (lbs.)	Slaughter Weight (lbs.)	Age at Slaughter (Days)	Pre-slaughter Shrink (%)	Cold Carcass Weight (lbs.)	Percent Cooler Shrink (%)	Dressing Percent (%)
*19-10	230	213	157	5.2	168.5	3.16	77.3
*19-9	220	209	146	5.0	161.0	3.13	77.0
19-8	224	214	157	4.5	163.5	2.68	76.4
19-1	221	211	157	4.5	162.0	5.04	76.8
19-6	220	212	175	3.6	163.0	4.00	76.9
19-2	226	217	168	4.0	170.0	3.41	78.3
19-4	220	211	175	4.1	161.0	3.82	76.3
19-7	223	213	168	4.5	167.0	2.85	78.4
19-3	220	210	157	4.6	161.0	2.41	76.7
Mean	222.7	212.8	162.2	4.5	164.1	3.39	77.1

*Barrows

Trial II

Hog No.	Feedlot Weight (lbs.)	Slaughter Weight (lbs.)	Age at Slaughter (Days)	Pre-slaughter Shrink (%)	Cold Carcass Weight (lbs.)	Percent Cooler Shrink (%)	Dressing Percent (%)
0-1	223	209	199	6.3	157	3.1	75.1
0-2	217	207	199	4.6	158	2.7	76.3
0-4	222	210	199	5.4	162.5	2.8	77.4
0-5	218	206	184	5.5	155	3.7	75.2
0-6	219	210	192	4.1	158	3.4	75.2
0-7	225	215	206	4.4	164	3.3	76.3
0-8	218	204	186	6.4	154	3.2	75.5
0-9	216	206	206	4.6	157.5	3.3	76.5
0-10	226	216	226	4.4	161.5	2.8	74.8
Mean	220.4	209.2	199.7	5.1	158.6	3.1	75.8

APPENDIX - Table III

Carcass Data - Trial I

Hog No.	Carcass Length (in.)	Specific Gravity R. Ham	Loin Lean Area 10th Rib (sq. in.)	Loin Lean Area Last Rib (sq. in.)	Average Live Probe (in.)	Average Backfat (in.)
*19-10	29.3	1.032	2.39	2.53	2.43	2.33
*19-9	29.0	1.036	2.99	3.10	1.95	2.16
19-8	28.7	1.045	3.23	3.38	2.25	2.23
19-1	28.7	1.038	3.18	3.19	1.93	2.02
19-6	30.2	1.049	3.75	3.84	1.85	1.83
19-2	29.2	1.045	3.62	3.90	2.02	1.92
19-4	30.2	1.040	3.69	3.69	1.55	1.90
19-7	29.6	1.042	3.15	3.61	2.22	2.31
19-3	27.8	1.034	2.77	3.15	2.10	1.99
Mean	29.2	1.040	3.20	3.38	2.03	2.08

*Barrows

Trial II

Hog No.	Carcass Length (in.)	Specific Gravity R. Ham	Loin Lean Area 10th Rib (sq. in.)	Loin Lean Area Last Rib (sq. in.)	Average Live Probe (in.)	Average Backfat (in.)
0-1	30.0	1.056	3.88	4.40	1.35	1.46
0-2	28.9	1.048	3.70	3.87	1.65	1.73
0-4	27.2	1.049	3.70	4.23	1.67	1.74
0-5	29.7	1.048	3.42	3.80	2.02	1.72
0-6	28.8	1.049	3.62	3.83	1.87	1.78
0-7	28.7	1.043	4.32	4.20	1.87	1.87
0-8	28.5	1.045	4.29	4.44	1.50	1.49
0-9	27.3	1.045	4.03	3.90	1.83	1.96
0-10	29.5	1.047	4.09	4.57	1.55	1.68
Mean	28.73	1.048	3.90	4.14	1.70	1.71

APPENDIX - Table IV

Cutting Data - Trial I

Hog No.	Skinned Ham (lbs.)	Weight of Cuts Trimmed Loin (lbs.)	Trimmed Shoulder (lbs.)	Trimmed Belly (lbs.)	Total Weight Lean Cuts (lbs.)	Total Weight Primal Cuts (lbs.)
*19-10	24.4	21.6	24.2	24.1	70.2	94.3
*19-9	25.6	20.0	23.1	25.9	68.7	94.6
19-8	26.3	21.0	23.1	27.2	70.4	97.6
19-1	26.4	20.4	25.0	26.4	71.8	98.2
19-6	28.9	22.8	24.2	25.0	75.7	100.7
19-2	30.8	24.0	27.5	25.2	82.3	107.5
19-4	30.5	23.0	24.8	22.7	78.3	101.0
19-7	26.0	24.4	25.5	24.1	75.9	100.0
19-3	27.2	20.8	23.3	23.8	71.3	95.1
Mean	27.3	22.0	24.5	24.9	73.8	98.8

*Barrows

Trial II

Hog No.	Skinned Ham (lbs.)	Trimmed Loin (lbs.)	Trimmed Shoulder (lbs.)	Trimmed Belly (lbs.)	Total Weight Lean Cuts (lbs.)	Total Weight Primal Cuts (lbs.)
0-1	30.1	25.7	26.4	23.2	82.2	105.4
0-2	29.3	25.7	24.4	21.4	79.4	100.8
0-4	30.4	24.2	28.5	23.6	83.1	106.7
0-5	27.2	23.2	24.8	23.3	75.2	98.5
0-6	28.2	25.3	26.5	24.2	80.0	104.2
0-7	29.5	25.3	27.6	22.0	82.4	104.4
0-8	29.6	23.6	25.6	22.7	78.8	101.5
0-9	29.5	22.6	24.6	23.5	76.7	100.2
0-10	29.9	25.8	28.6	21.4	84.3	105.7
Mean	29.3	24.6	26.3	22.8	80.2	103.0

APPENDIX - Table V

Cutting Data - Trial I

Hog No.	Primal Cut Yield Live Basis (%)	Primal Cut Yield Carcass Basis (%)	Lean Cut Yield Live Basis (%)	Lean Cut Yield Carcass Basis (%)	Fat Trim Carcass Basis (%)
*19-10	43.3	56.0	32.2	41.7	35.6
*19-9	45.3	58.8	32.9	42.7	28.6
19-8	45.6	59.7	32.9	43.1	31.8
19-1	46.5	62.7	34.0	44.3	29.9
19-6	47.5	61.8	35.7	46.4	24.5
19-2	46.4	63.2	37.9	48.4	27.3
19-4	47.9	62.7	37.1	48.6	25.2
19-7	47.0	59.9	35.6	45.5	30.5
19-3	45.3	59.1	34.0	44.3	29.8
Mean	46.1	60.2	34.7	45.0	29.24

*Barrows

Trial II

Hog No.	Primal Cut Yield Live Basis (%)	Primal Cut Yield Carcass Basis (%)	Lean Cut Yield Live Basis (%)	Lean Cut Yield Carcass Basis (%)	Fat Trim Carcass Basis (%)
0-1	50.4	67.1	39.3	52.4	23.6
0-2	48.7	63.8	38.4	50.3	27.9
0-3	50.8	65.7	39.6	51.1	27.0
0-4	47.8	63.6	36.5	48.5	28.7
0-5	49.6	66.0	38.1	50.6	26.9
0-6	48.6	63.7	38.3	50.2	28.8
0-7	49.8	65.9	38.6	51.2	24.0
0-8	48.6	63.6	37.2	48.7	28.6
0-9	48.9	65.5	39.0	52.2	25.9
Mean	49.3	65.0	38.3	50.6	26.8

APPENDIX - Table VI

Cooking Data - Trial I

Hog No.	Specific Gravity Center Loin	Specific Gravity Blade Loin	Shear Value Roast (lbs.)	Shear Value Deep Fat (lbs.)	Cooking Loss Roast (%)	Cooking Loss Deep Fat (%)
*19-10	1.057	1.054	6.25	6.80	18.9	20.2
*19-9	1.066	1.055	9.05	9.25	11.2	13.9
19-8	1.066	1.066	6.80	5.70	16.2	20.0
19-1	1.071	1.066	6.85	5.85	13.9	20.5
19-6	1.062	1.062	7.80	6.05	17.7	16.2
19-2	1.070	1.064	6.45	5.55	16.3	13.8
19-4	1.060	1.063	7.10	7.95	21.2	16.6
19-7	1.056	1.055	9.50	8.75	18.5	15.7
19-3	1.060	1.053	6.65	8.90	16.14	15.1
Mean	1.063	1.060	7.38	7.20	16.67	16.89

*Barrows

Trial II

Hog No.	Specific Gravity Center Loin	Specific Gravity Blade Loin	Shear Value Roast (lbs.)	Shear Value Deep Fat (lbs.)	Cooking Loss Roast (%)	Cooking Loss Deep Fat (%)
0-1	1.079	1.065	9.80	9.55	23.4	30.9
0-2	1.076	1.069	7.95	9.40	19.0	25.7
0-4	1.067	1.059	7.40	9.10	20.6	29.7
0-5	1.073	1.070	6.75	9.40	23.1	24.1
0-6	1.074	1.067	8.50	9.40	16.1	23.9
0-7	1.066	1.051	7.0	7.8	20.2	25.8
0-8	1.081	1.065	7.70	7.8	15.1	26.6
0-9	1.067	1.063	9.50	9.25	17.9	31.4
0-10	1.064	1.057	7.95	8.4	21.1	27.6
Mean	1.072	1.063	7.95	8.90	19.6	27.3